Mapping Cyclist Activity and Injury Risk in a Network Combining Smartphone GPS Data and Bicycle Counts

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Background

- A high number of cyclist injuries occur every year in cities
  - Ex. Montreal – 10 years from 1999-2008, 9,000 cyclists were injured
    - 62% at intersections
    - 38% along segments
- Given the importance of cyclist safety – research has been carried out to identify risk factors and map risk in the network
  - Such research requires 3 main sources of data:
    1. Geo-coded injury data
    2. Geometric design and built environment characteristics
    3. Exposure measures – cyclists and motor vehicles

Background

- In 2010 - San Francisco Municipal Transportation Agency launched *CycleTracks* - Smartphone application
- In 2012 - Georgia Tech launched *Cycle Atlanta* – Smartphone application

- Both applications have 3 purposes:
  1. Collect cyclist trip data – see where cyclists are riding
  2. Gauge current infrastructure
  3. Guide future planning

- Based on these applications: In 2013 - the city of Montreal developed their own smartphone application, *Mon RésoVélo* - to serve similar purposes

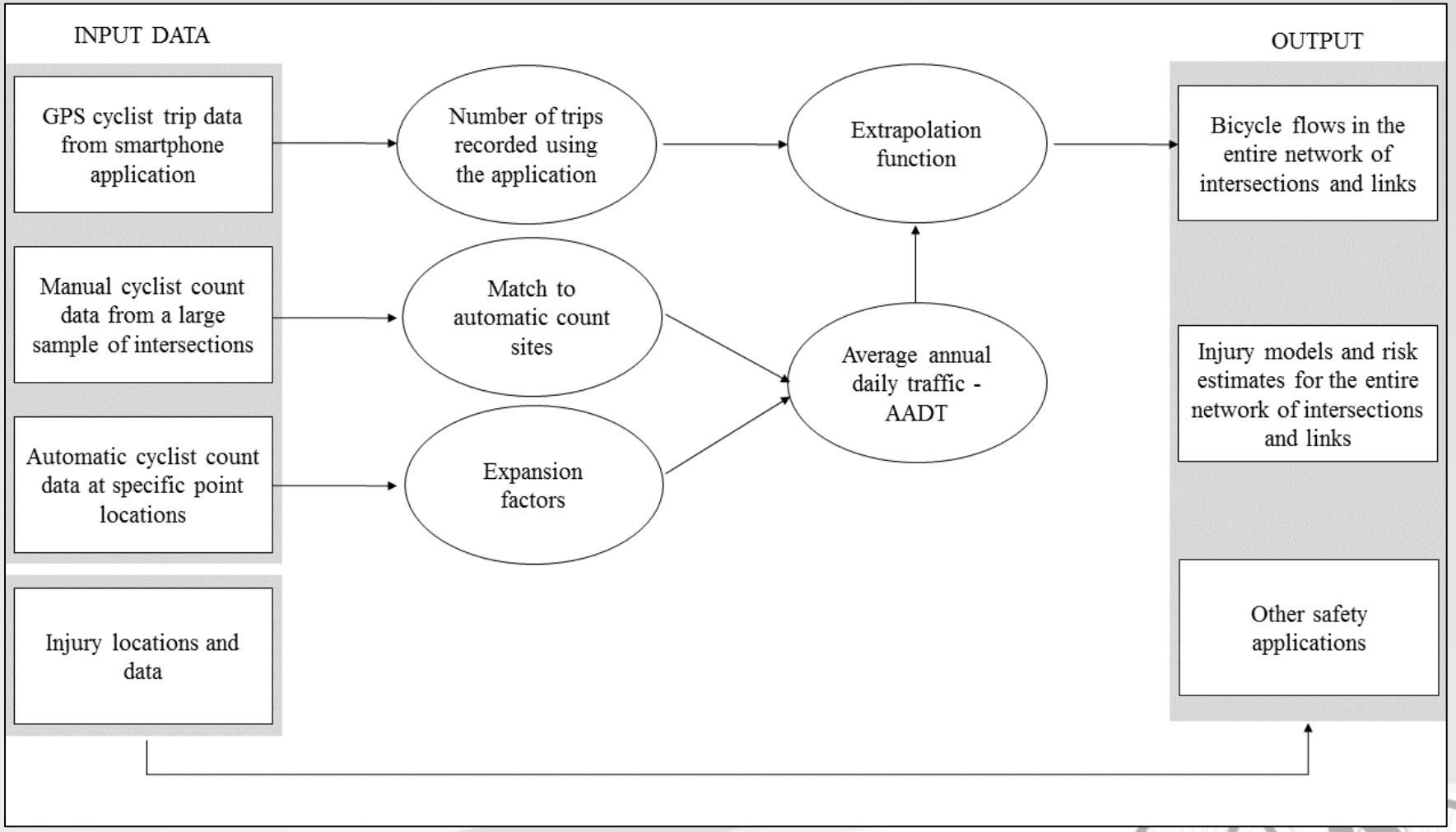
Objectives

- This study aims to:

