Is There Safety in Numbers for Cyclists and Pedestrians?

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November 20, 2013

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Today's webinar presenters

Simon Blenski, Bicycle and Pedestrian Planner, City of Minneapolis

Dr. Luis Miranda-Moreno, Researcher, McGill University

Dr. Krista Nordback, Research Associate, Oregon Transportation Research and Education Consortium (OTREC), Portland State University

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Today's webinar presenters

Simon Blenski is a Bicycle and Pedestrian Planner for the City of Minneapolis Public Works Department, where he manages Minneapolis' non-motorized traffic count program, evaluates pilot projects, and works to implement crash countermeasures for bicyclists and pedestrians. Simon holds a Master's in Urban and Regional Planning from the University of Minnesota-Twin Cities.

Krista Nordback, Ph.D., P.E. is a research associate at the Oregon Transportation Research and Education Consortium (OTREC) at Portland State University. She earned her Ph.D. in civil engineering from the University of Colorado-Denver, focusing on transportation engineering. Her doctoral dissertation, "Estimating Annual Average Daily Bicyclists and Analyzing Cyclist Safety at Urban Intersections," develops a new method for estimating bicycle traffic and provides the first safety performance functions for bicyclists in the U.S. Findings include evidence of fewer collisions per cyclist at intersections with higher bicycle volumes; in other words, cyclists are safer in numbers.

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Today's webinar presenters

Luis Miranda-Moreno works as a researcher and professor in the department of Civil Engineering at McGill University; he holds master's and PhD degrees in Transportation Engineering from the University of Waterloo, Ontario, and a bachelor's degree in civil engineering. His research focuses on the development of traffic data collection and monitoring technologies and methods, in particular for non-motorized modes. He has also developed an expertise in road safety and the impact of transportation systems on the environment. He has done research and projects for transportation agencies and industry. He is currently working in a project for the National Cooperative Highway Research Program (NCHRP) and the Canadian foundation for Innovation (CFI) on traffic data collection tools and methods. He has published about 60 peer-reviewed journal articles as well as many conference papers and government reports.

Is There Safety in Numbers for Cyclists and Pedestrians?

APBP Webinar
Wednesday, November 20, 2013

Krista Nordback, P.E., Ph.D.
Oregon Transportation Research and Education Consortium (OTREC)
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Overview

- Motor Vehicle Safety in Numbers
- Bike & Ped Safety in Numbers
- Conclusions

MOTOR VEHICLE SAFETY IN NUMBERS

8

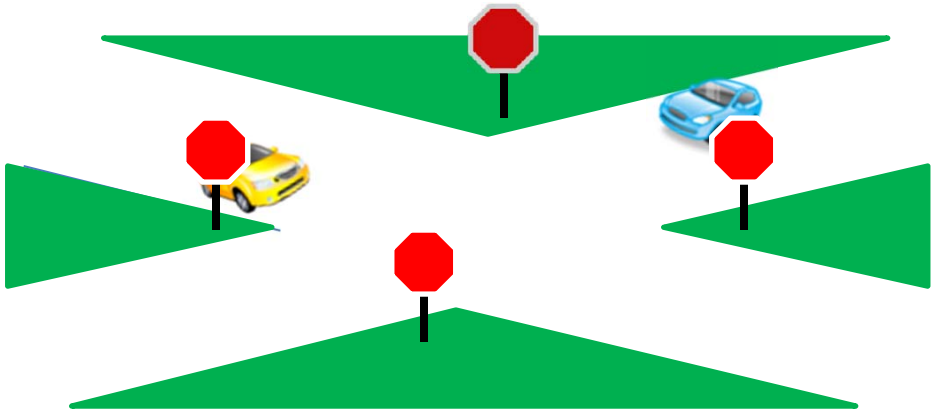
Which intersection is safer?

Intersection 1
1 crash per year

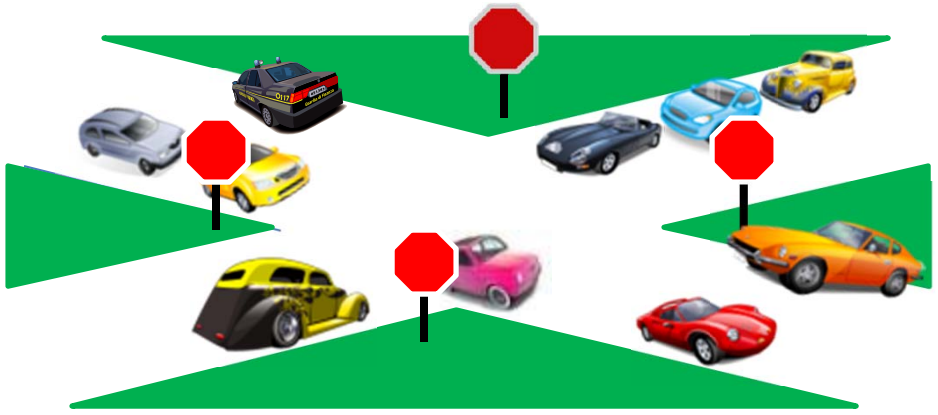
Intersection 2
6 crashes per year

Which intersection is safer?

Intersection 1
1 crash per year



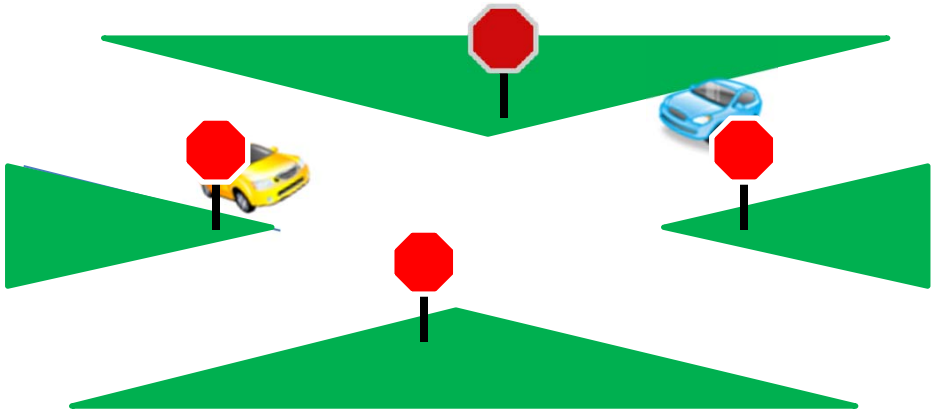
Intersection 2
6 crashes per year



Which intersection is safer?

Intersection 1
1 crash per year

0.0004 crashes/vehicle



Intersection 2
6 crashes per year

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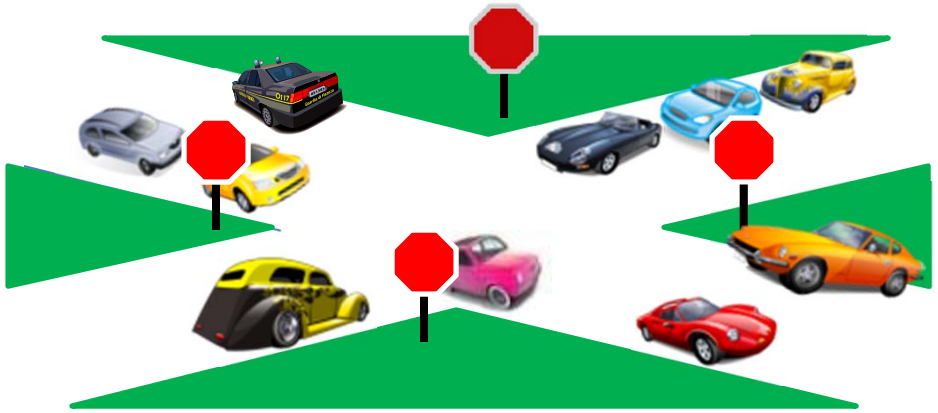
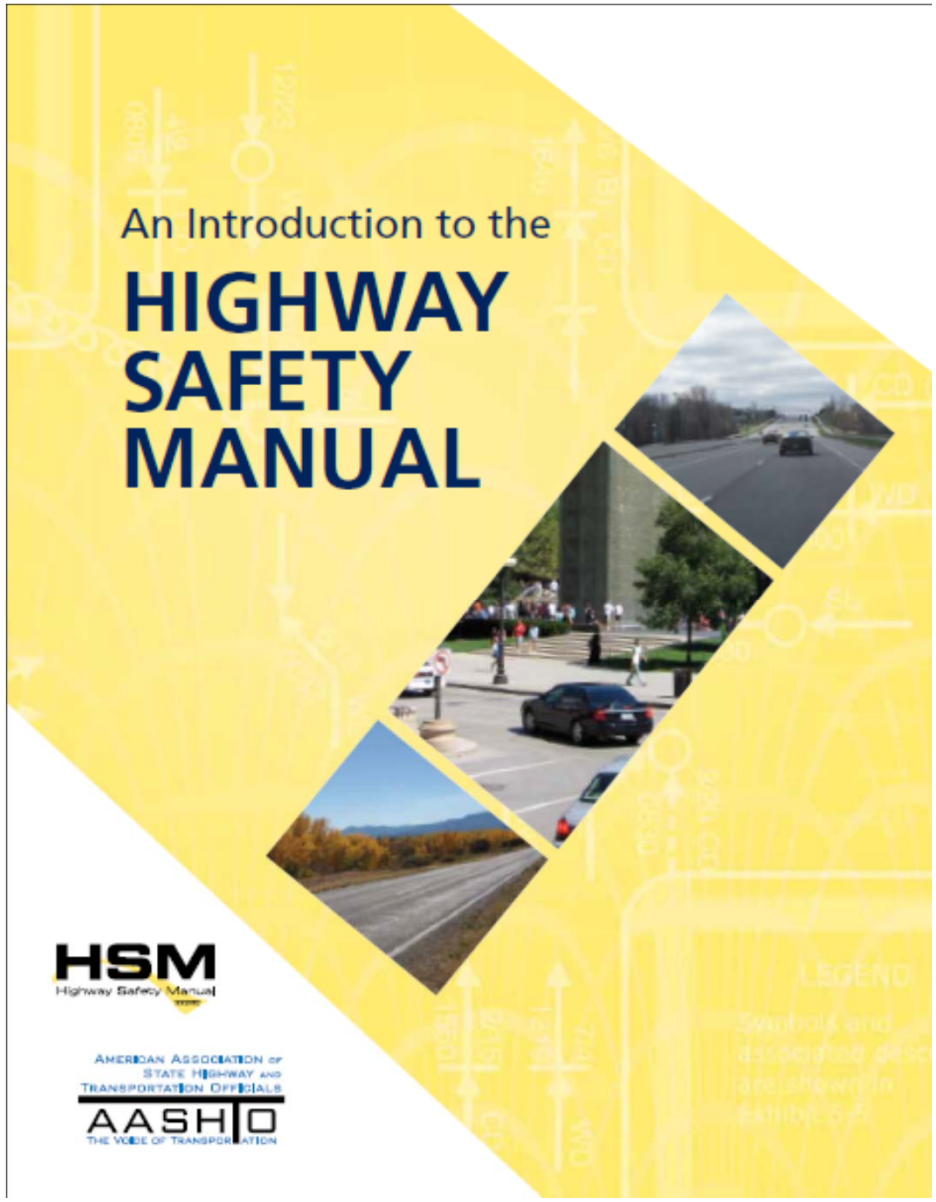
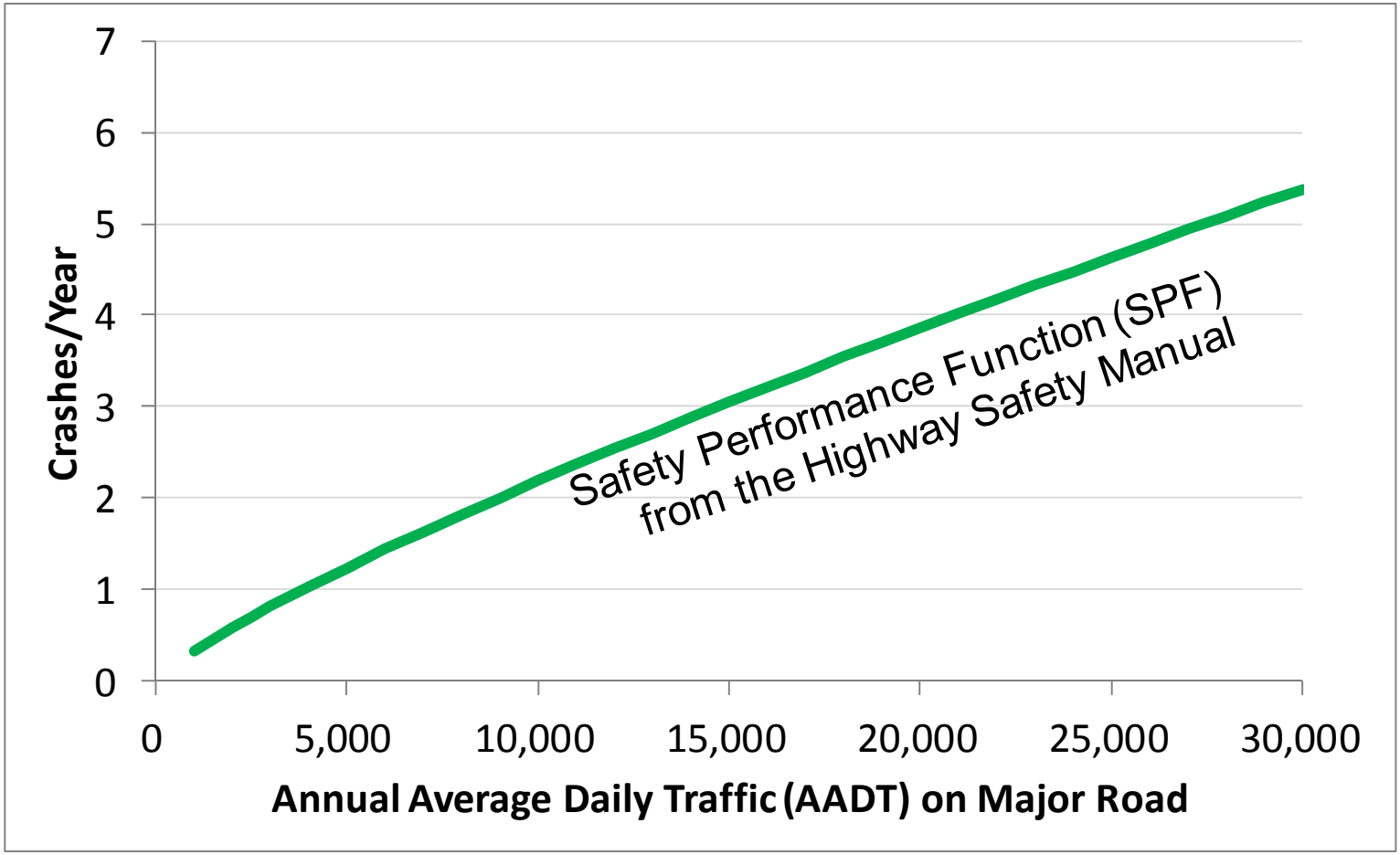


Highway Safety Manual

First Edition 2010!



Which intersection is safer?



