# Methods and Measures for Assessing Exposure to Risk, Crash Risk, and Equity

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Annual CTS
**TRANSPORTATION
RESEARCH
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## Introduction

| | Bike crash deaths (2016) | Pedestrian crash deaths (2016) |
|---|---|---|
| US wide | 840 | 5,987 |
| Minnesota | 7 | 58 |
| Minneapolis | 1 | 9 |

❑ **Protecting vulnerable road users** is a priority for both transportation managers and the public

## Research Questions

❑ How crash risk is correlated with different factors, such as exposure, traffic facility, land use, socioeconomic variables, etc.?

❑ Do people living in racially-concentrated, low-income (ACP50) areas experience higher pedestrian and bike crash risk?

ACP50 area: where 50% or more of the residents are people of color and 40% or more of the residents have family incomes that are less than 185% of the federal property threshold (by DPW in Minneapolis)

## Data Sources and Years

| Data type | Data source | Year |
| --- | --- | --- |
| Crash | Department of Public Safety in MDOT | 2005-2016 |
| Actual exposure | Department of Public Work in Minneapolis | 2007-2014 |
| Built environment | Minnesota Geospatial Information Office | Mixed |
| Downtown | Department of Public Work in Minneapolis | 2017 |
| Traffic facilities | Department of Public Work in Minneapolis | - |
| Road functions | Department of Public Work in Minneapolis | 2016 |
| Socioeconomic data | U.S. Census Bureau | 2016 |
| Liquor sale location | Open Minneapolis | 2018 |

## Method

**Bike and pedestrian crash probability at intersection and mid-block level**

**Model construction**

- ❑ Crash probability
- ✓ Crash data in Minneapolis (2005-2016)
- ✓ 0-1 variable

- ❑ Logit model
- ❑ 28 Independent variables

- ❑ Actual exposure
- ✓ Bike count
- ✓ Pedestrian count
- ✓ AADT

- ❑ 437 mid-blocks
- ❑ 173 intersections

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- ❑ 173 intersections

- ❑ With estimated exposure (from direct demand models based on counts)

- ❑ 26 other same independent variables

- ❑ 12,594 mid-blocks
- ❑ 6,646 intersections

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### Crash probability prediction

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### Crash probability comparison

- ❑ Compare the crash probabilities between ACP50 areas and non-ACP50 areas with t-test

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## Crash Distribution

**Crash Severity Distribution**



| Severity | Pedestrian | Bike |
|---|---|---|
| All | 3495 | 3302 |
| Killed | 52 | 15 |
| Severe injury crash | 334 | 166 |
| Moderate injury crash | 1131 | 1035 |
| Minor injury crash | 1843 | 1916 |
| Property damage crash | 115 | 143 |
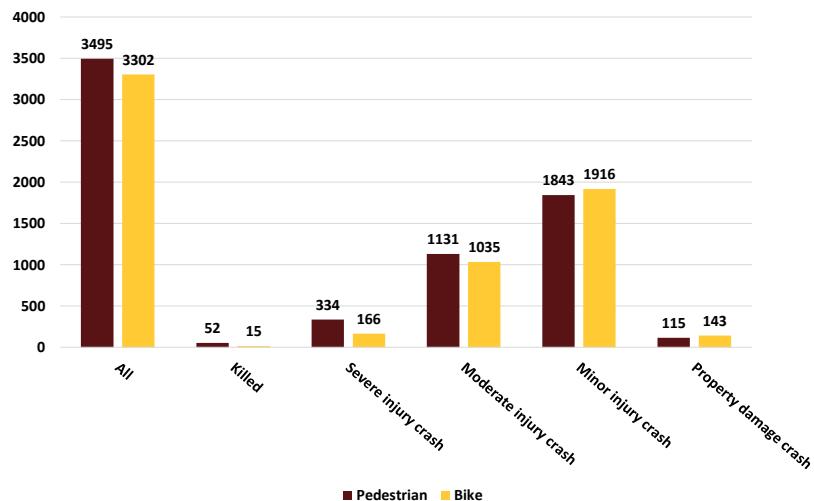
■ Pedestrian  ■ Bike