  - Combine smartphone GPS traces and manual and automatic, short-term (hours) and long-term (months and years) counts to estimate:
    - Average annual daily bicycle volumes
    - Injuries
    - Risk

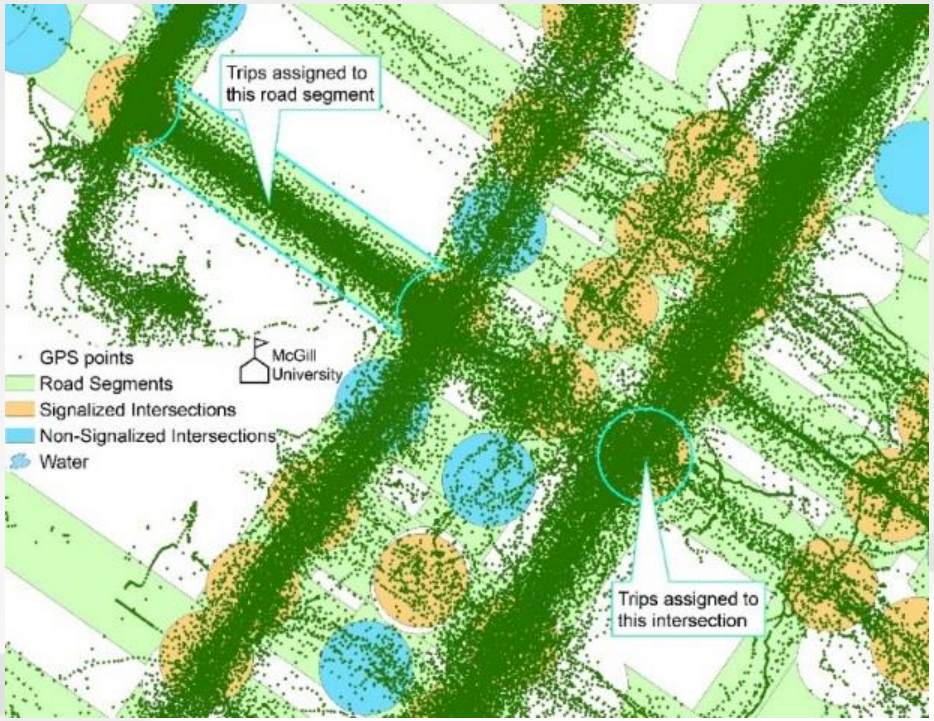
  throughout the entire Montreal network of road segments and intersections

Methodology



Methodology

1. Assign the GPS traces to the network elements
    - Map all raw GPS observations (x,y)
    - Use buffer approach to assign to segments and intersections
        - 35 metres to capture most trips



Methodology

2. Obtain AADB volumes from short-term and long-term counts and develop an extrapolation function for the GPS data
    - Compute AADB at manual count sites from permanent counter data
    - Develop a function to associate this AADB with GPS flows:

$$AADB_{ik} = \beta_k \cdot T_{ik} + \alpha_k \quad \text{with} \quad \alpha_k = f(x_i; \gamma)$$

where:

$AADB_{ik}$= average annual daily bicycle volume at location *i* of type *k*

i= network element *i* of type *k* (signalized intersection, non-signalized intersection or segment)

β_k = parameter weighing the number of GPS traces denoted as T_i

α = correction factor associated with geometric design and/or built environment characteristics

Methodology

3. Validate the predicted AADB from GPS data through the development of Safety Performance Functions (SPF)
    - Develop SPF models with both sources of bicycle flow data
    - Compare parameter coefficients and variable significance