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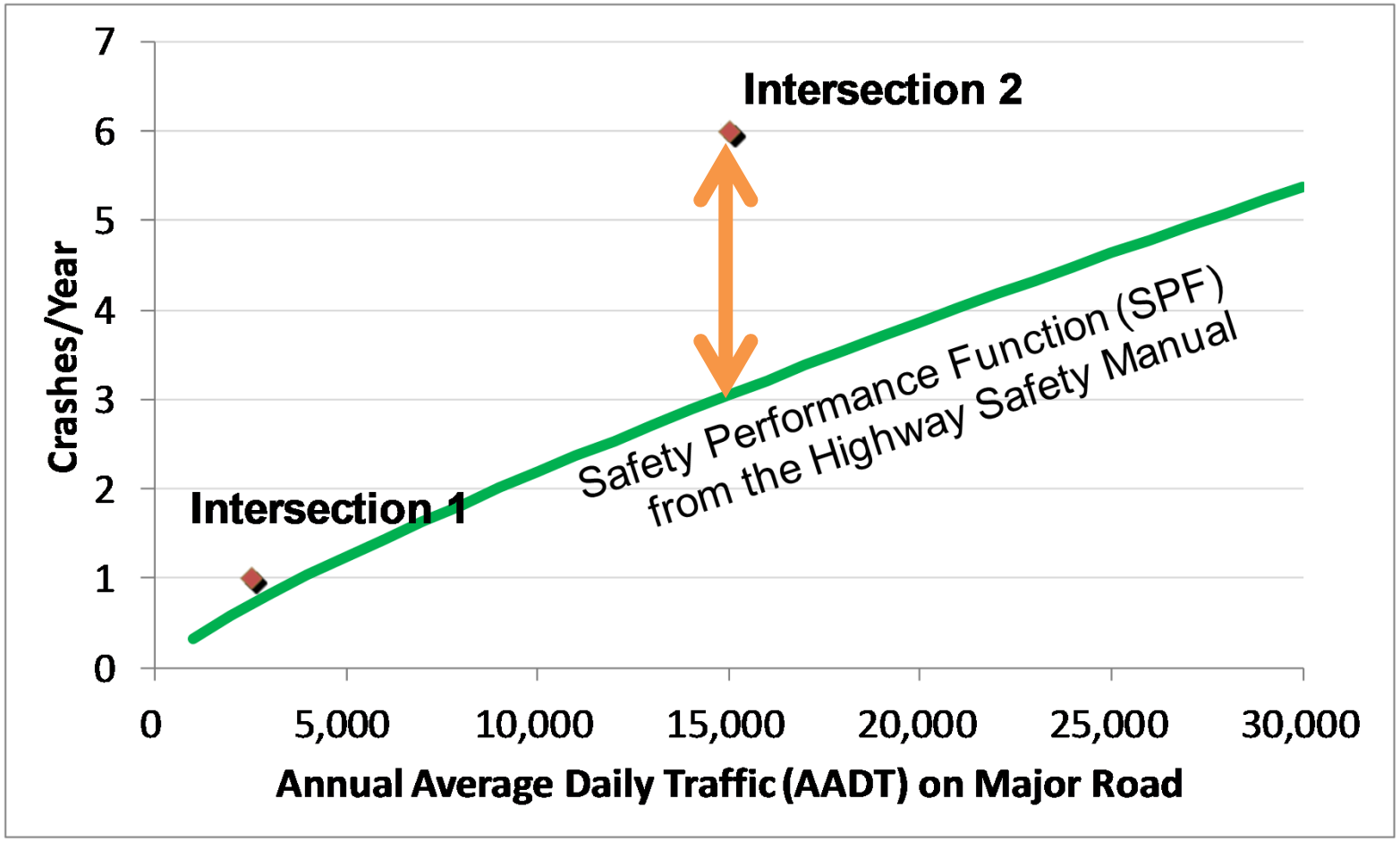
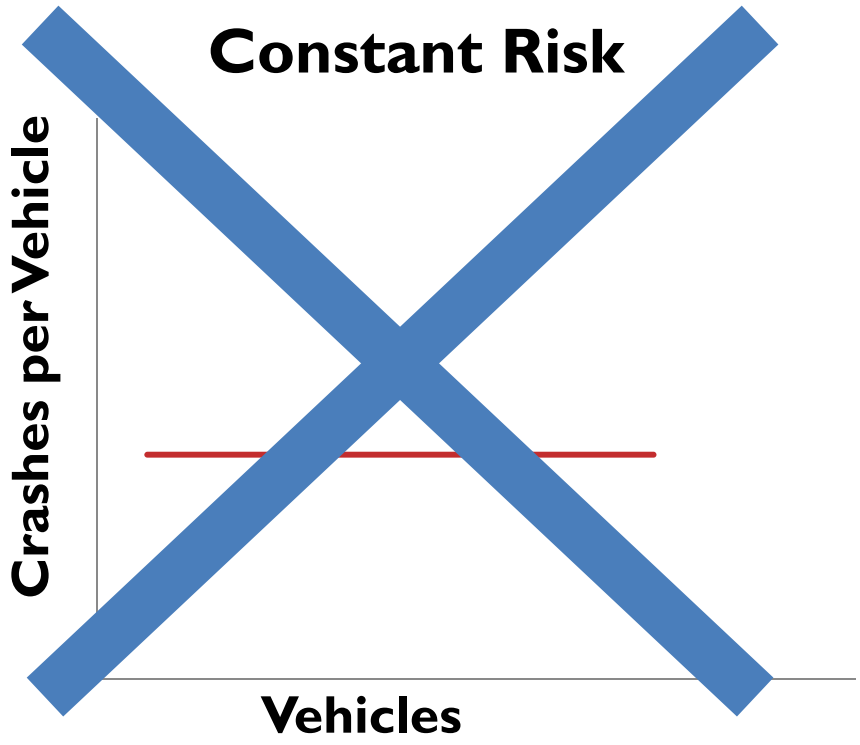
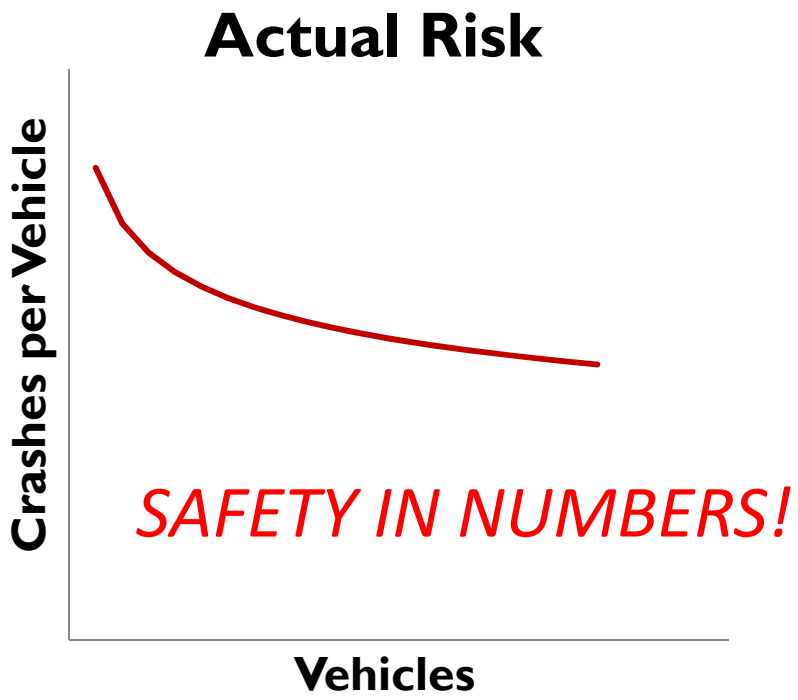


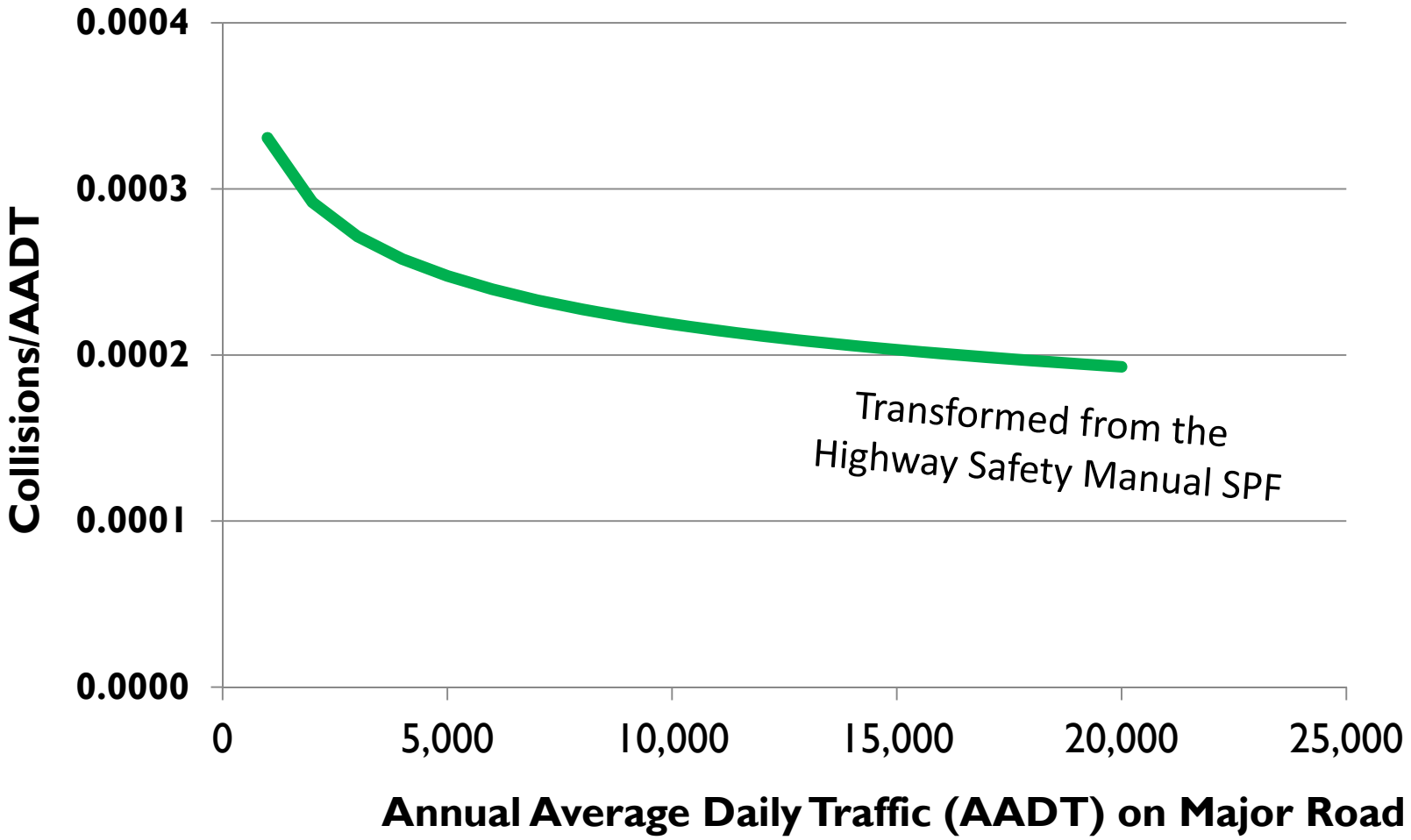
Individual Risk

Risk = Crashes per Vehicle





Risk Performance Function



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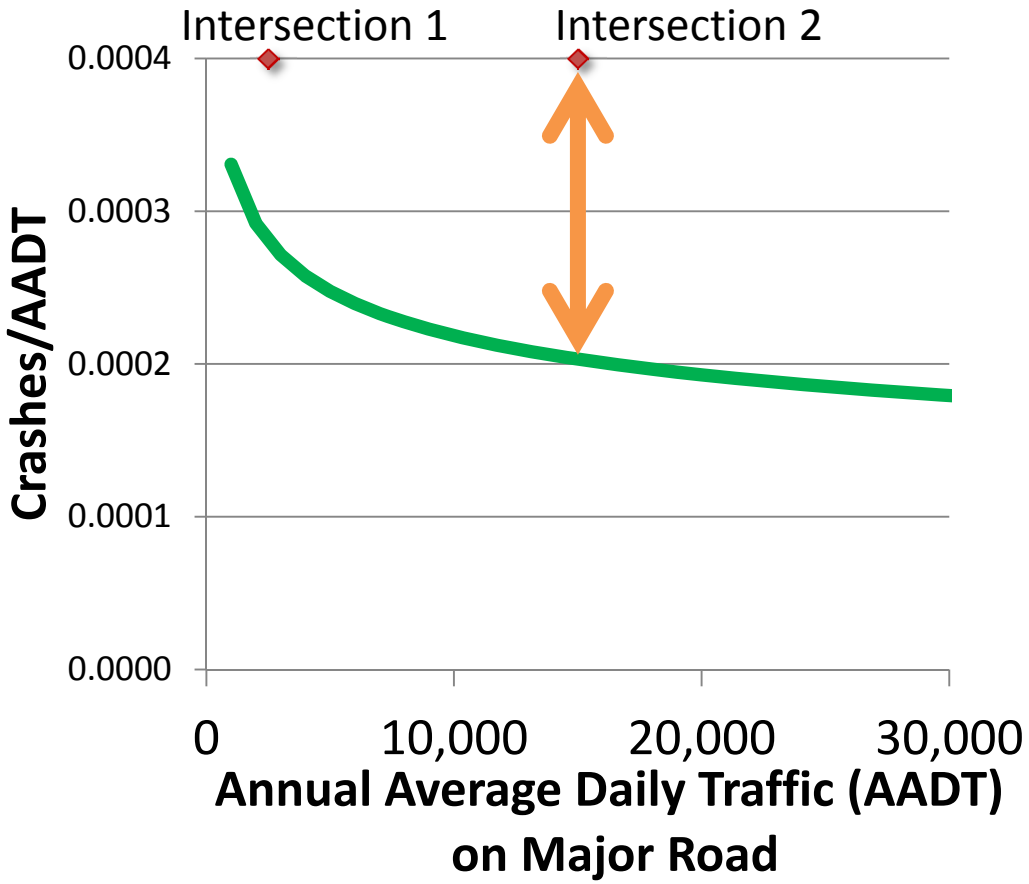
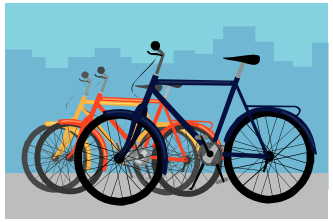


BICYCLIST & PEDESTRIAN SAFETY IN NUMBERS

Why study bicyclist & pedestrian safety?

- More fatalities/mile than drivers
- Safety used as a reason not to cycle
- Not well understood



Highway Safety Manual

For urban and suburban roads & intersections:

Bicycle Collisions =

Motor Vehicle Crashes X f(speed, road type)

NOTHING FOR RURAL ROADS

Highway Safety Manual

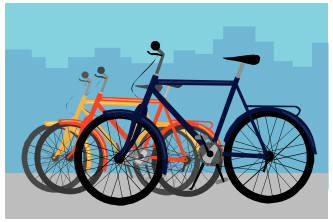
For urban and suburban roads & intersections:

Pedestrian Collisions =

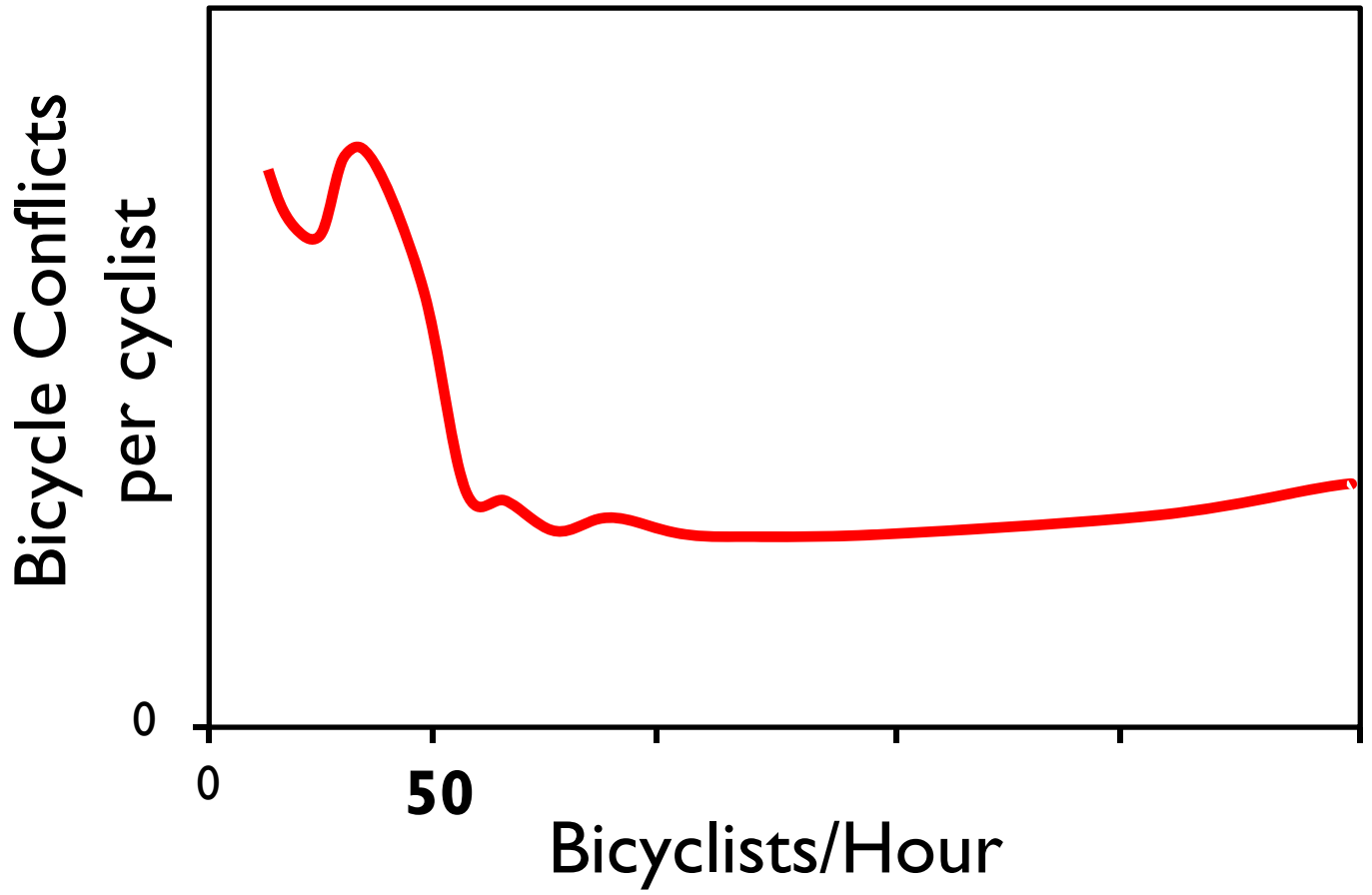
Motor Vehicle Crashes X f(speed, road type)

Except pedestrians are included in SPF for signalized intersections.