## Crash Distribution



Pedestrian crash distribuition in Minneapolis (2005-2016)

Bike crash distribution in Minneapolis (2005-2016)

## Descriptive Statistics for Crashes
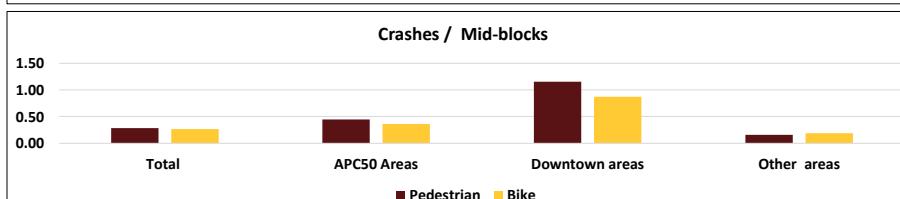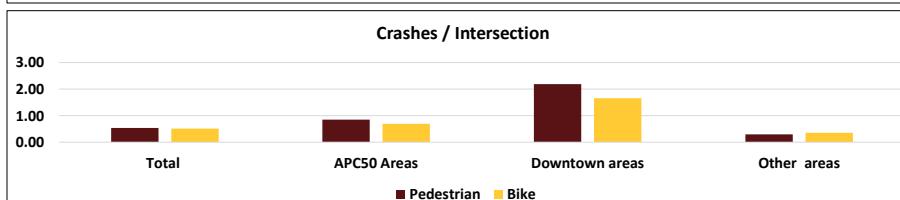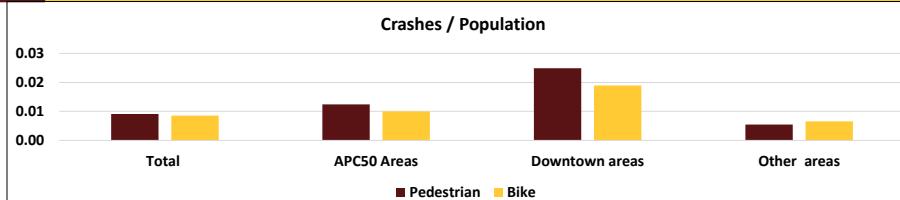
## Four Crash Probability Models

Four crash probability models (0-1 dependent variables)
- ✓ **Pedestrian intersection**
- ✓ **Pedestrian mid-block**
- ✓ **Bike intersection**
- ✓ **Bike mid-block**

Seven categories of independent variables
- ✓ Exposure
- ✓ Built environment
- ✓ Downtown
- ✓ Traffic facilities
- ✓ Road functions
- ✓ Socioeconomic
- ✓ Liquor sale locations

## Correlation of Crash Risk and Exposure

| | | Pedestrian models | | Bike models | |
|---|---|---|---|---|---|
| | | Intersection (size = 173) | Mid-block (size = 437) | Intersection (size = 173) | Mid-block (size = 437) |
| | | Coef. | Coef. | Coef. | Coef. |
| Exposure | Pedestrian count | + ** | + | + | + |
| | Bike count | - | - | + | + |
| | AADT | + *** | + ** | + | + ** |

Note: Shaded, asterisk = statistically significant correlation
    *P>z at 95% level; ** P>z at 99% level; *** P>z at 99.9% level