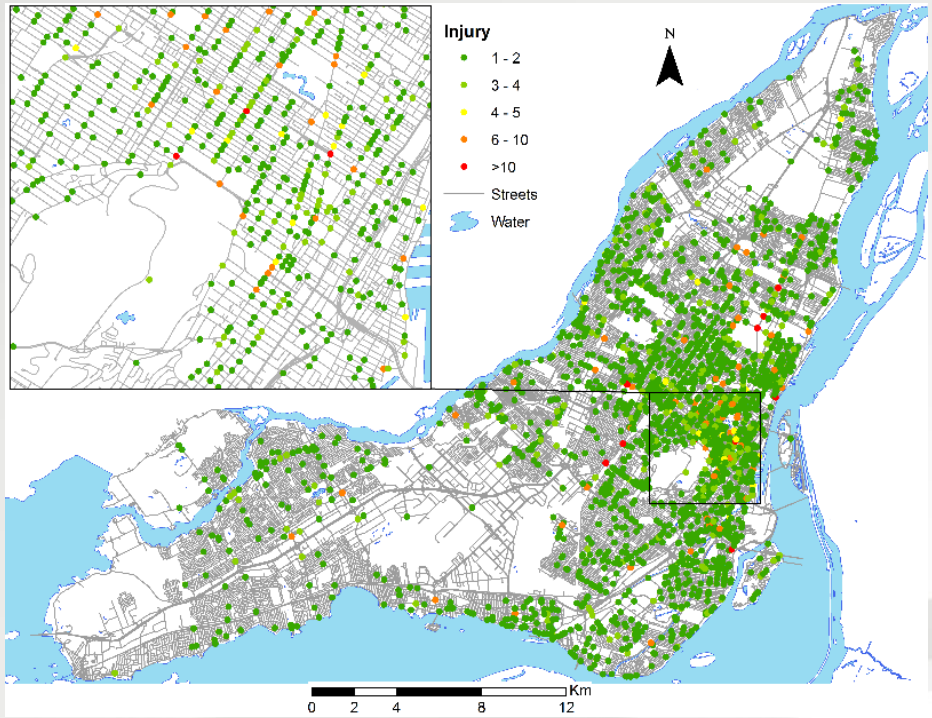
4. Apply the predicted AADB for segments and intersections for safety applications
    - Map flows, injuries and risk throughout the entire network
    - Identify hotspots

Data – Bicycle Counts

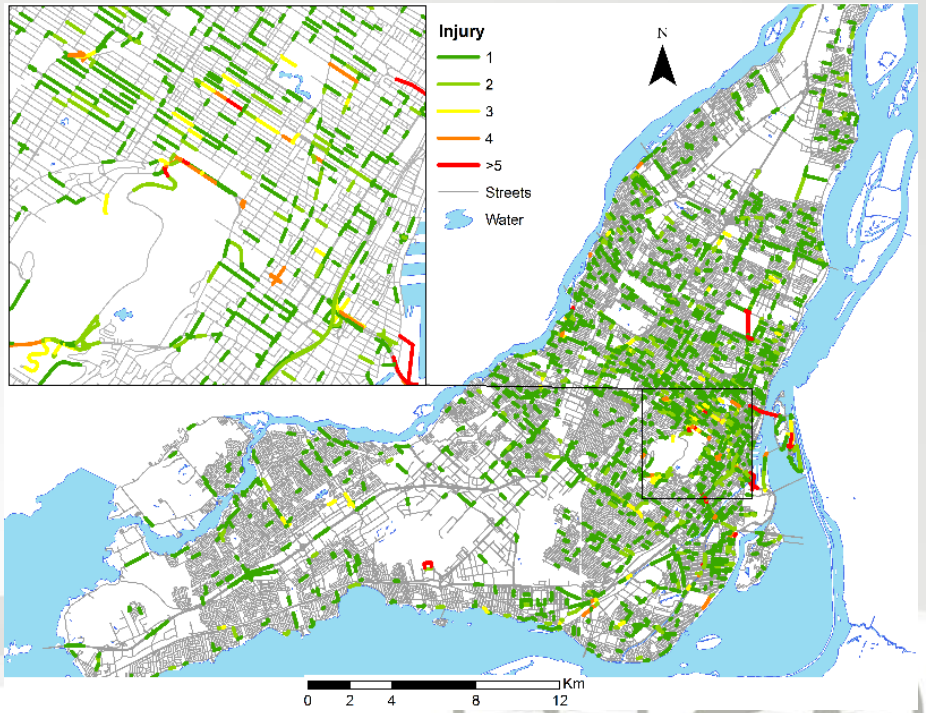
- Smartphone GPS trips:
  - Cyclist trip data from *Mon RésoVelo* smartphone application
    - When cyclists begin their trip they start the app and upon arriving at their destination, they stop the app
    - July 2nd to November 15th, 2013 (137 days)
      - 1,000 cyclists
      - 10,000 trips
      - 16 million GPS points
- Short- and long-term bicycle counts:
  - 8-hour manual counts at over 600 signalized intersections in 2009
  - 1-hour manual counts at over 400 non-signalized intersections in 2012
  - Long-term counts along different road segments – since 2008