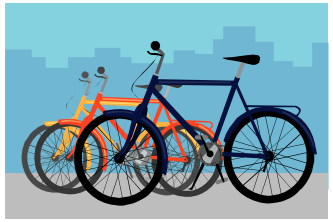
NOTHING FOR RURAL ROADS



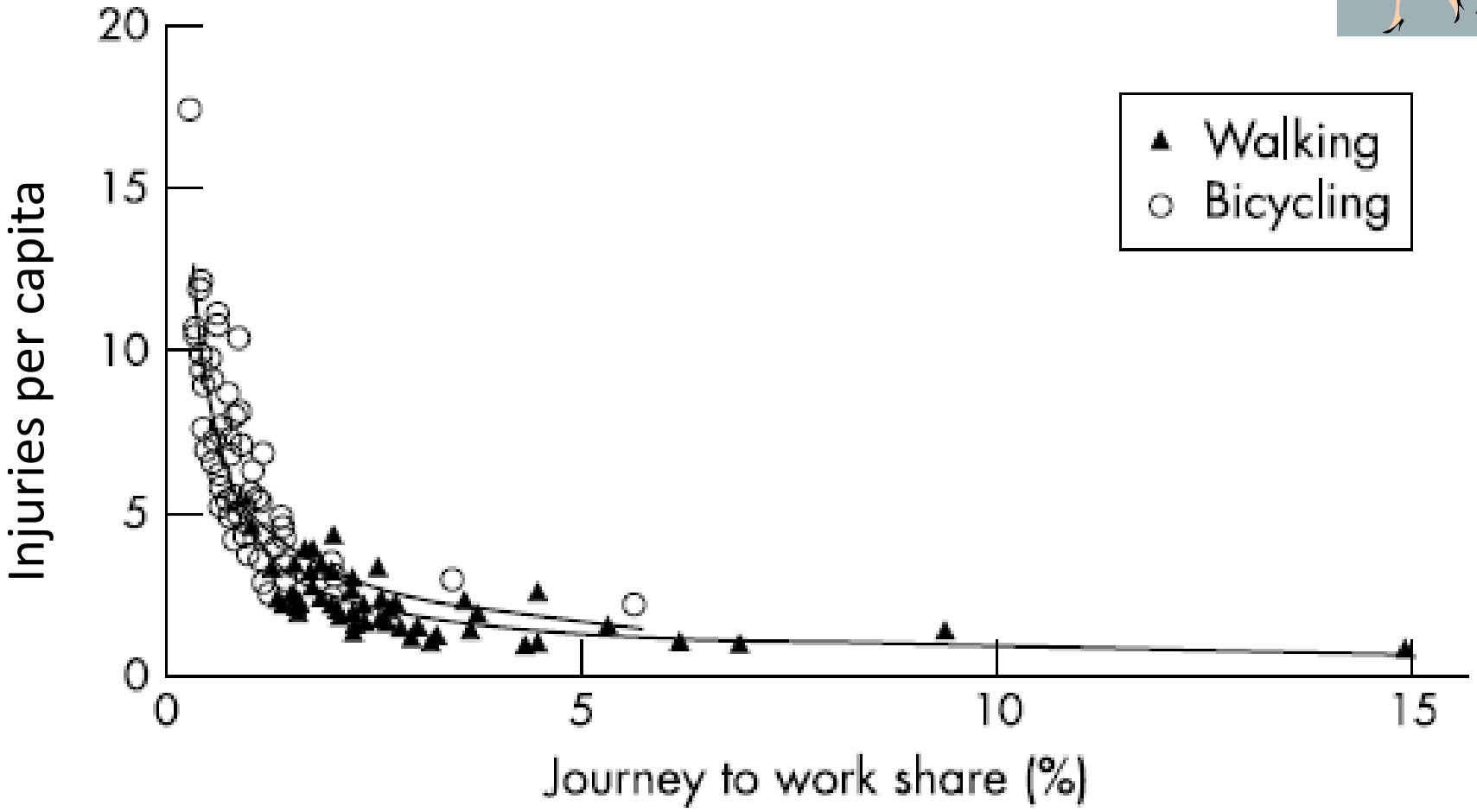
Bicyclist Risk Performance Function



Ekman 1996, Malmö, Sweden

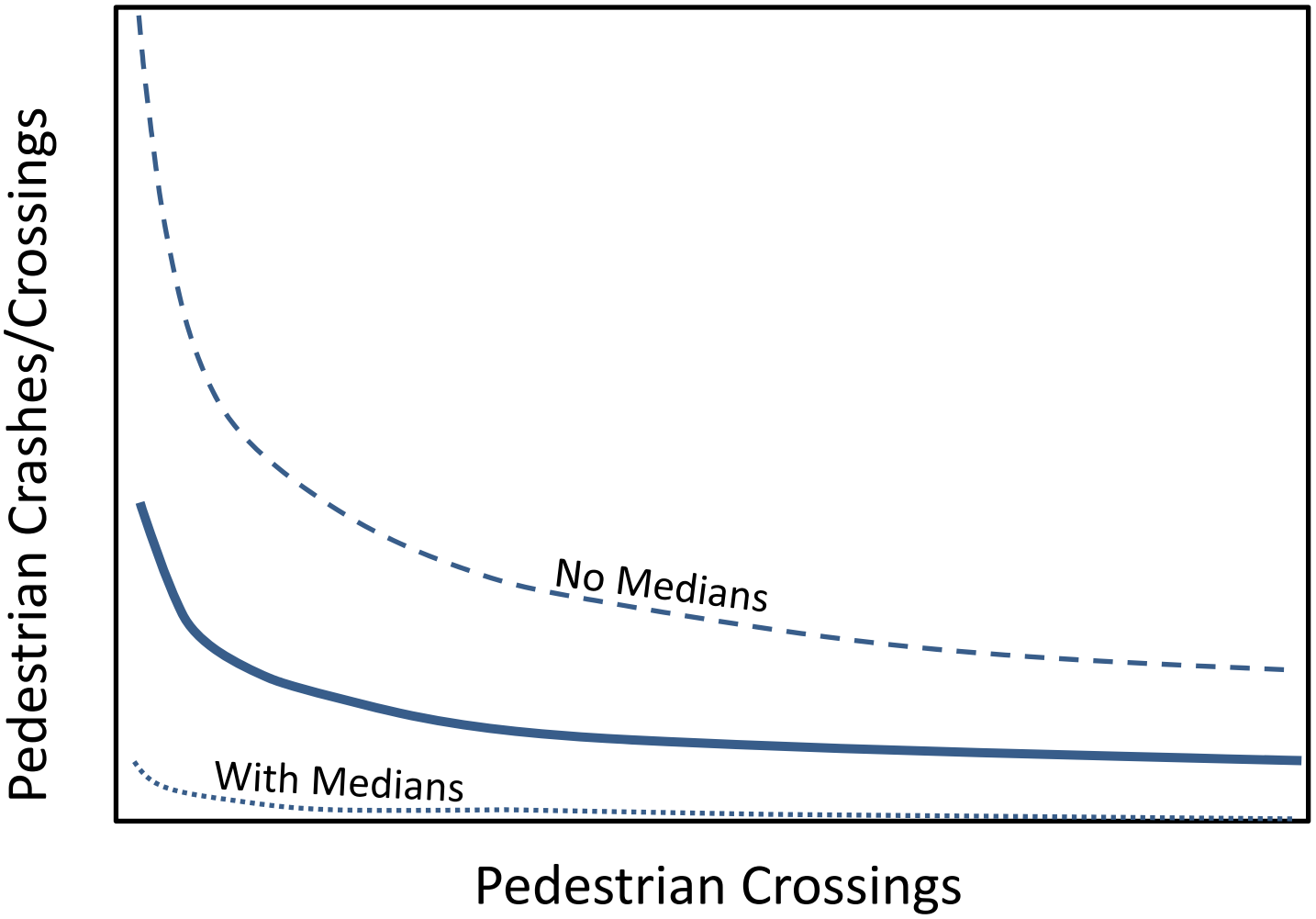


68 Cities in California



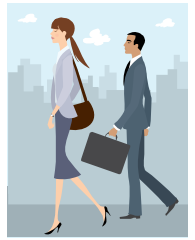
Jacobsen, P. (2003). "Safety in Numbers: more walkers and bicyclists, safer walking and bicycling." Injury Prevention (9): 205-209.

81 Intersections in Alameda County, CA



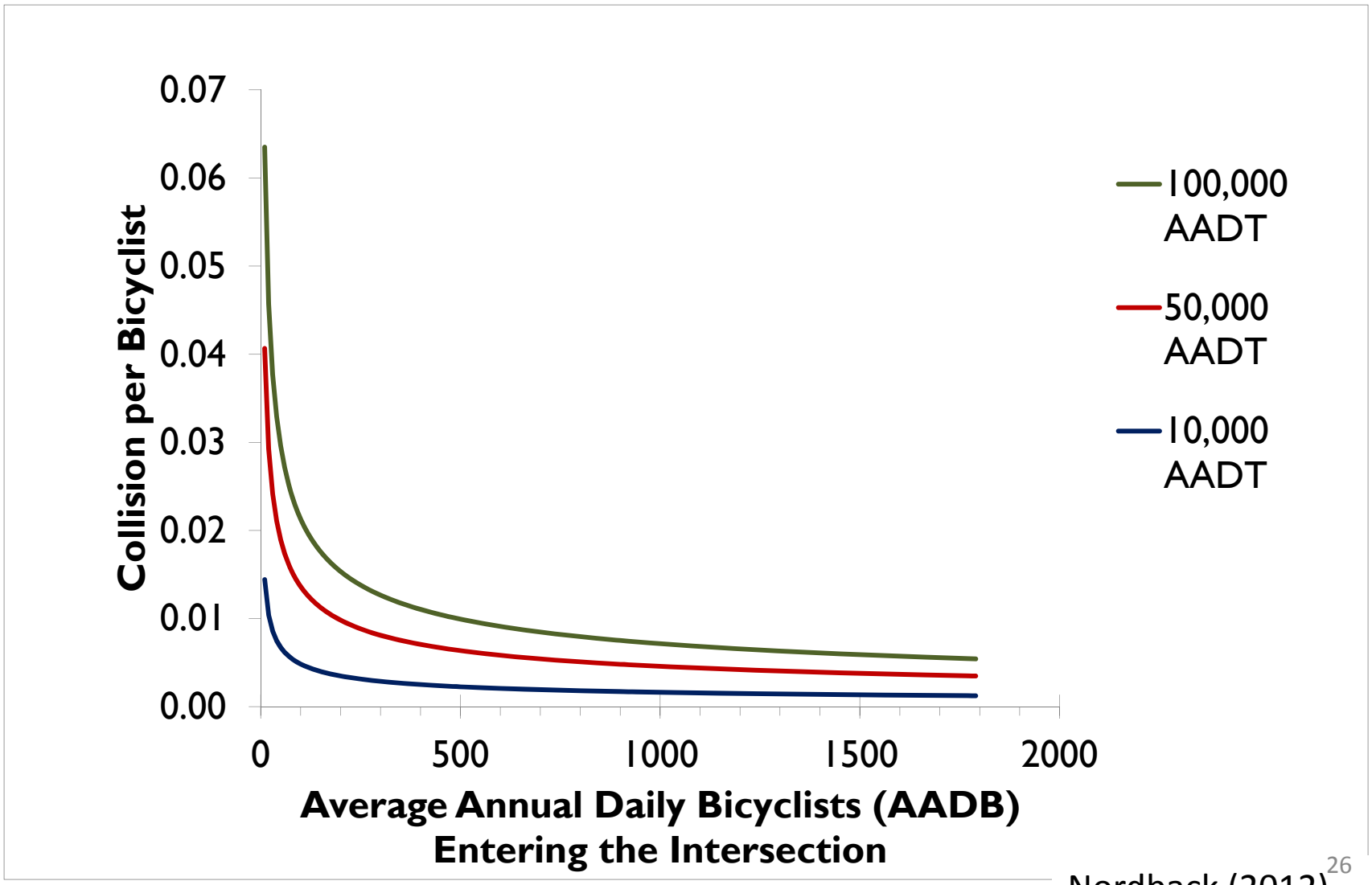
Schneider, et al. (2010).

Elvik, 2009



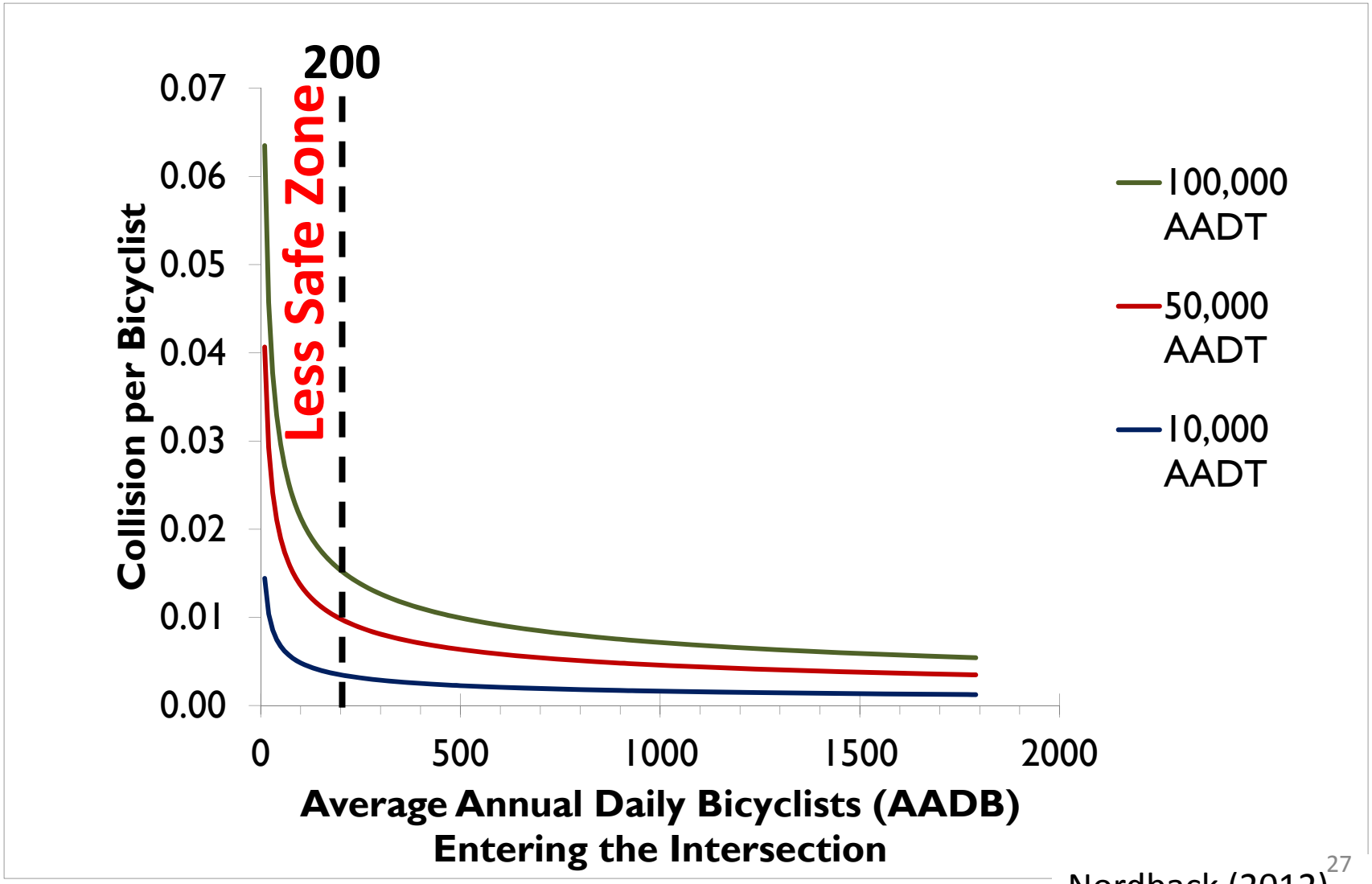
- Summarized literature:
  - 14 models: safety-in-numbers for walking
  - 8 models: safety-in-numbers for biking
- "…in theory, the total number of accidents could go down if a substantial share of trips by motorized transport is transferred to walking or cycling."

106 Intersections in Boulder, CO



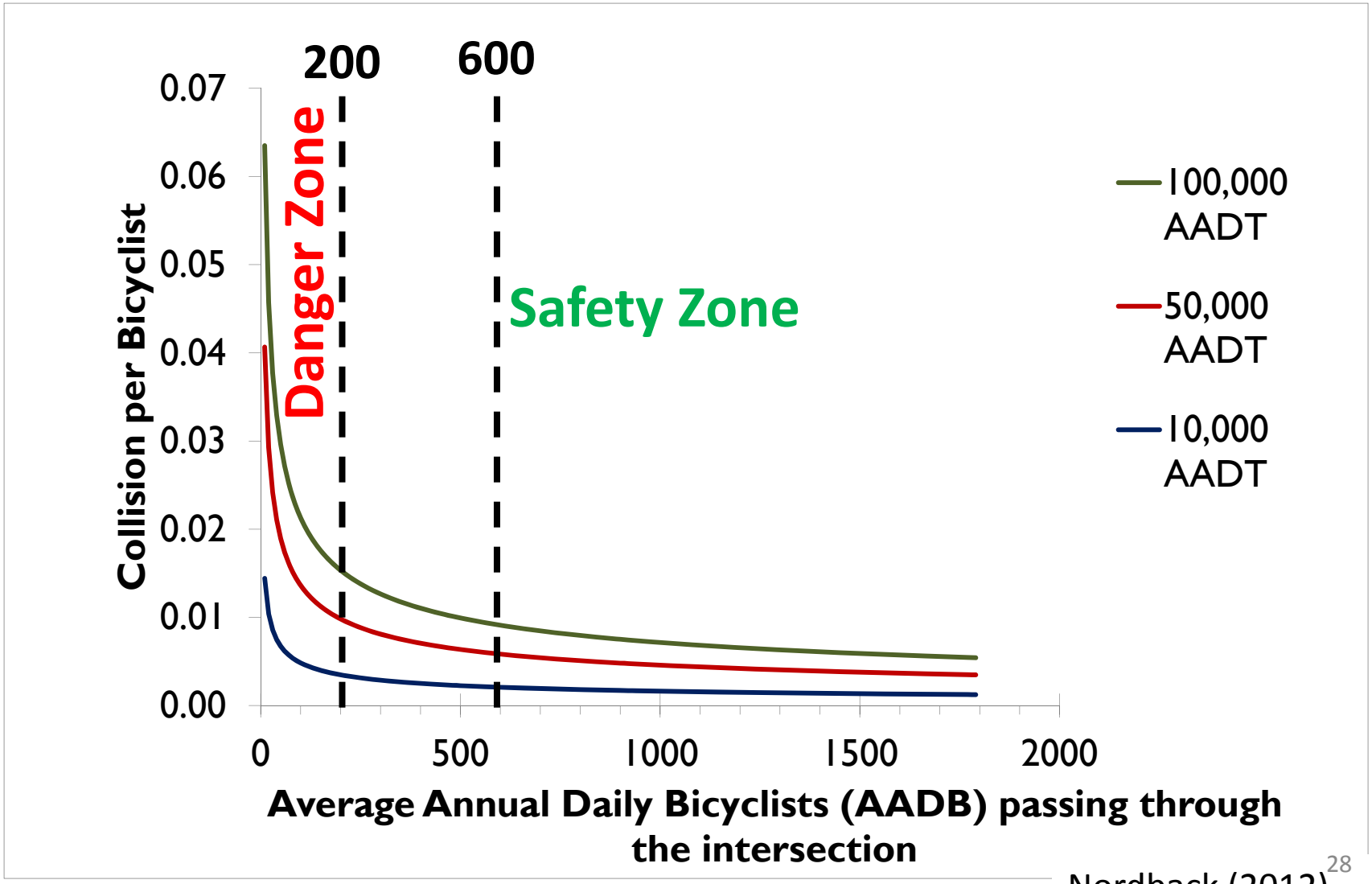
Nordback (2012)[26]