## Correlation of Crash Risk and Built Environment

| | | Pedestrian models | | Bike models | |
|---|---|---|---|---|---|
| | | Intersection (size = 173) | Mid-block (size = 437) | Intersection (size = 173) | Mid-block (size = 437) |
| | | Coef. | Coef. | Coef. | Coef. |
| Built environment | Population density | + | - | + | + |
| | Job density | - | + | - | - |
| | Job accessibility | - | - | + | - |
| | Intersection number | - | + | + | - |
| | Transit stop | + | + | - | - |
| | %commercial | - | + | - | + *** |
| | %office | - | - | - | + |
| | %industrial | - | - | - | + * |
| | %open space | - * | - | - | + |
| | Entropy | + | - | + * | - |

Note: Shaded, asterisk = statistically significant correlation
   *P>z at 95% level; ** P>z at 99% level; *** P>z at 99.9% level

## Correlation of Crash Risk and Downtown, traffic facilities, road functions

| | | Pedestrian models | | Bike models | |
|---|---|---|---|---|---|
| | | Intersection (size = 173) | Mid-block (size = 437) | Intersection (size = 173) | Mid-block (size = 437) |
| | | Coef. | Coef. | Coef. | Coef. |
| Downtown | Downtown | + | - | - | + |
| Traffic facilities | Sidewalk /Bike lane | - | + | - | - |
| | Trail | - | | - | |
| | Stop sign | + | + *** | + | + * |
| | Street light | - | + * | + | + |
| | Traffic signal | + | - | + | - |
| Road functions | Major | - | + | - | - |
| | Secondary | + | + | + | + |

Note: Shaded, asterisk = statistically significant correlation
   *P>z at 95% level; ** P>z at 99% level; *** P>z at 99.9% level

## Correlation of Crash Risk and socioeconomic, liquor

| | | Pedestrian models | | Bike models | |
|---|---|---|---|---|---|
| | | Intersection (size = 173) | Mid-block (size = 437) | Intersection (size = 173) | Mid-block (size = 437) |
| | | Coef. | Coef. | Coef. | Coef. |
| Socioeconomic | %child | - | - | - | + |
| | %old | - | - | - | + |
| | %male | + * | + | + | - |
| | Average household size | + | + | - | + |
| | Average vehicle number | - | - | - | - |
| Liquor sale location | Off sale | + ** | + * | + * | - |
| | On sale | - | + | - | + |

Note: Shaded, asterisk = statistically significant correlation
   *P>z at 95% level; ** P>z at 99% level; *** P>z at 99.9% level