Data - Injuries

- 6 years, 2003-2008, from ambulance interventions
  - Over 5,000 cyclists injured at intersections
  - Over 3,500 cyclists injured along segments



Intersections



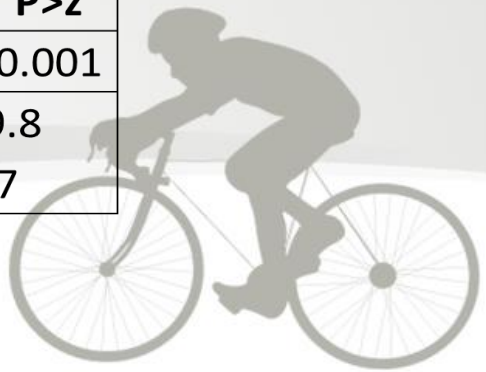
Segments

Results

- AADB Models

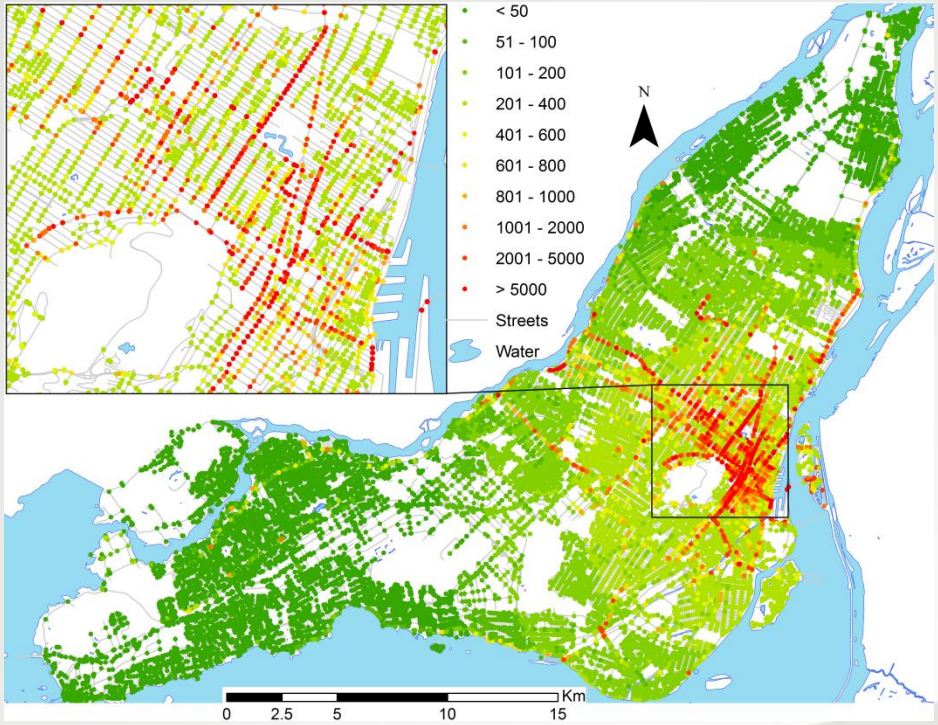
Signalized Intersections			Non-Signalized Intersections		
Variable	**Coef.**	**P>z**	**Variable**	**Coef.**	**P>z**
GPS count - No facilities	11.5	0	GPS count - No facilities	1.28	0
GPS count - Bicycle path	6.71	0	GPS count - Bicycle path	1.15	0
GPS count - Cycle track	17.43	0	GPS count - Cycle track	4.14	0
Distance to downtown*	-15.34	0	Distance to downtown*	-24.1	0
Constant	238.4	0	Constant	378.4	0
R-squared	0.696		R-squared	0.58	