106 Intersections in Boulder, CO



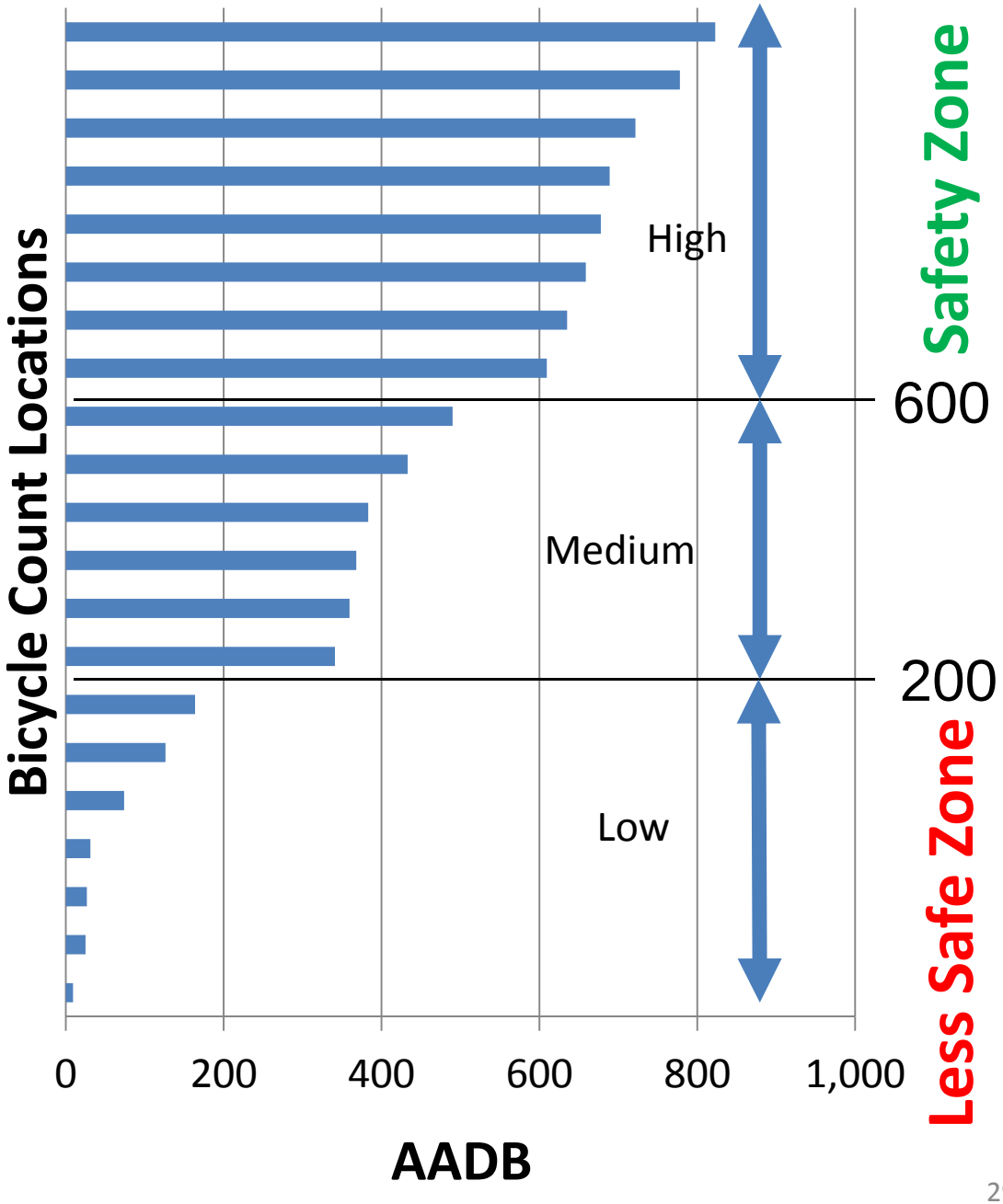
Nordback (2012)[27]

106 Intersections in Boulder, CO



Nordback (2012)[28]

2010 Annual Average Daily Bicyclists (AADB)



COLORADO DOT DEPARTMENT OF TRANSPORTATION

What if?

If the model holds, imagine Boulder had 1% bicycle mode share, instead of >9%.

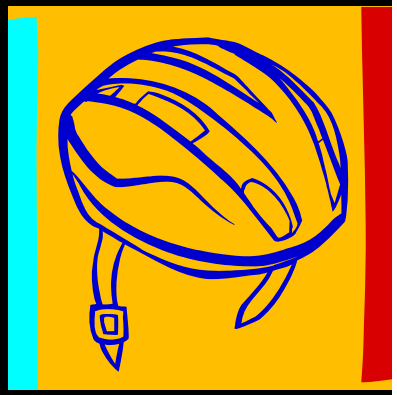
- Fewer than half the bicyclist-motorist collisions would occur.

  BUT

- Cyclist risk would increase almost three-fold.

Other Approaches

- Robinson, 2005: Helmet law in Victoria, Australia, 30% decline in cycling associated with higher risk of death and serious injury per cyclist.



- City Level
  - Marshall & Garrick – Cities with more cycling are safer for ALL ROAD USERS.
  - Portland
  - NYC
  - Minneapolis

Marshall and Garrick, 2011

24 CALIFORNIA CITIES

	Less Safe Cities	Safer Cities
Non-Highway Road Fatalities *(total over 11 years)*	676	200
per city per year	5.1	1.5
Non-HW Fatalities per 100,000 pop. (per year)	8.6	2.5
Mode Shares		
Driving	95.8%	84.1%
Transit	1.7%	6.6%
Walking	1.7%	5.4%
Biking	0.7%	4.1%

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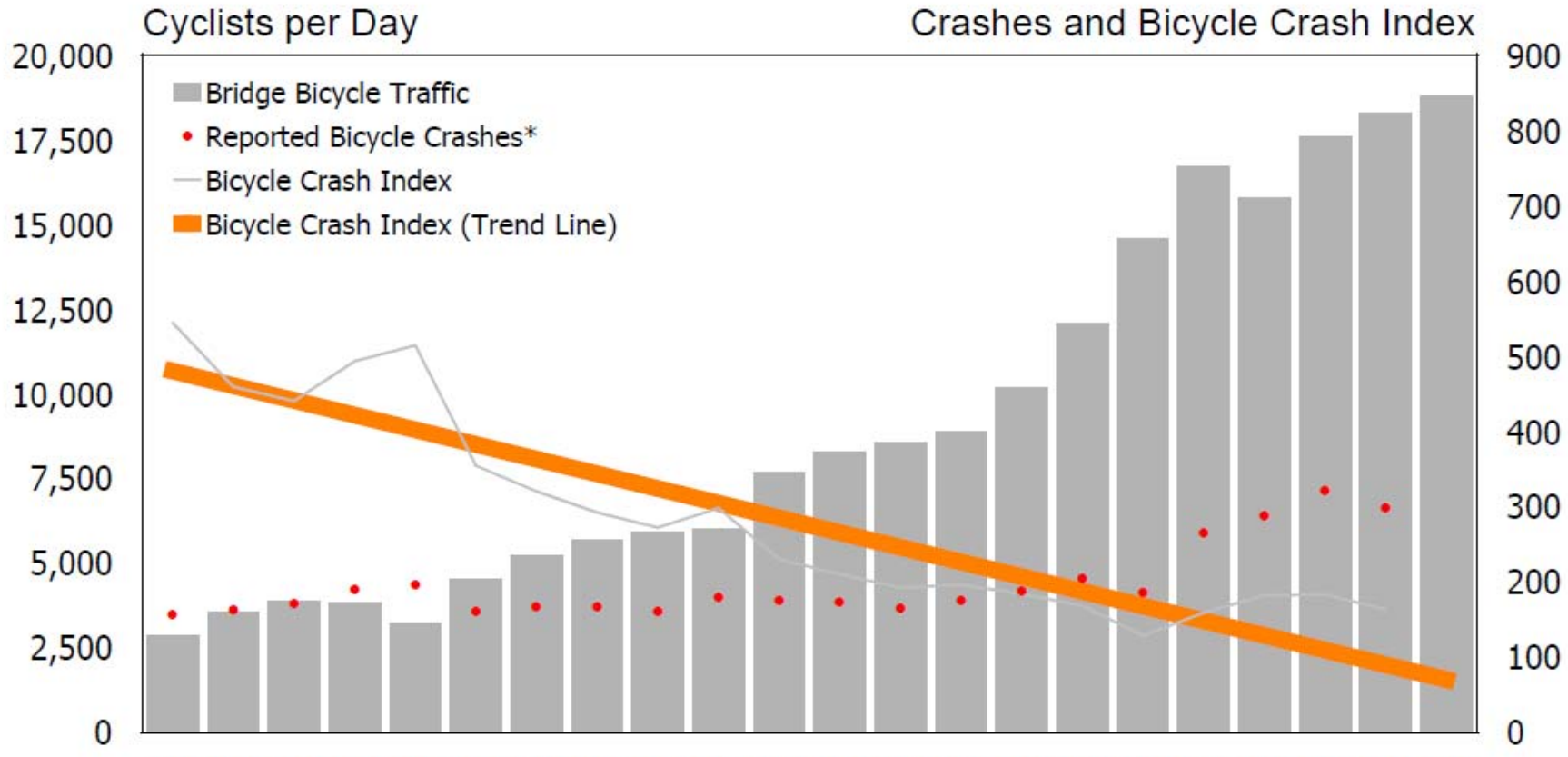
Combined Bicycle Traffic over Five Main Portland Bicycle Bridges Juxtaposed with Bicycle Crashes



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Bridge Bicycle Traffic	2,850	3,555	3,885	3,830	3,207	4,520	5,225	5,690	5,910	6,015	7,686	8,250	8,562	8,875	10,192	12,046	14,563	16,711	15,794	17,576	18,257	18,794
Reported Bicycle Crashes*	155	163	171	189	195	160	167	166	161	179	175	173	164	174	188	203	186	265	287	321	297	*
Bicycle Crash Index	544	459	440	493	514	354	320	292	272	298	230	210	192	196	184	168	128	159	182	183	163	*
Bicycle Fatalities	2	0	4	3	2	1	5	3	0	0	5	0	4	1	4	0	6	0	4	0	2	2

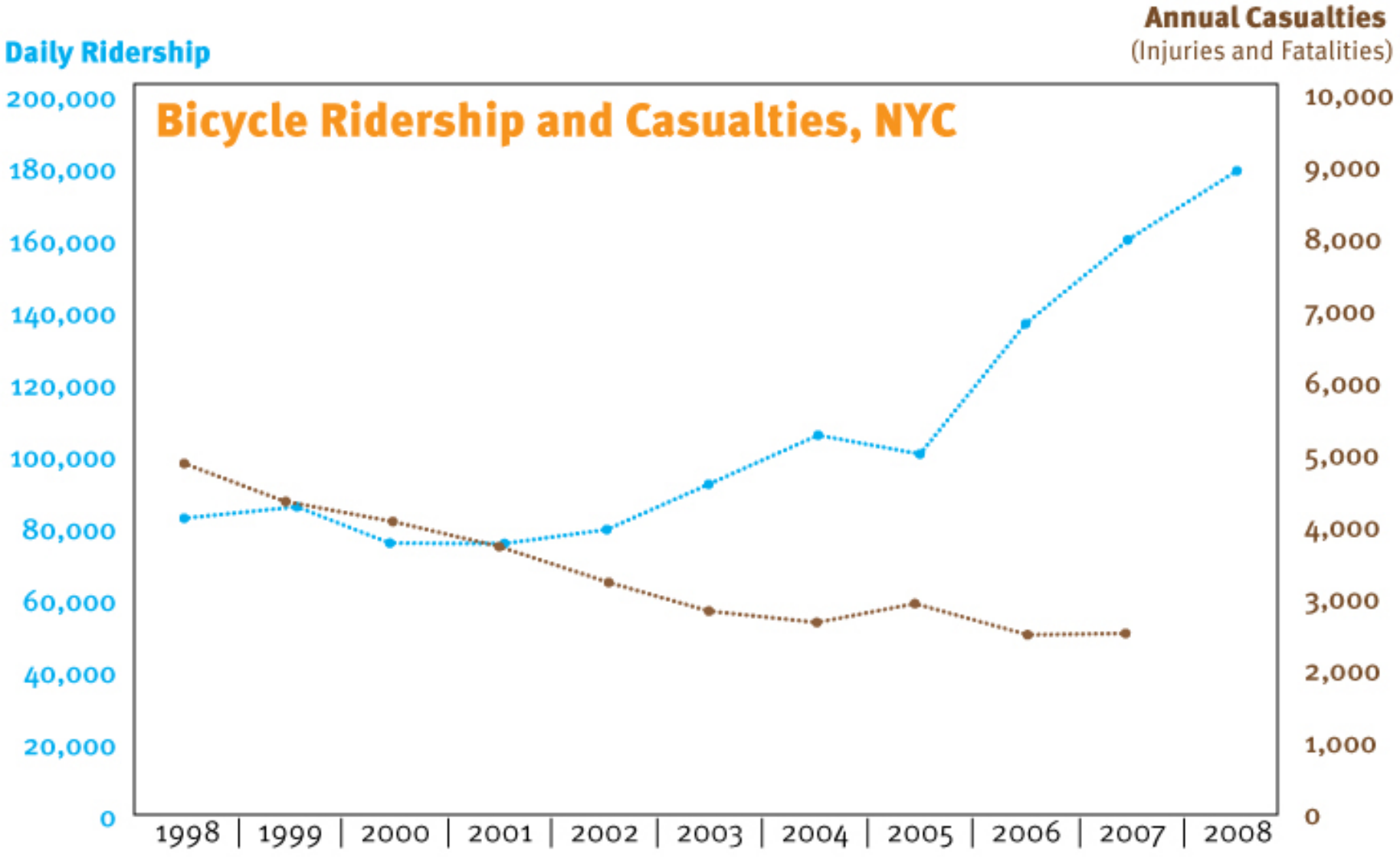
Extrapolated from peak period counts

Year

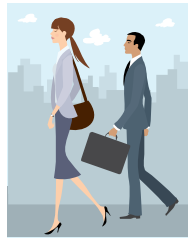
Source: City of Portland

"Crash Rate" represents an indexing of annual reported crashes to daily bicycle trips across the four main bicycle bridges.
*2008, 2009 Reported Bicycle Crashes data reflects a decision by the Portland Police Bureau to lower the threshold for reporting bicycle-involved crashes. This change, beginning in January 2008 means that crashes previously unreported by Portland Police are now entering the reporting system. There have been no indications in the operation of our system that leads the city to condude that the increase in reported crashes is representative of changes in actual crash activity with in the city.

New York City

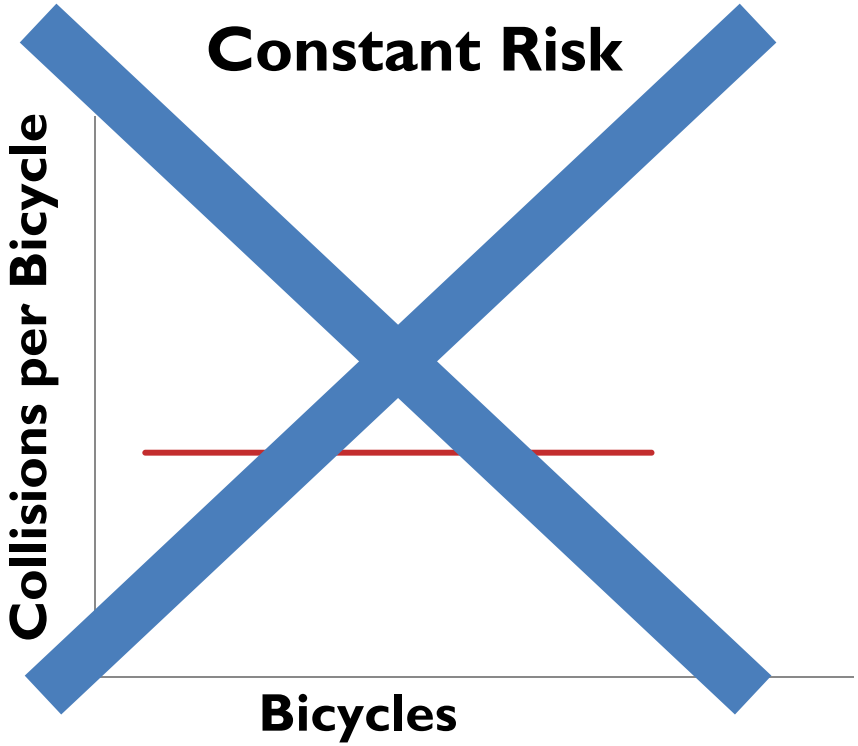


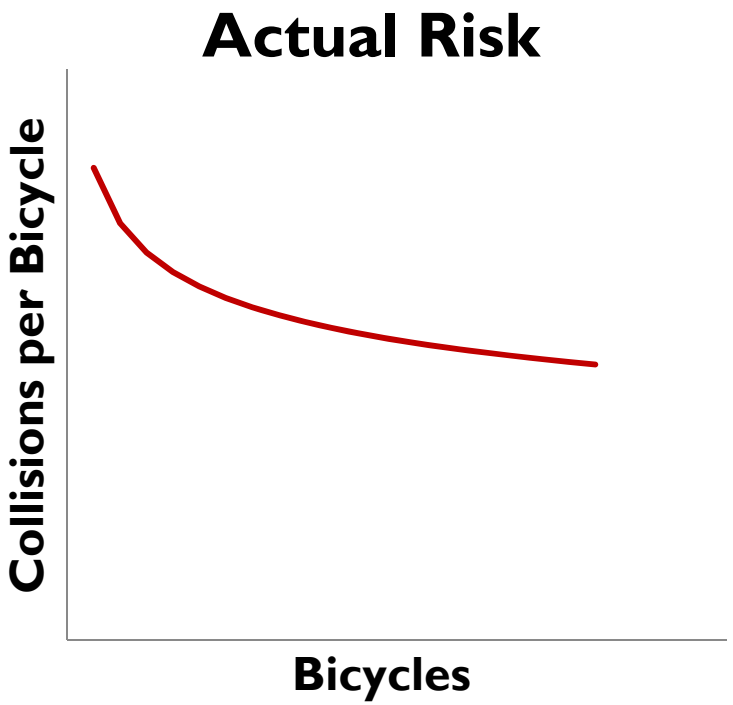
SOURCE: http://transalt.org/files/issues/bike/images/ridership_graph.jpg



Conclusions

- Bicyclists & pedestrians collisions vary with volume!





Conclusions

- Bicyclists & pedestrians are safer in numbers.
  - But we don't know why.
- Bicyclists at intersections with over **200** bicyclists per day tend to be safer per person.
- This has policy implications…

We still need safer road design!

Thank you for listening!