## Crash Probability at Intersections

## Crash Probability in Mid-blocks



Pedestrian crash probability distribution in mid-blocks in Minneapolis

Bike crash probability distribution in mid-blocks in Minneapolis
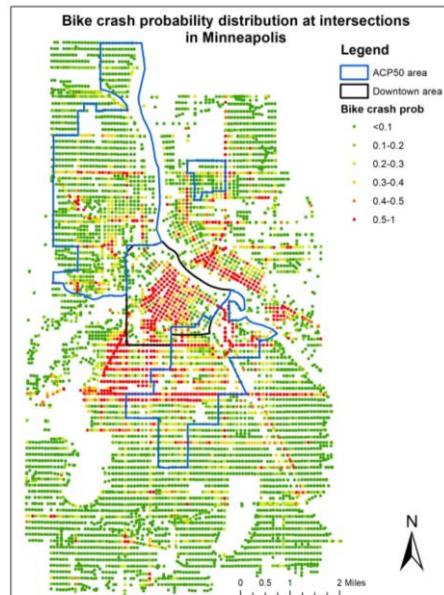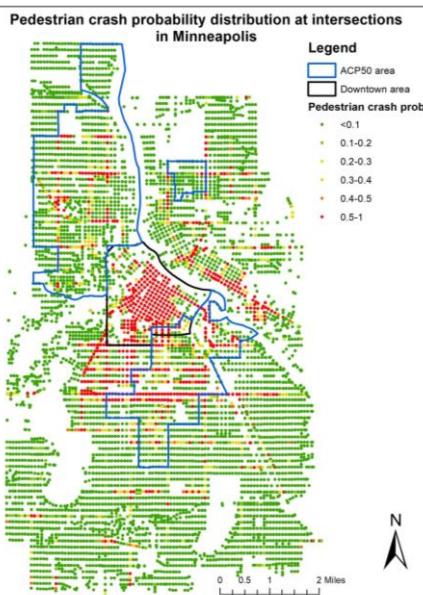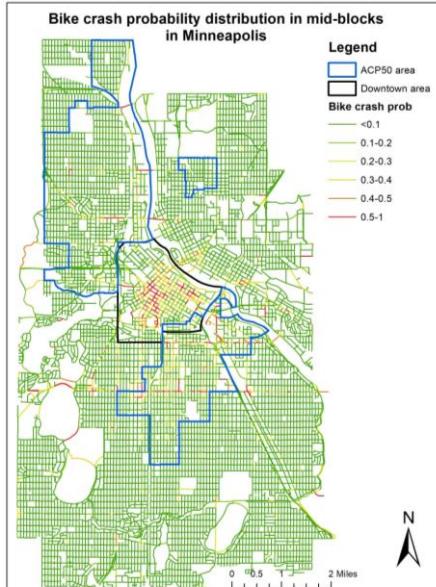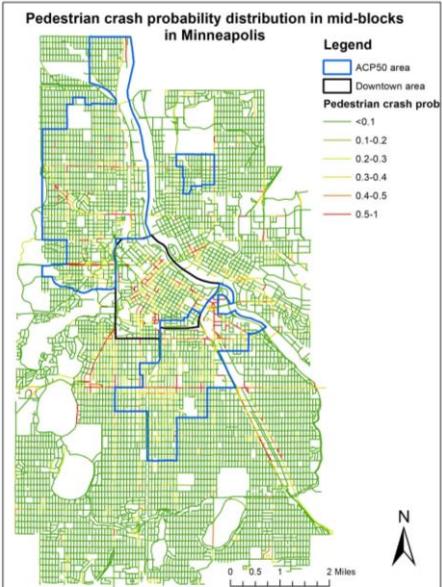
## Crash Probability Comparison (with downtown)

T-test result between bike and pedestrian crash probability at intersections

| Intersection | ACP50 area mean | Non-ACP50 area mean | P-value |
|---|---|---|---|
| Bike | 0.21 | 0.17 | *** |
| Pedestrian | 0.18 | 0.12 | *** |

T-test results between bike and pedestrian crash probability in mid-blocks

| Mid-block | ACP50 area mean | Non-ACP50 area mean | P-value |
|---|---|---|---|
| Bike | 0.08 | 0.05 | *** |
| Pedestrian | 0.13 | 0.07 | *** |

## Crash Probability Comparison (without downtown)

T-test results between bike and pedestrian crash probability at intersections

| Intersection | ACP50 area mean | Non-ACP50 area mean | P-value |
|---|---|---|---|
| Bike | 0.21 | 0.15 | *** |
| Pedestrian | 0.18 | 0.09 | *** |

T-test results between bike and pedestrian crash probability in mid-blocks

| Mid-block | ACP50 area mean | Non-ACP50 area mean | P-value |
|---|---|---|---|
| Bike | 0.08 | 0.04 | *** |
| Pedestrian | 0.13 | 0.06 | *** |

## Some Exploratory Results

- ✓ **AADT is positively** associated with pedestrian intersection and mid-block models, and bike mid-block model

- ✓ **Off sale liquor location is positively** associated with pedestrian intersection and mid-block models, and bike intersection model

- ✓ Several other variables from different types shows significant relationship with bike or pedestrian crash risk at intersection or block street level

- ✓ Pedestrians and bicyclists living in the ACP 50 areas experience **higher crash risks** at both intersection and mid-block

## Some Potential Implications

❑ Limit vehicle behavior near sidewalk and bike lane

❑ Education of proper alcohol use

❑ Focus on improving pedestrian and bike safety in ACP50 areas