Segments						
Variable	**Cycle Track**		**Bicycle Path**		**No Facility**	
	Coef.	**P>z**	**Coef.**	**P>z**	**Coef.**	**P>z**
GPS flow	20.1	0	9.4	0	46.6	0.001
Constant	1557.1		1387.1		1579.8	
R-Squared	0.52		0.76		0.27	

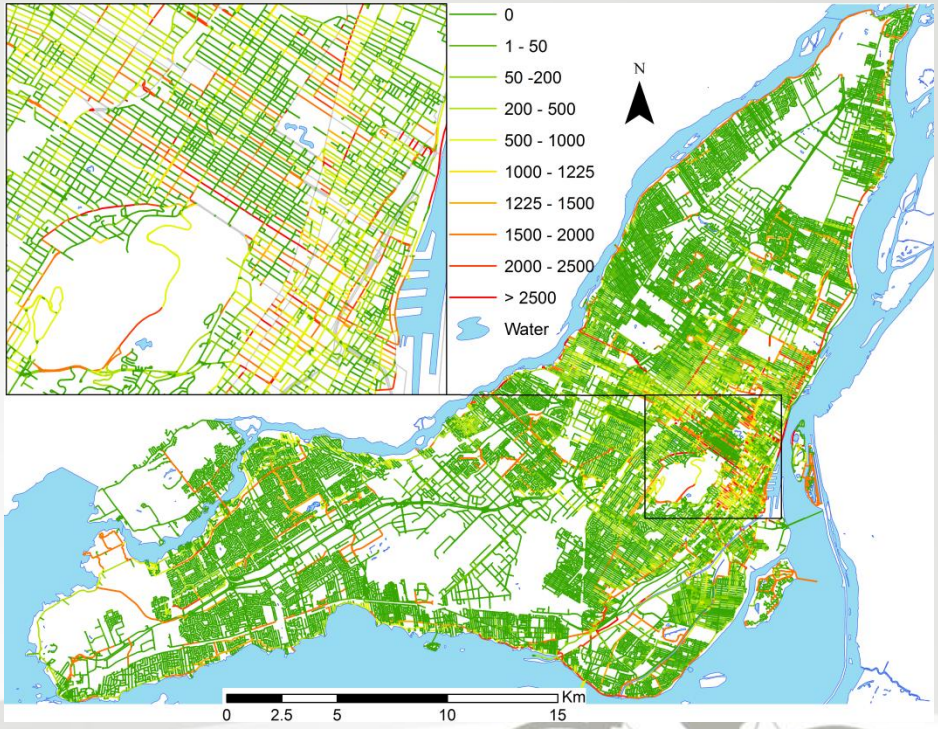


Results

AADB maps



Intersections



Segments

Results

Variable	AADB from manual counts		AADB from GPS trips	
	Coef.	P-value	Coef.	P-value
Ln* bicycle flow	0.510	0.000	0.531	0.000
Ln* right turn motor-vehicle flow	0.174	0.008	0.156	0.012
Ln* left turn motor-vehicle flow	0.138	0.012	0.131	0.013
Crosswalk width	0.010	0.002	0.010	0.002
Bus stop	0.468	0.002	0.595	0
Raised median	-0.478	0.002	-0.475	0.002
Constant	-6.53		-6.57	
Log-likelihood	-621.1		-628.2	
AIC	1258.1		1272.5	