Krista Nordback, P.E., Ph.D.
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Portland State University
503-725-2897
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References

- AASHTO, *Highway Safety Manual. 1st ed. 2010, Washington, D.C.: American Association of State Highway and Transportation Officials (AASHTO).*
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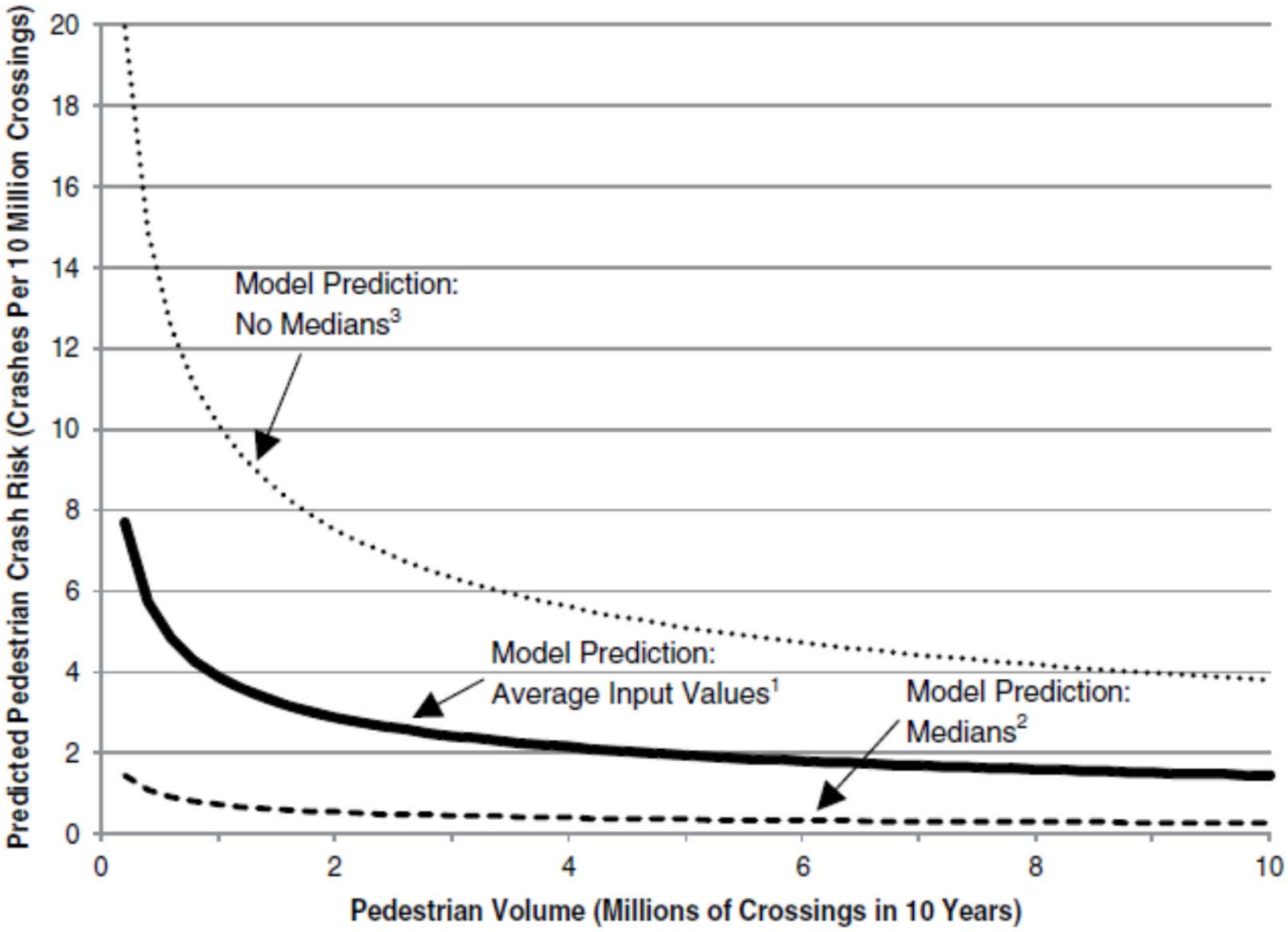
Schneider, 2010



Bicycle and pedestrian safety:
Link between crash risk, flows and built environment

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Some background

Literature

- Many studies have looked at the relationship between ped/bike collision frequency and volumes *(Elvik, 2009, Strauss & Miranda-Moreno, 2012).*

$$\lambda = \alpha_0 Z^{\alpha_1} F^{\alpha_2}$$

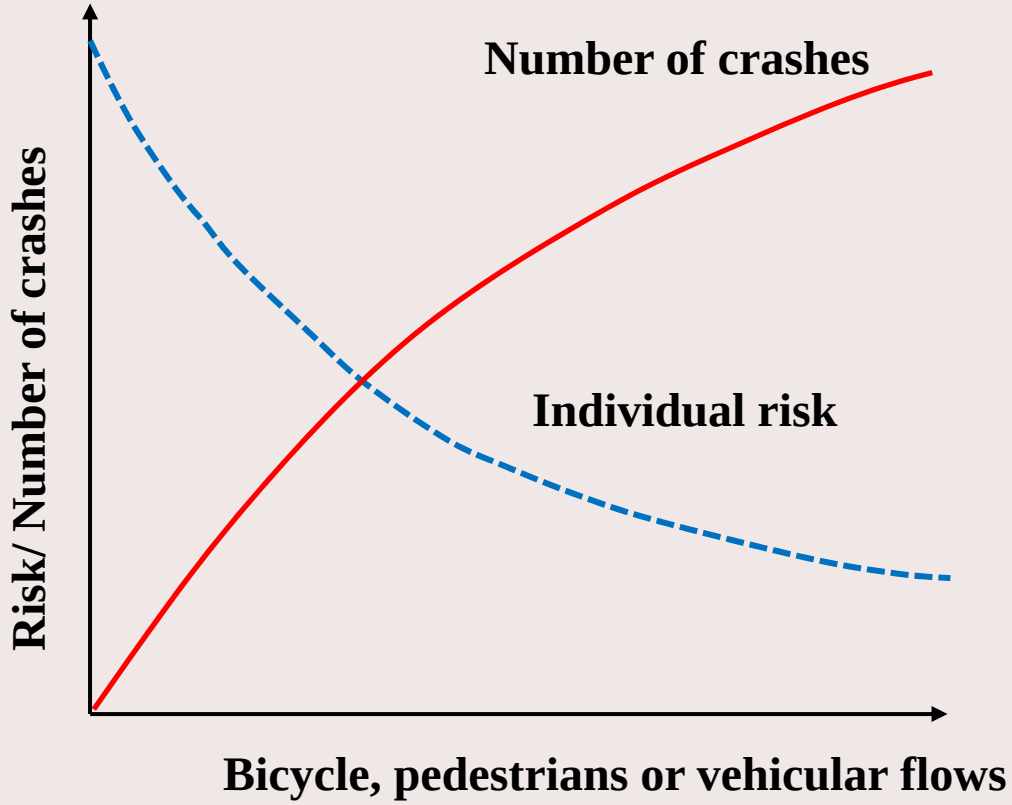
λ = mean number of collisions
Z = Bike or pedestrian volume
F = Vehicular traffic volume
$\alpha_0, \alpha_1, \alpha_2$ = parameters

Non-linear association (Elvik, 2009)

Authors	Year	Country	Study units	Sample size	Number of accidents	Type of accident	Measure of exposure	Exponent		
								Motor vehicles	Pedestrians	Cyclists
Brüde, Larsson	1993	Sweden	Junctions	285	165	Pedestrian	Entering motor vehicles, crossing pedestrians	0.50	0.72	
Brüde, Larsson	1993	Sweden	Junctions	377	432	Cyclist	Entering motor vehicles, entering cyclists	0.52		0.65
Leden, Gårder, Pulkkinen	1998	Sweden	Junctions		276	Cyclist	Entering cyclists			0.47
Leden	2002	Canada	Junctions	749	39	Pedestrian	Right turning motor vehicles, crossing pedestrians	0.86	0.48	
Leden	2002	Canada	Junctions	126	27	Pedestrian	Left turning motor vehicles, crossing pedestrians	1.19	0.33	
Lyon, Persaud	2002	Canada	Junctions	684	5280	Pedestrian	Entering motor vehicles, entering pedestrians	0.57	0.74	
Lyon, Persaud	2002	Canada	Junctions	263	1065	Pedestrian	Entering motor vehicles, entering pedestrians	0.40	0.41	
Lyon, Persaud	2002	Canada	Junctions	122	159	Pedestrian	Entering motor vehicles, entering pedestrians	0.53	0.66	
Lyon, Persaud	2002	Canada	Junctions	123	319	Pedestrian	Entering motor vehicles, entering pedestrians	0.58	0.71	
Jacobsen	2003	United States	Cities	68		Pedestrian	Share of working trips on foot		0.41	
Jacobsen	2003	United States	Cities	68		Cyclist	Share of working trips on bicycle			0.31
Jacobsen	2003	Denmark	Towns	47		Pedestrian	Kilometres walked per inhabitant per day		0.36	
Jacobsen	2003	Denmark	Towns	47		Cyclist	Kilometres cycled per inhabitant per day			0.44
Jacobsen	2003	14 European	Country	14		Cyclist	Kilometres cycled per inhabitant per day			0.58
Jacobsen	2003	8 European	Country	8		Pedestrian	Trips on foot per inhabitant pe day		0.13	
Jacobsen	2003	8 European	Country	8		Cyclist	Trips on bicycle per inhabitant per day			0.48
Robinson[a]	2005	Australia	States	7		Cyclist	Kilometres cycled per inhabitant per day			0.52
Jonsson	2005	Sweden	Road sections	393	130	Pedestrian	Motor vehicle kilometres, pedestrians crossing and walking along road	0.83	0.38	
Jonsson	2005	Sweden	Road sections	393	343	Cyclist	Motor vehicle kilometres, cyclists crossing and riding along road	0.76		0.35
Geyer et al.	2006	Oakland	Junctions	247	185	Pedestrian	Entering motor vehicles, crossing pedestrians	0.16	0.61	
Harwood et al.	2008	United States	Junctions	450	728	Pedestrian	Entering motor vehicles, entering pedestrians	0.05	0.41	
Harwood et al.	2008	United States	Junctions	1433	4824	Pedestrian	Entering motor vehicles, entering pedestrians	0.40	0.45	
							Mean (simple)	0.57	0.50	0.48

Average values

Non-linear relationship



More volumes → lower crash risk (safety in number effect)
→ But also more crashes

Question #1
Can we observe the same thing in Montreal?

Answer: Yes, the same thing…

- A non-linear association between bike/pedestrian flows and crashes
- This applies to both: signalized and non-signalized intersections and to all modes

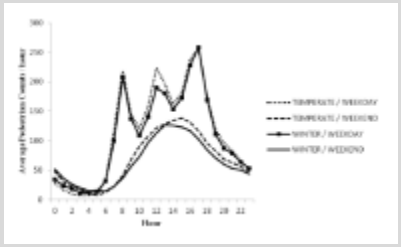
Data integration

Sensors for automatic data collection

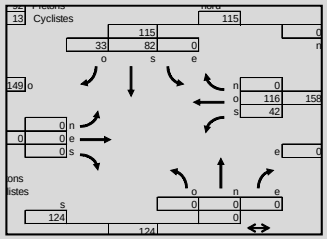
Manual counts

Road geometry/built environment inventory

Standardization of volumes



Expansion factors



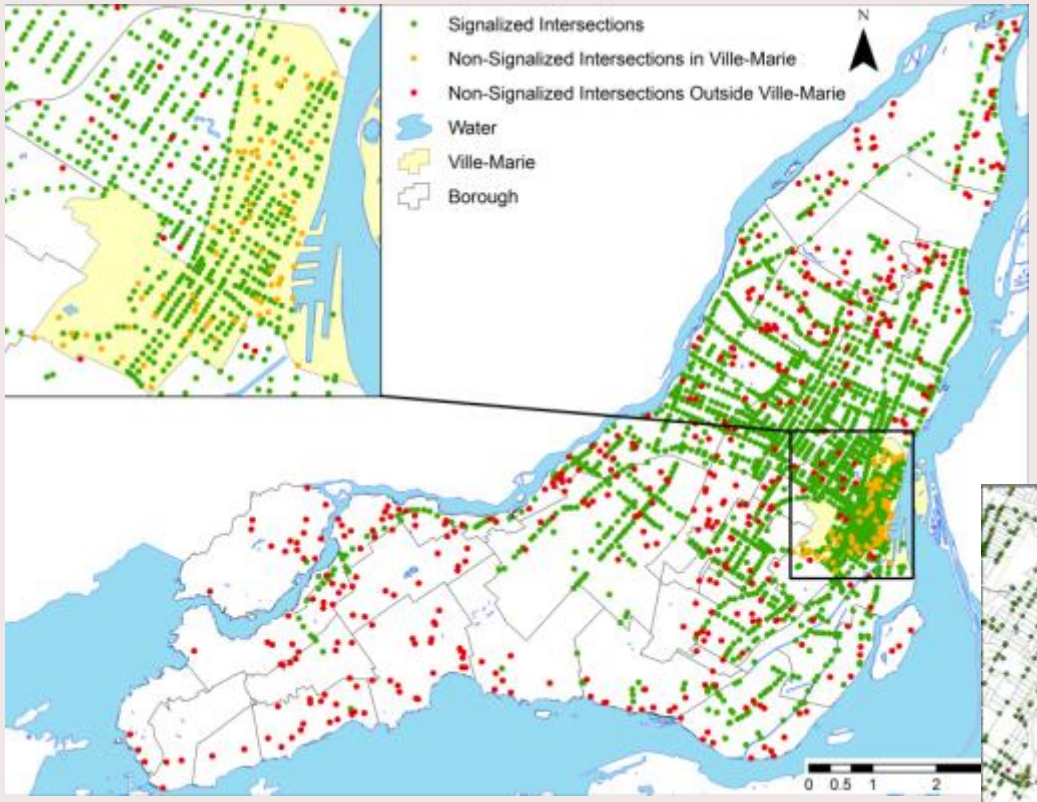
Manual counts (8 hours)

Accident data

Analysis and modeling

Intersections inventory / crash history

Signalized and non-signalized intersections



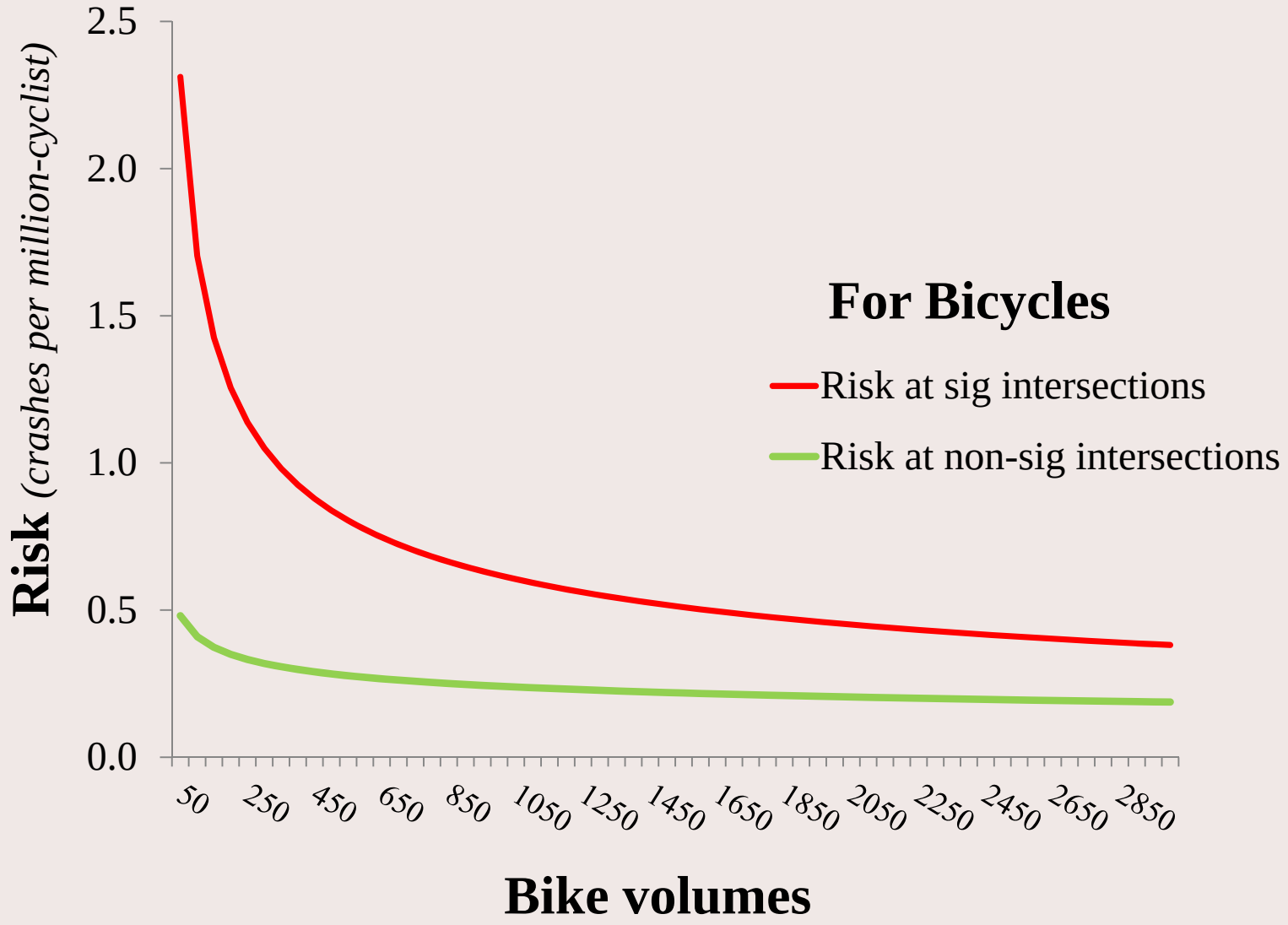
Cyclist injury data

Link #1:

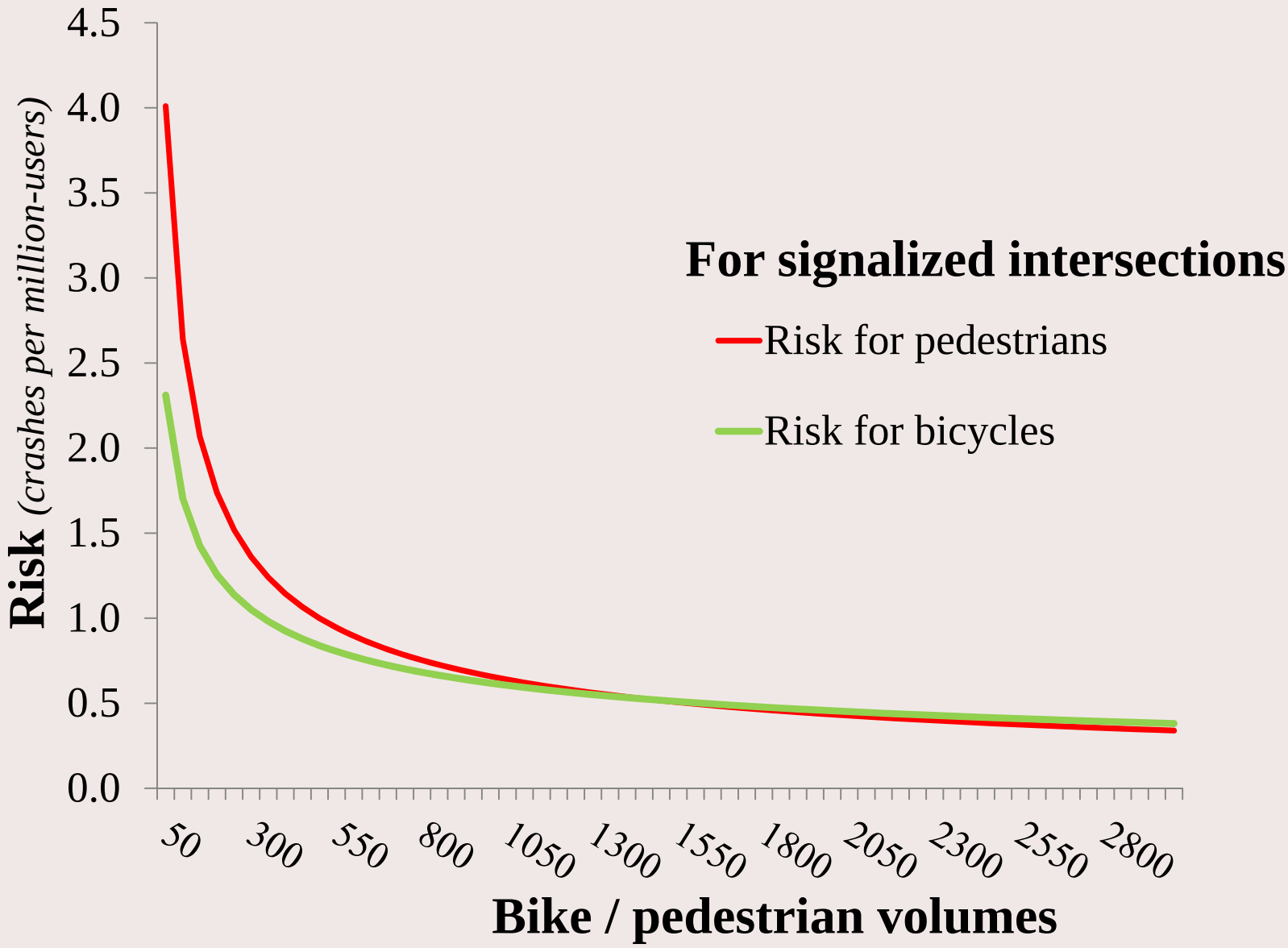
Link between flows and crashes

Results #1

Link between **bike flows and risk**



Bike risk vs pedestrian risk



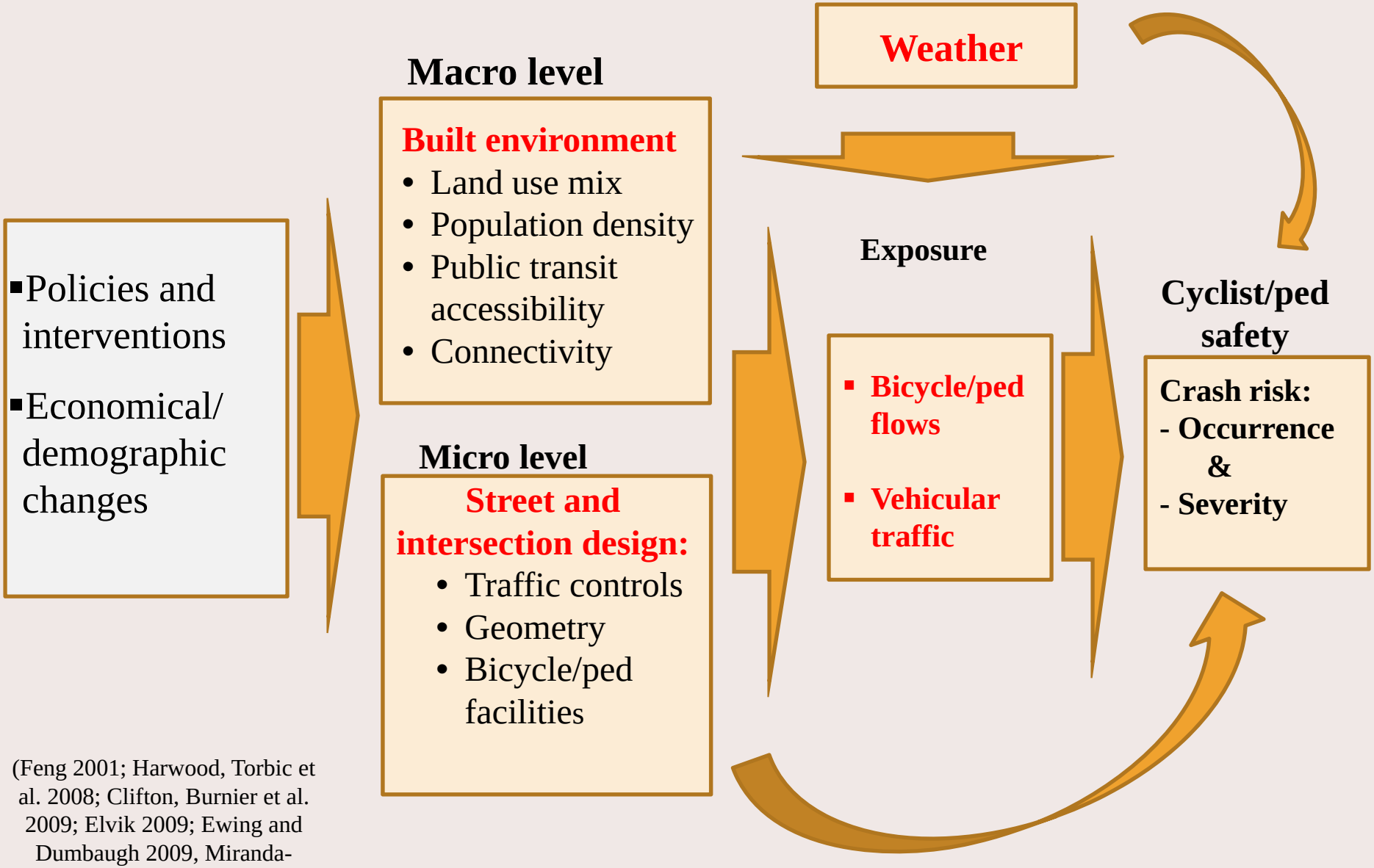
Question #2:

While one can observe the "safety in numbers" effect, **what causes this effect?**

Possible causes

- **Road user adaptions?** E.g., drivers reduce speeds or become more aware as non-motorized volumes increase?
- **Designs?** Intersections with higher volumes are on average safer? Appropriate designs or interventions attract more cyclists – higher numbers in safer environments.
- Two additional findings in Montreal:
  - Flows are strongly associated with designs and built environment.
  - Geometry designs can affect both safety and volumes

Framework

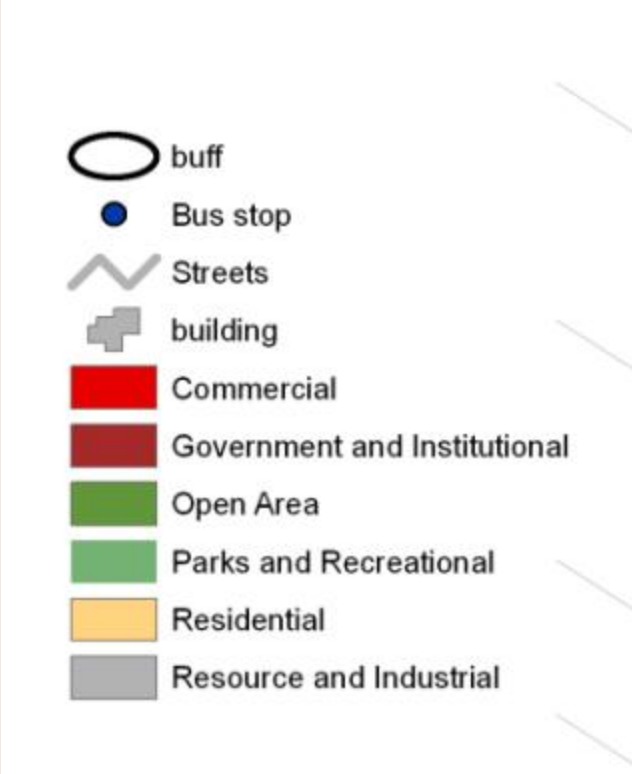


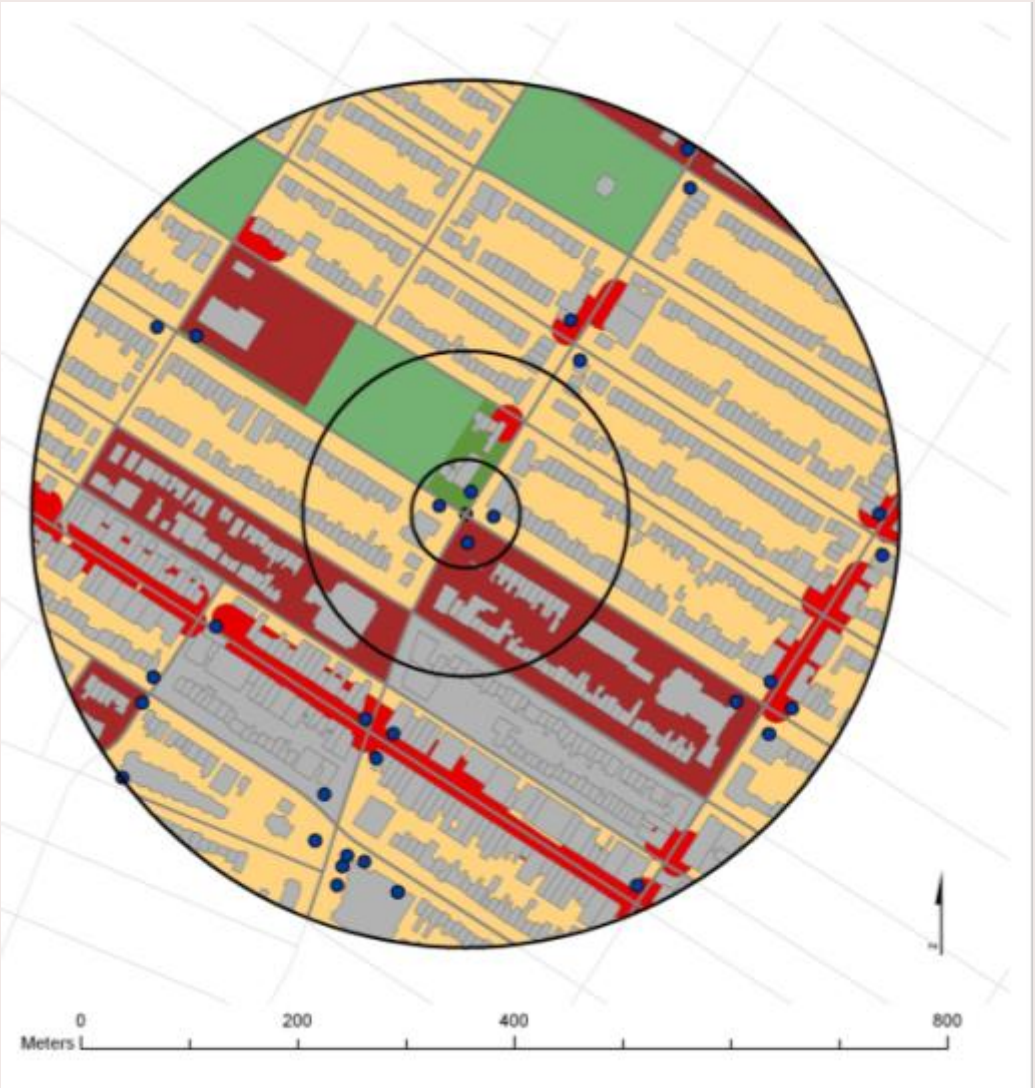
(Feng 2001; Harwood, Torbic et al. 2008; Clifton, Burnier et al. 2009; Elvik 2009; Ewing and Dumbaugh 2009, Miranda-Moreno, et al. 2011).

Link #2:

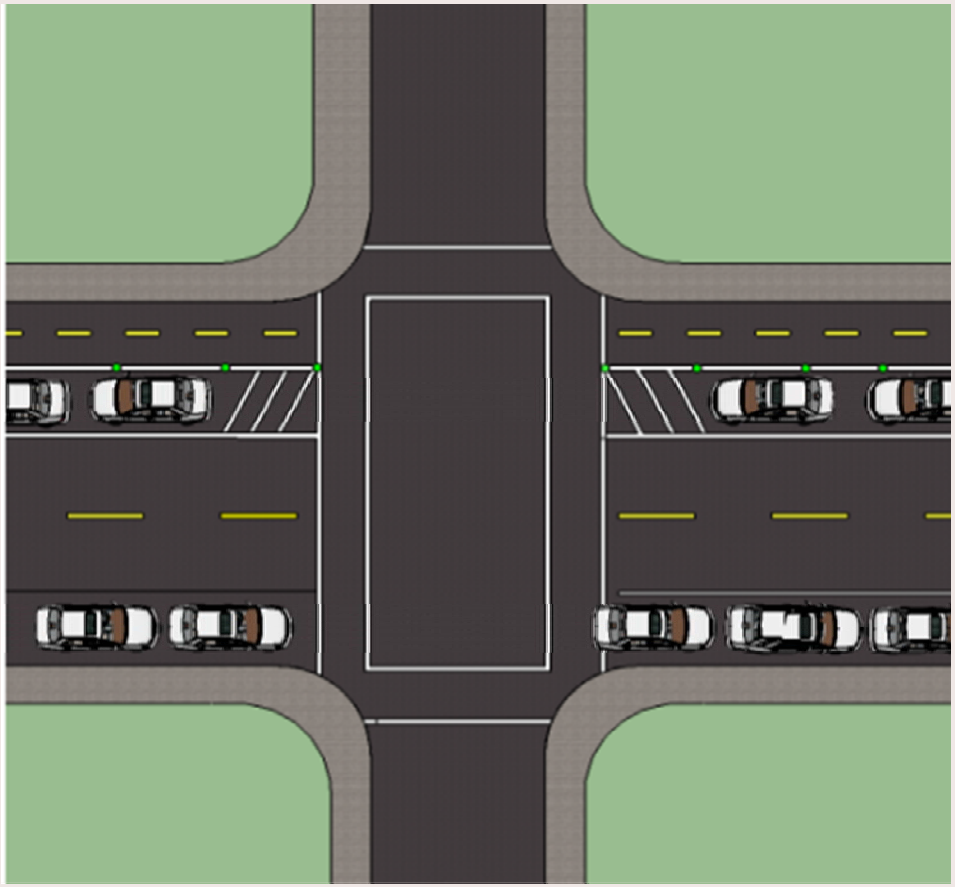
Link between flows, built environment and geometry

Built environment





Intersection geometry

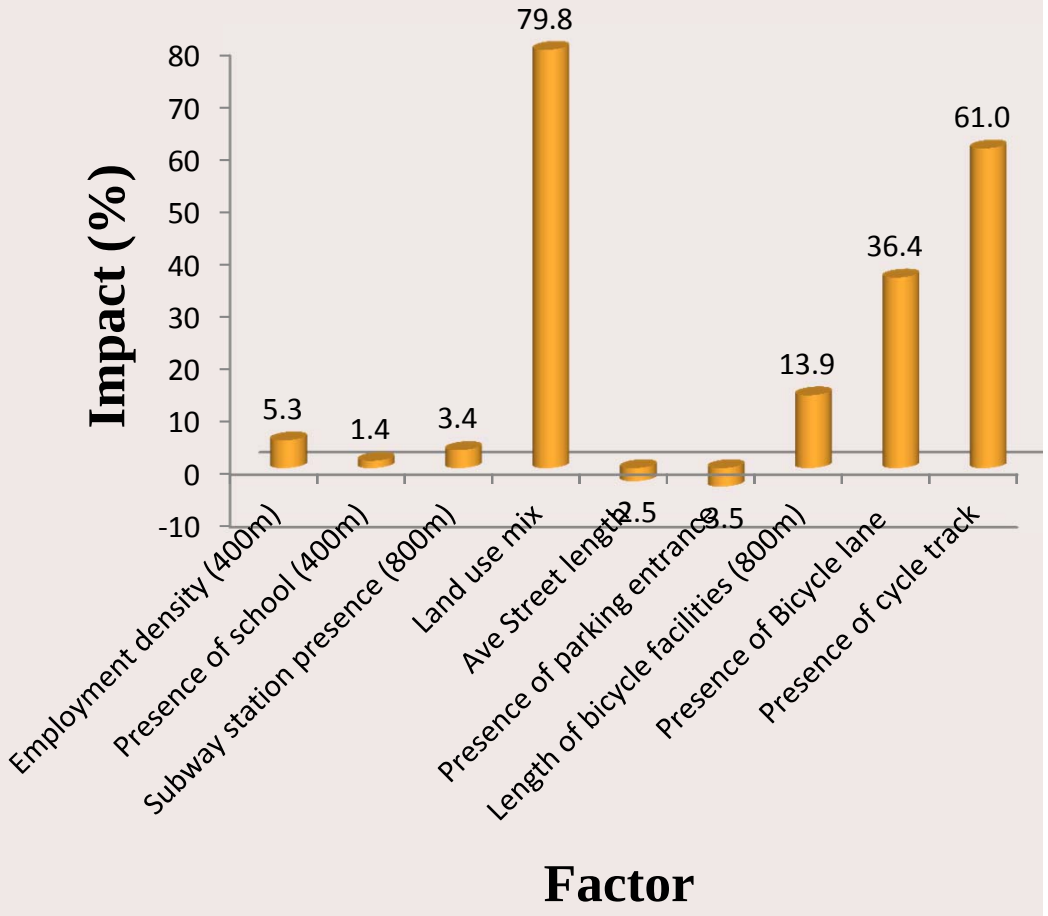


- ✓ Road width
- ✓ Number of lanes
- ✓ Median presence
- ✓ Parking
- ✓ Curb extensions
- ✓ Pedestrian light
- ✓ etc

Results #2

Link #2: Link between built environment/geometry and flows

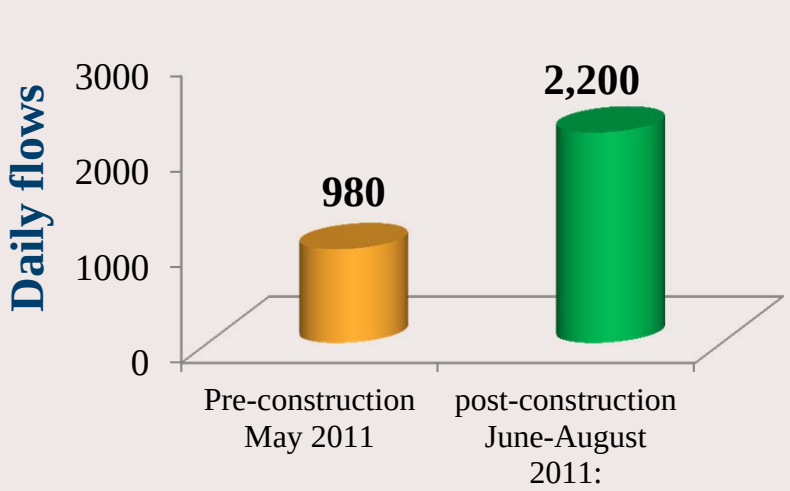
Factor	Impact (%)
Employment density	5.3
Presence of school	1.4
Subway station presence	3.4
Land use mix	79.8
Ave Street length	-2.5
Presence of parking entrance	-3.5
Length of bicycle facilities	13.9
Presence of Bicycle lane	36.4
Presence of cycle track	61.0



Impact of new infrastructure

1) Bicycle lanes, Ave. Laurier, Montreal

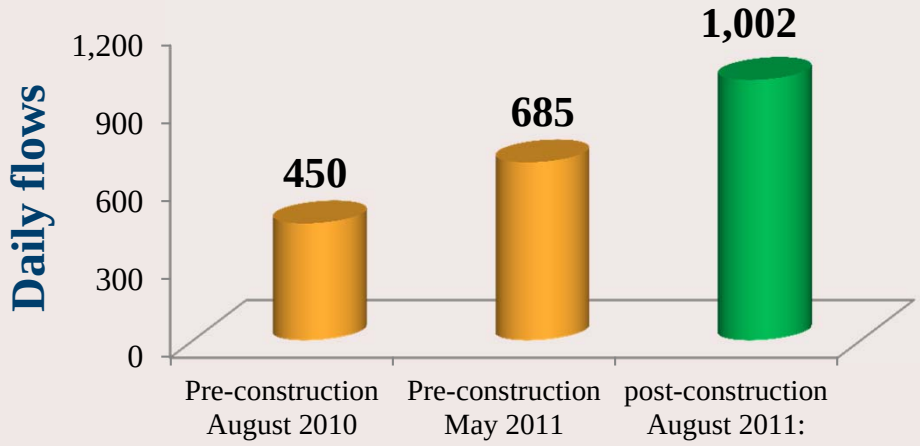
Standardized daily flows



Increase: > 100% with respect to May 2011

2) Cycle track, Ave. Laurier, Ottawa

Standardized daily flows



Increase: ~ 50% with respect to May 2011

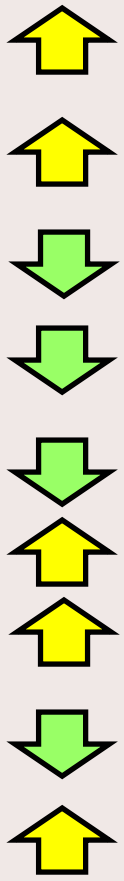
Link #3:

Link between geometry and crashes

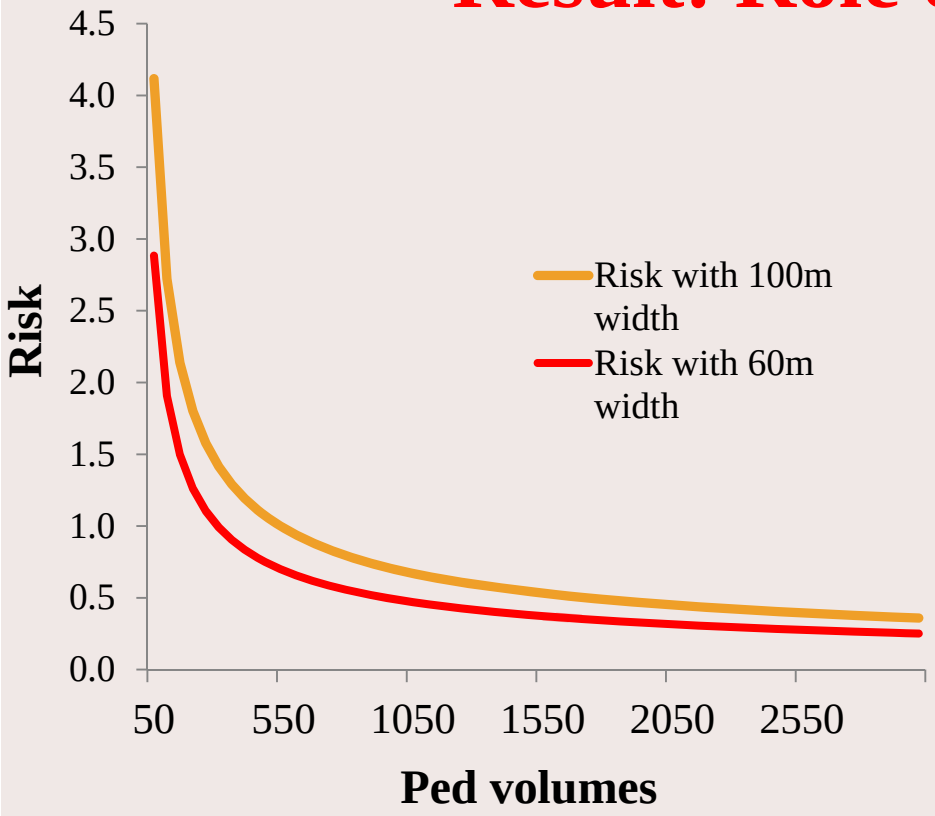
Result #3

Role of geometry at signalized intersections

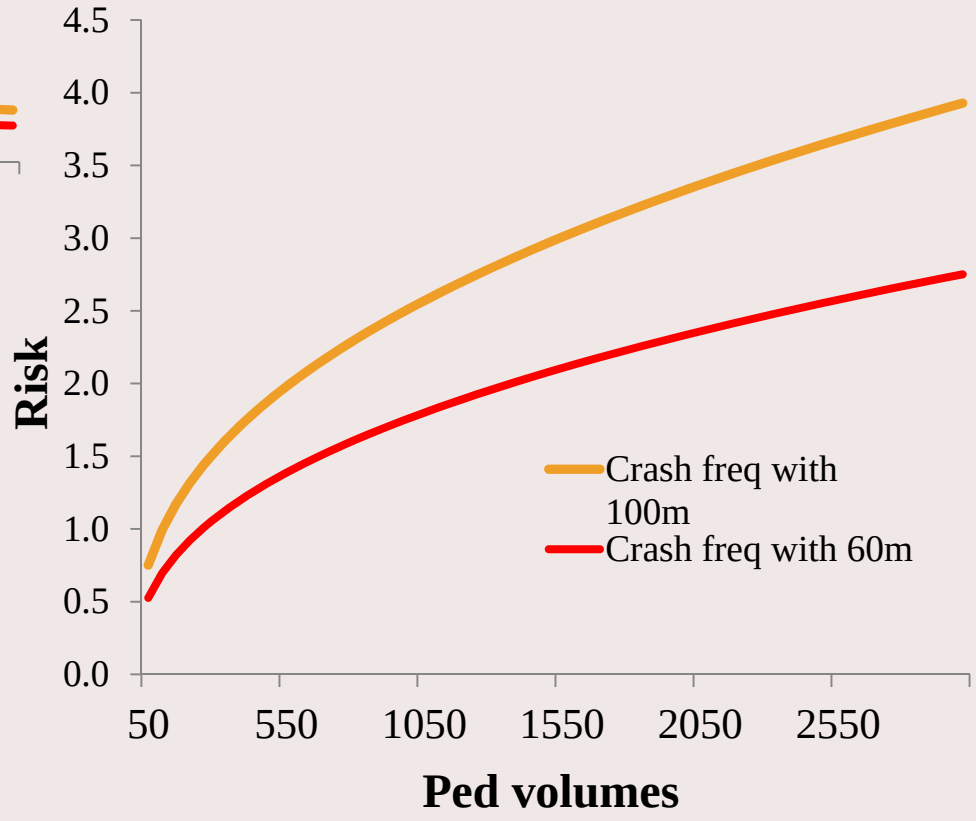
Variables	Coef.	Impact (%)
Ln total pedestrian flows	0.404	40.5%
Ln total traffic flows	0.612	61.2%
Full pedestrian phase (light)	-0.478	-38.0%
Half pedestrian phase (light)	-0.281	-24.5%
Exclusive left turn	-0.175	-4.9%
Commercial exit/entrance	0.046	3.5%
Length of crosswalk	0.0089	59.2%
Curb extension presence	-0.270	-27.1%
No of lanes	0.114	73.8%



Result: Role of geometry factors



- Designs cannot only help increasing volumes but also
- Help reducing number of crashes and risk

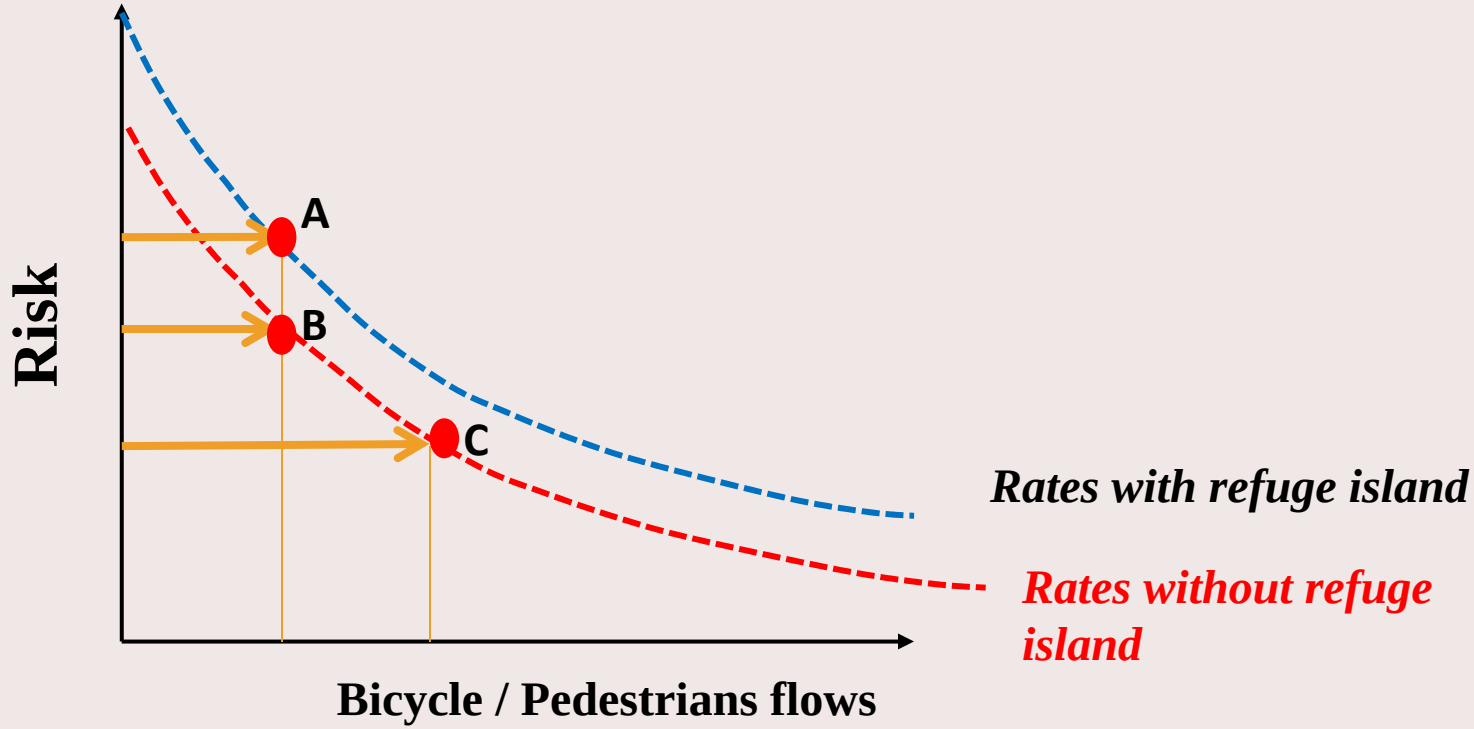


Some conclusions

Some conclusions

- We found a non-linear association between bike & pedestrian flows and crashes at intersections.

- The road designs are the critical factors: **They affect flows and safety.**



Some conclusions

Limitations of past studies:

- Most studies have used cross-sectional crash data.

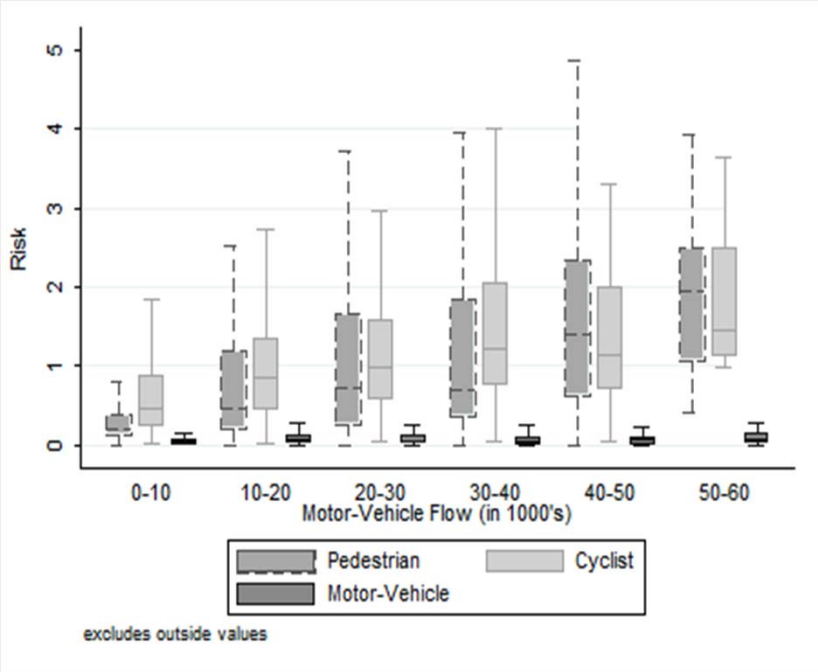
- Most studies do not control for the potential bias associated with the complex links between flows, geometry and built environment as well as safety.

- Keep in mind that as volumes increase "design standards" also increase or vice versa.

  ⇒If this hypothesis is true: safety in numbers may be inflated ...

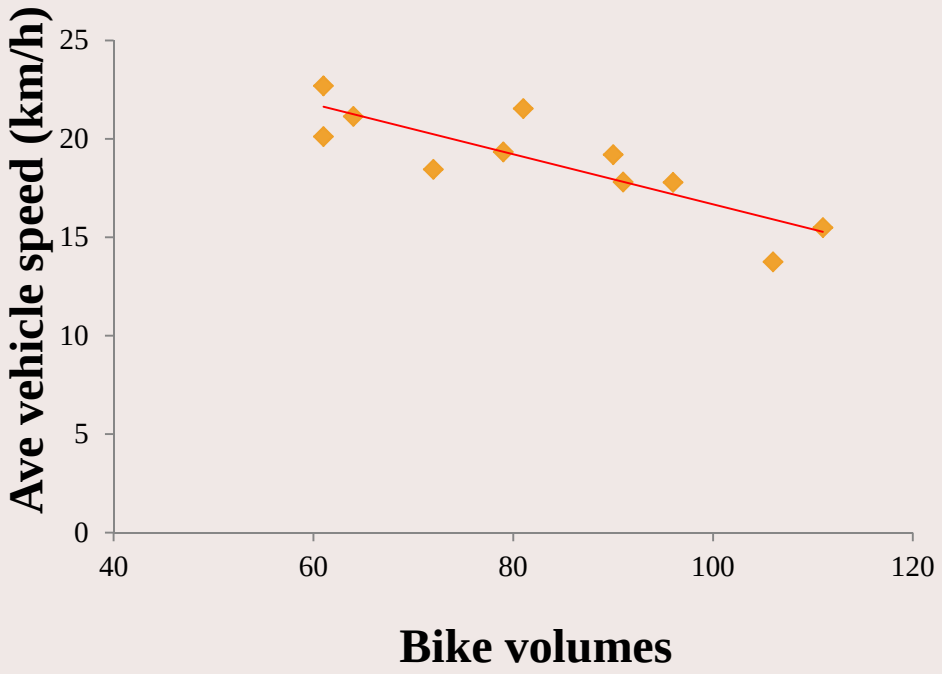
Some conclusions

- Should we talk about “the safer numbers” instead of “safety in numbers”? **We want higher volumes but in safer environments**
- If “safety in numbers” exists, we cannot use it as a treatment (policy).
- Ped/Bicyclist risk at intersections is already many times higher than for motorized users.



Work in progress

- We need to learn more the effect of treatments and “safety in numbers” using microscopic data: vehicle speeds, conflict (surrogate) analysis, etc.



Some reference

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- Strauss, J., **Miranda-Moreno, L.** Morency M. (2013). "Cyclist Activity and Injury Risk Analysis at Signalized Intersections: A Bayesian Modeling" *Accident Analysis and Prevention, 59, pp. 9-17.*

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- Ukkusuri, S., **Miranda-Moreno, L.**, Ramadurai, G., Isa-Tavarez, J., (2012). "The Role of Built Environment on Pedestrian Crash Frequency", *Journal of Safety Science*, 50, 1141–1151.

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- **Miranda-Moreno L.**, Strauss, J., Morency, P. (2011). "Disaggregate Exposure Measures and Injury Frequency Models of Cyclist Safety at Signalized Intersections". *Journal of Transportation Research Record*, 2236, pp 74-82.

Thanks!