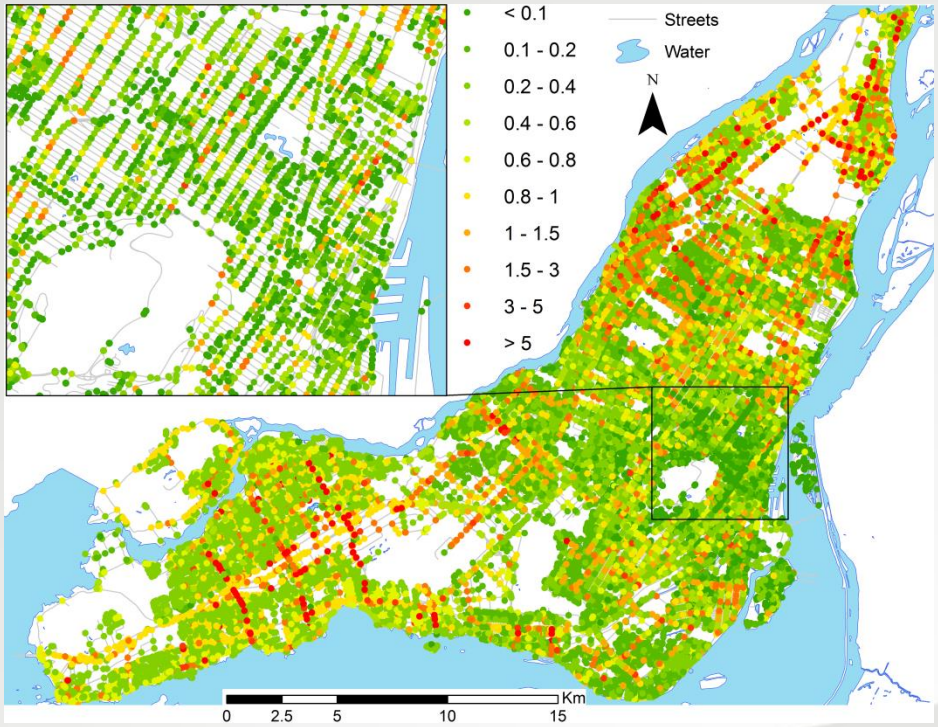
* Ln = natural logarithm

Results

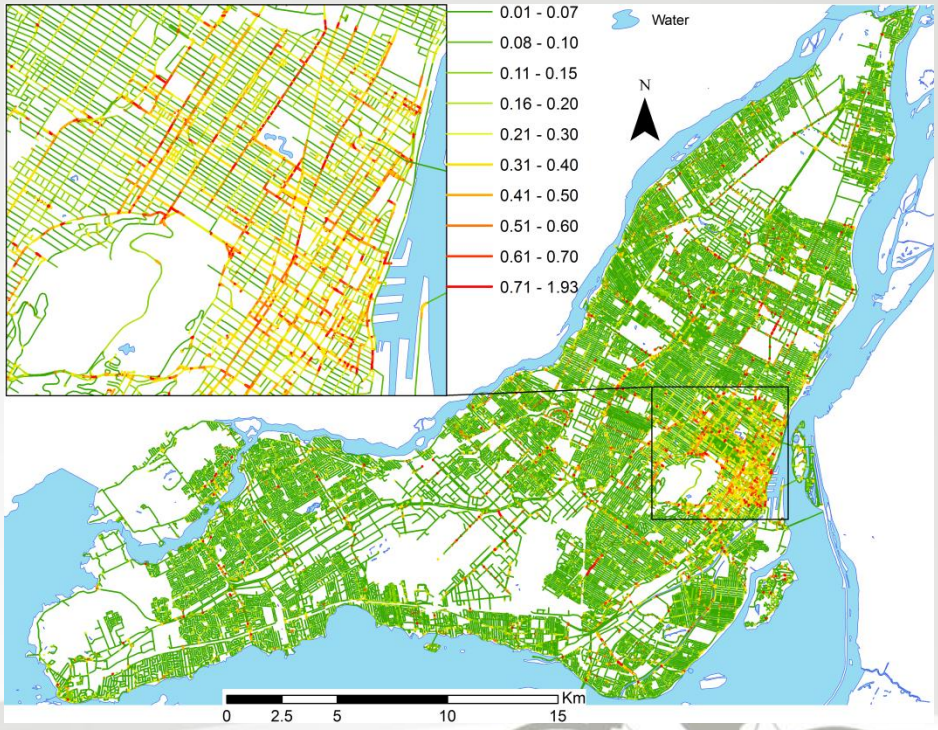
	Variable	Coef.	Std. Err.	P-value
Signalized Intersections	Ln* bicycle flow	0.330	0.017	0
	Bus stop	0.413	0.081	0
	Three approaches	-0.685	0.114	0
	Constant	-2.57	0.139	0
	Alpha	0.796		
	AIC	5141		
	Observations (entire population)	2288		
Non-Signalized Intersections	Ln* bicycle flow	0.385	0.011	0
	Arterial or collector	1.048	0.047	0
	Three approaches	-0.913	0.041	0
	Constant	-3.94	0.070	0
	Alpha	1.539		
	AIC	19384		
	Observations (entire population)	23819		
Segments	Ln* bicycle flow	0.336	0.020	0
	Arterial or collector	0.684	0.052	0
	Downtown boroughs	0.495	0.071	0
	Constant	-4.99	0.091	0
	Alpha	5.187		
	AIC	14963		
	Observations (entire population)	44314		

Results

Risk maps



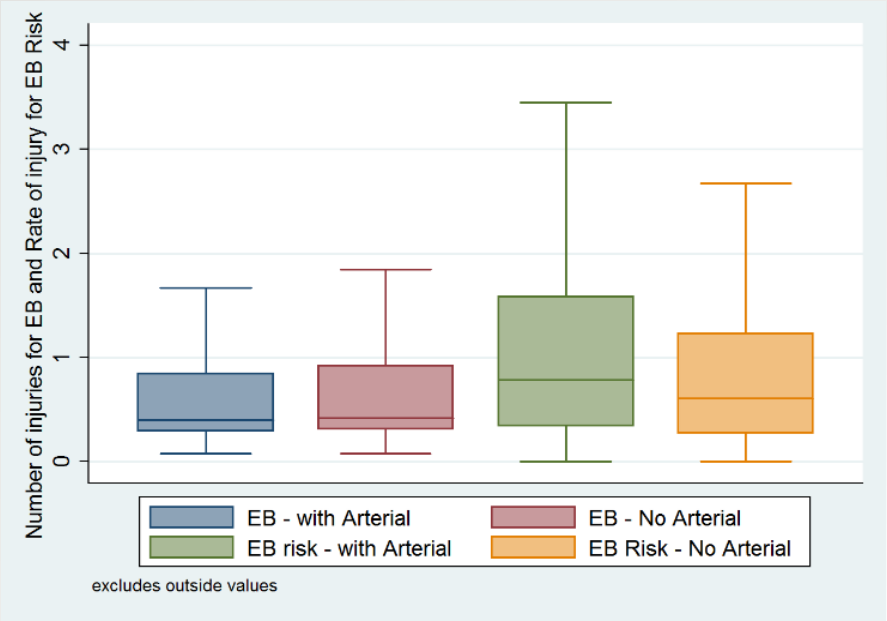
Intersections



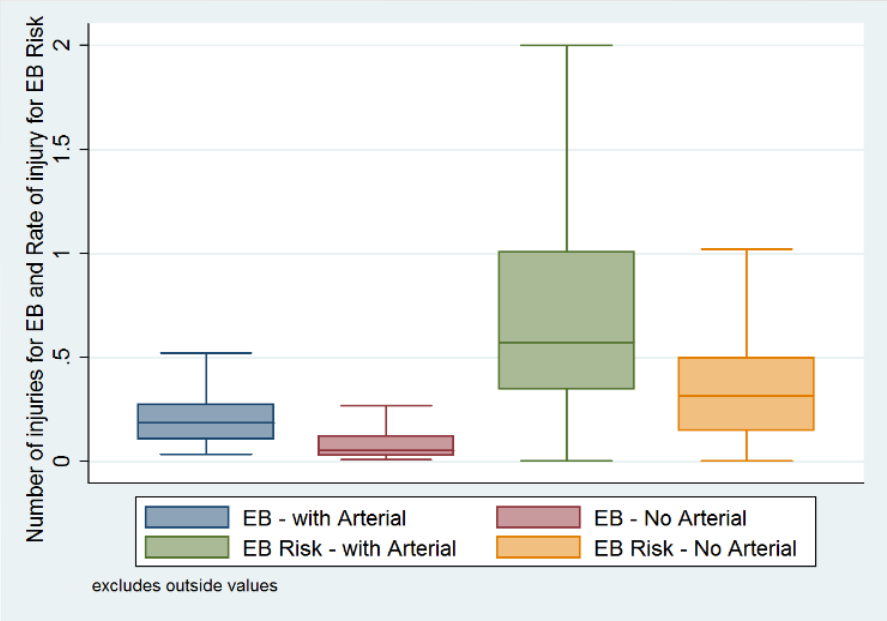
Segments

Results

- Intersections with and without arterials



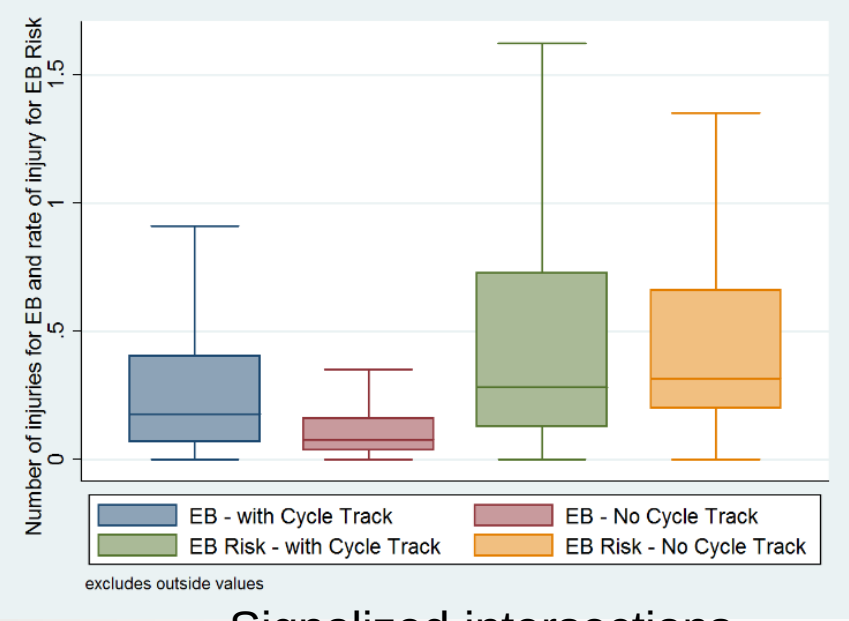
Signalized intersections



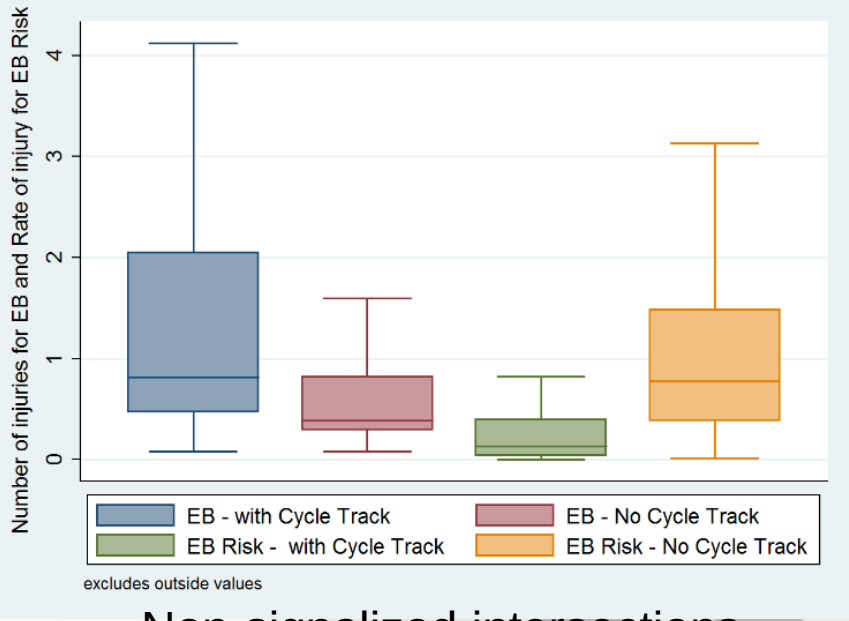
Non-signalized intersections

Results

- Intersections with and without cycle tracks



Signalized intersections



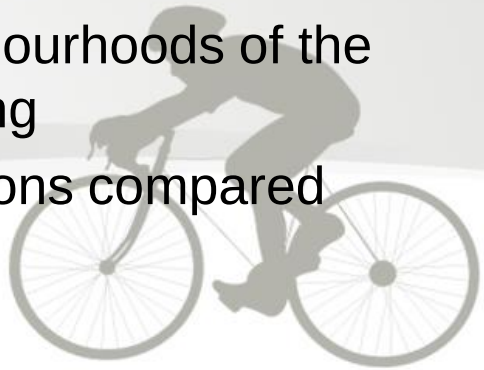
Non-signalized intersections

Conclusion

- Explored the use of smartphone GPS data to estimate exposure measures for the entire network
  - Validated for signalized intersections – remains to be validated for non-signalized intersections and segments

- Mapped bicycle flows and risk in the entire network
  - Can be used to identify hotspots and accounts for the entire population of sites

- Overall findings
  - Cyclist risk is greatest outside the central neighbourhoods of the island which is also where infrastructure is lacking
  - Cyclist injuries and risk are highest for intersections compared to segments



Thank you

- Questions?