Is There Safety in Numbers for Cyclists?
Cases from Minneapolis, MN
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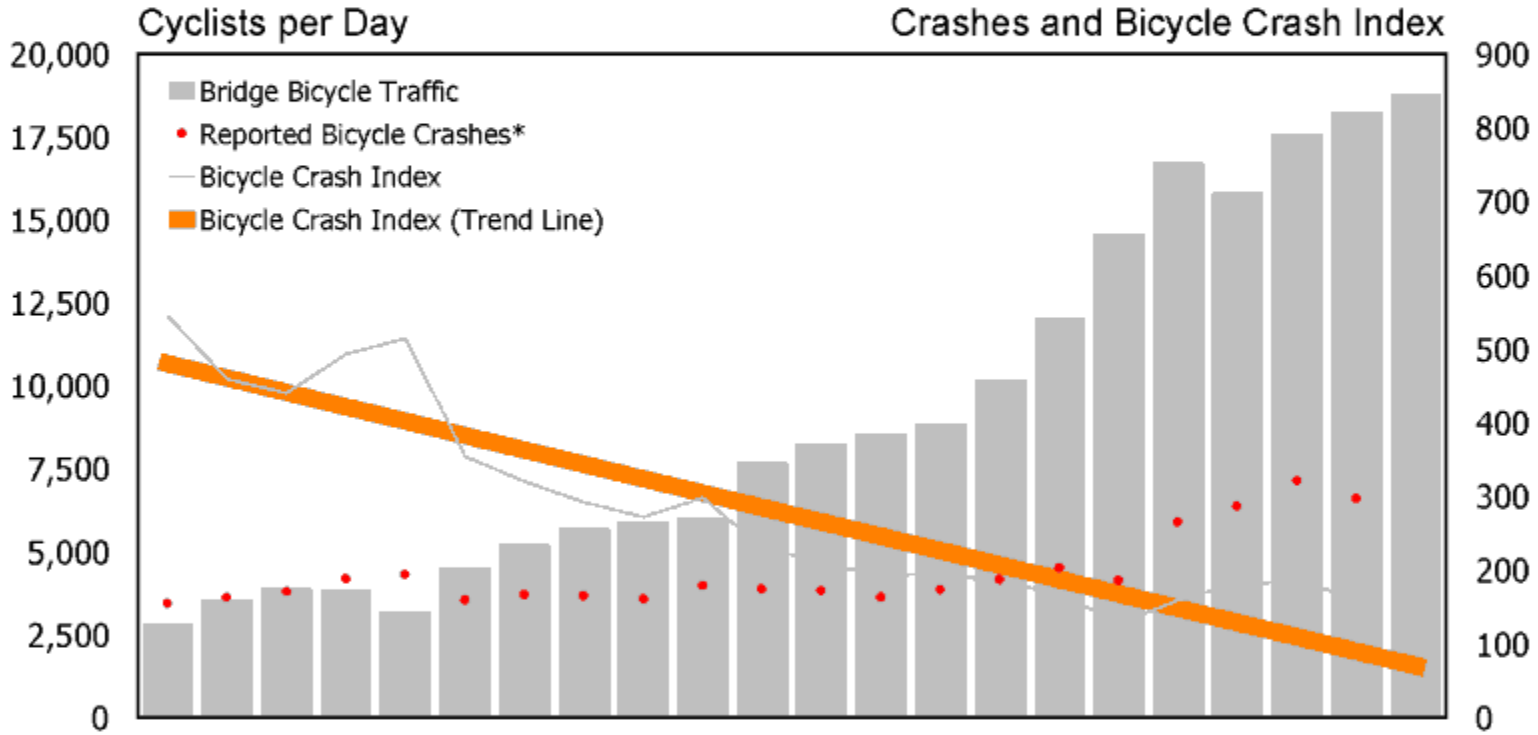
www.minneapolismn.gov/bicycles
APBP Webinar - November 20, 2013

Portland, OR bicycle crash rate

Combined Bicycle Traffic over Five Main Portland Bicycle Bridges Juxtaposed with Bicycle Crashes

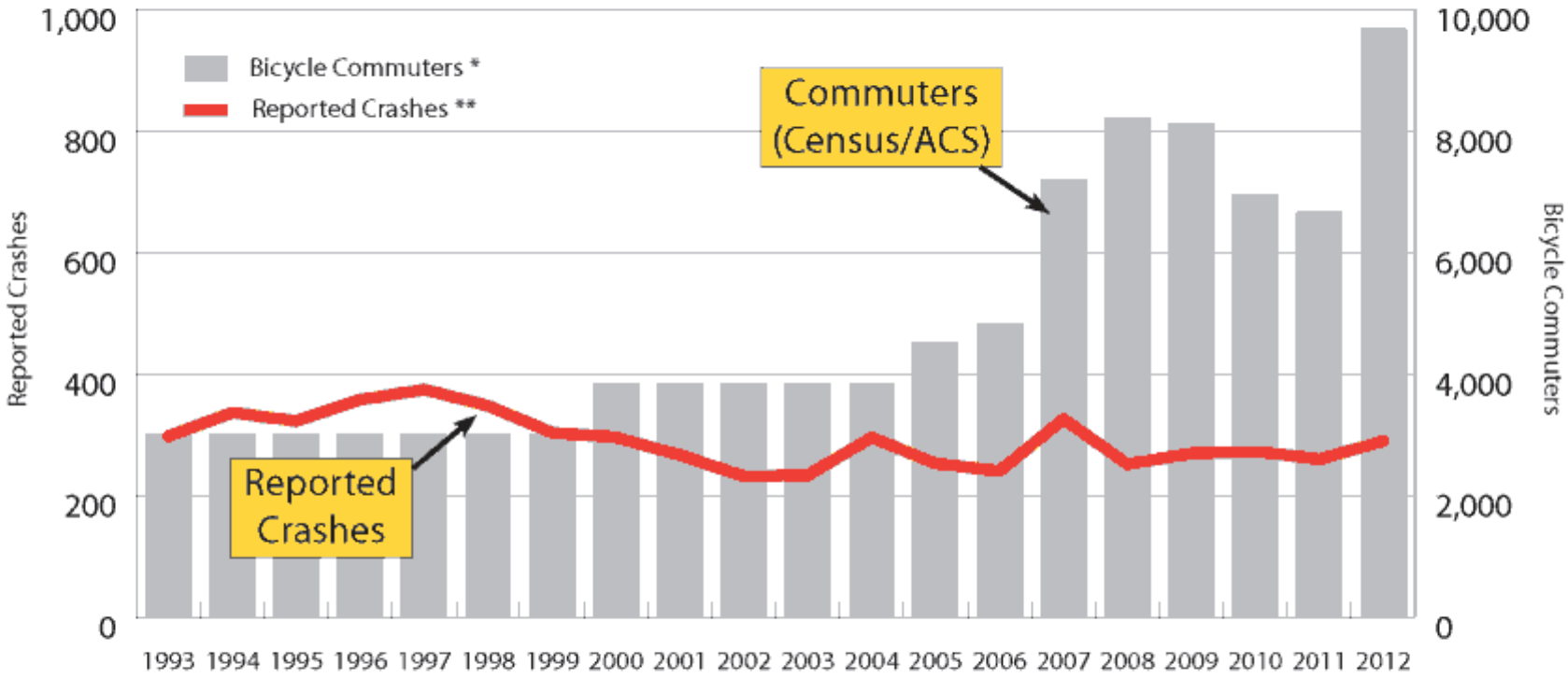


	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Bridge Bicycle Traffic	2,850	3,555	3,885	3,830	3,207	4,520	5,225	5,690	5,910	6,015	7,686	8,250	8,562	8,875	10,192	12,046	14,563	16,711	15,794	17,576	18,257	18,794
Reported Bicycle Crashes*	155	163	171	189	195	160	167	166	161	179	175	173	164	174	188	203	186	265	287	321	297	*
Bicycle Crash Index	544	459	440	493	514	354	320	292	272	298	230	210	192	196	184	168	128	159	182	183	163	*
Bicycle Fatalities	2	0	4	3	2	1	5	3	0	0	5	0	4	1	4	0	6	0	4	0	2	2

Extrapolated from peak period counts

Year

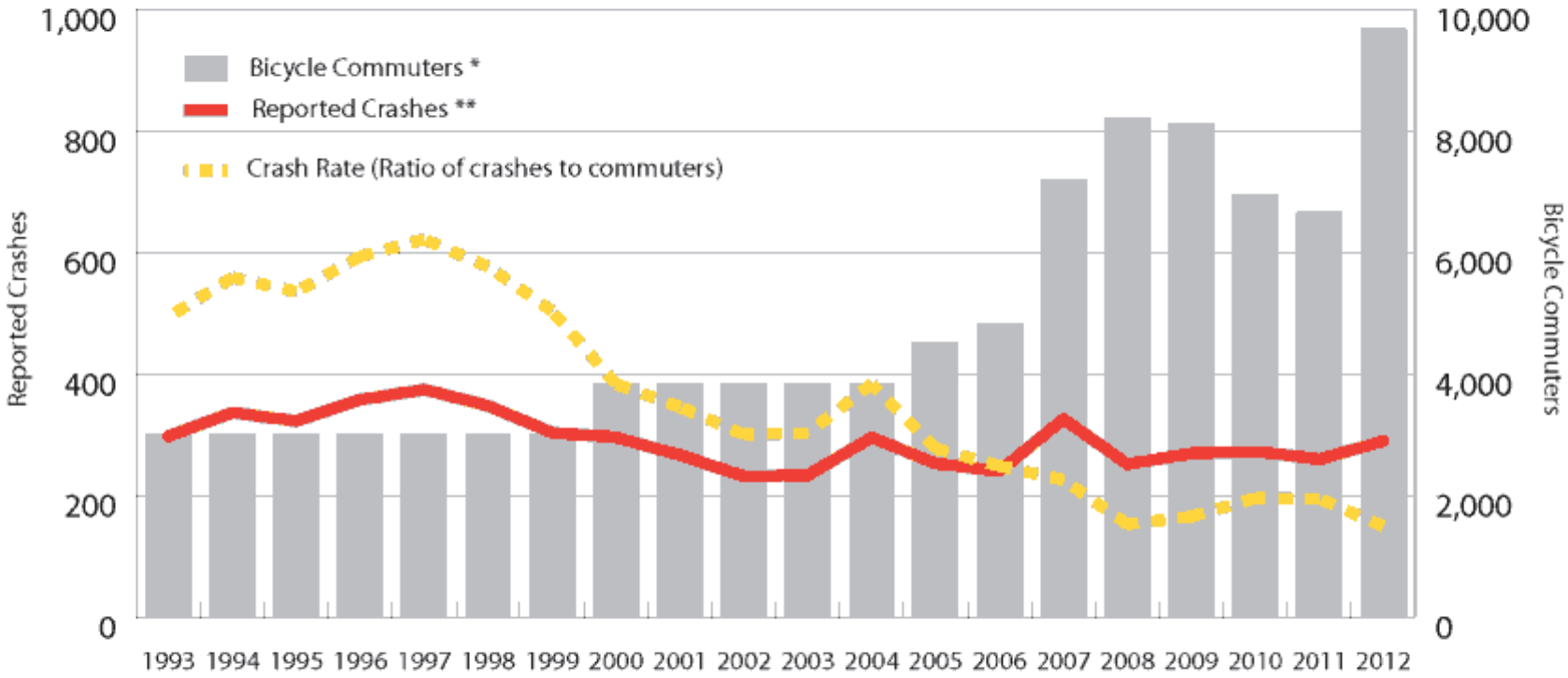
Minneapolis bicycle crash rate



*1993-1999 data based on the 1990 Decennial Census, 2000-2004 data based on the 2000 Decennial Census, 2005-2012 data based on American Community Survey 1-year estimates, "Bicycle Commuters" refers to Minneapolis workers aged 16 or older who commute primarily by bicycle.

**As reported to Minneapolis Public Works, by the MPD and Minneapolis Park Police

Minneapolis bicycle crash rate



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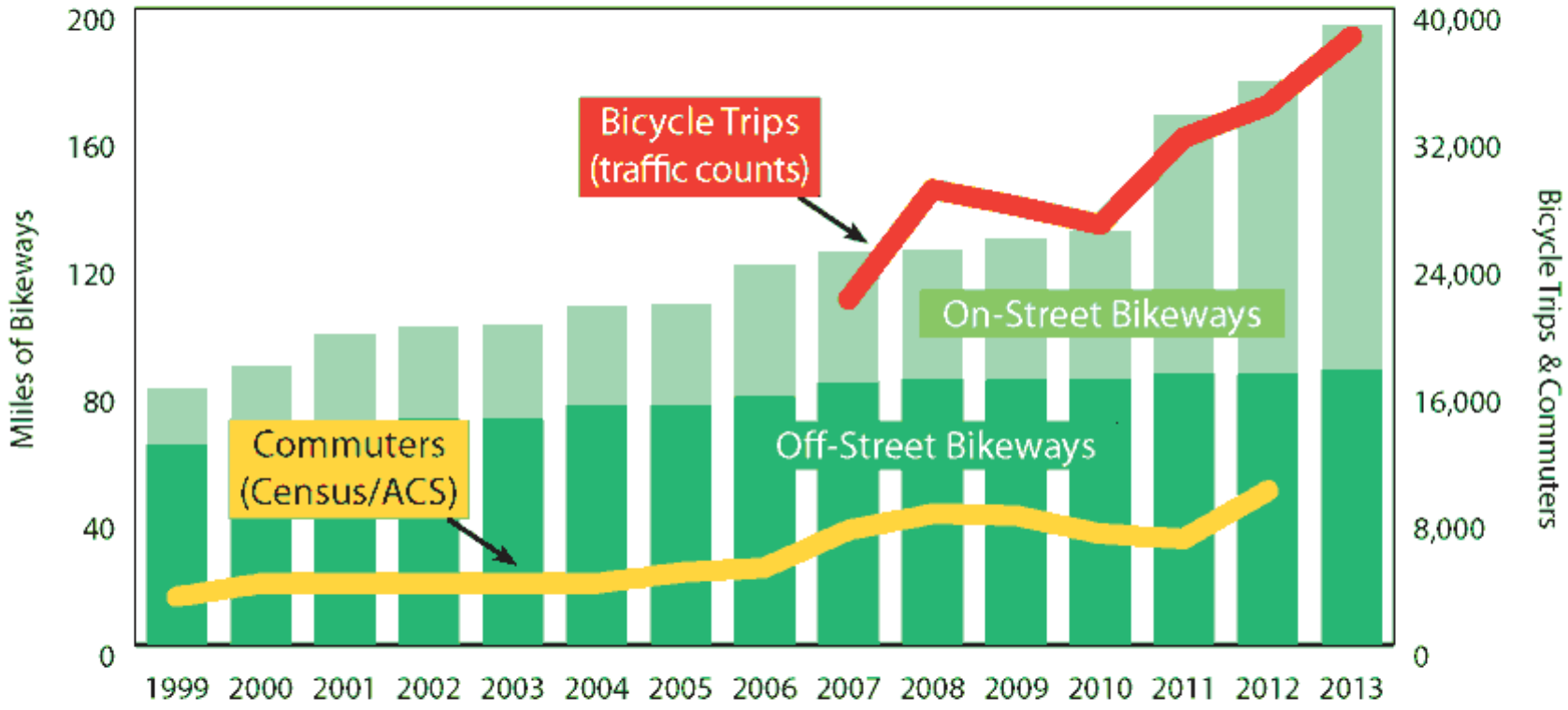
**As reported to Minneapolis Public Works, by the MPD and Minneapolis Park Police

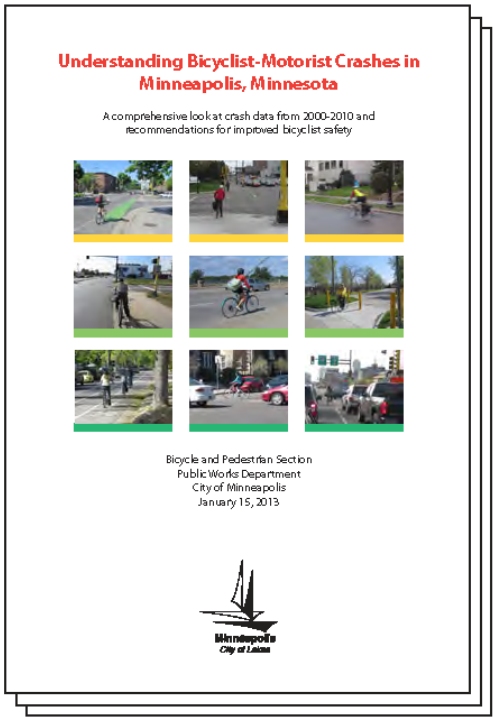
More bikeways ⟷ More bicyclists



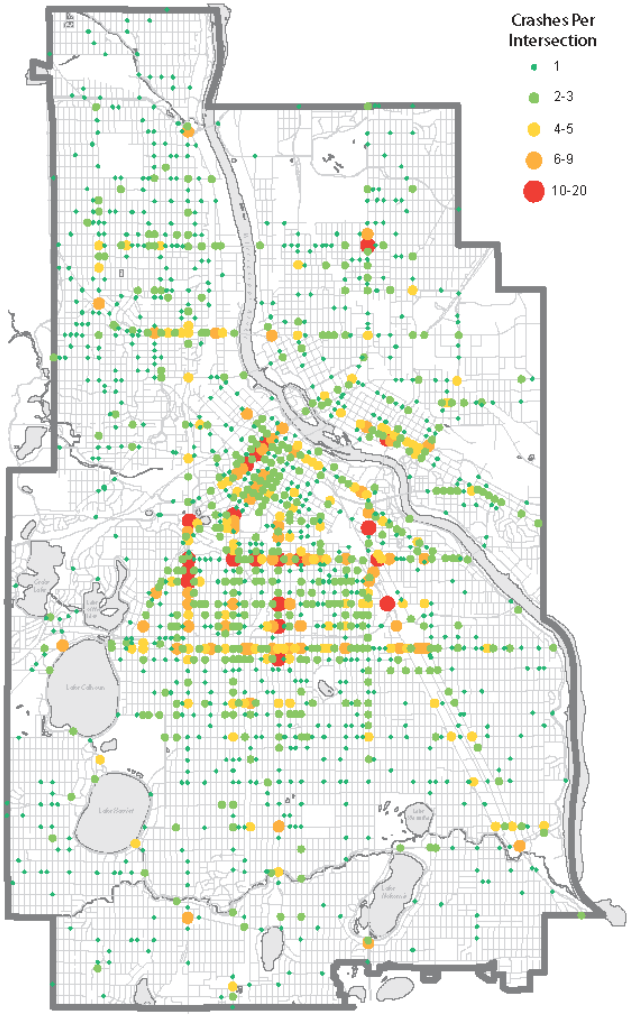
Source: U.S. Census Bureau 1990-2000 Decennial Census, 2005-2012 American Community Survey, Minneapolis Public Works Non-Motorized Traffic Counts 2007-2013.

Minneapolis bicycle crash analysis

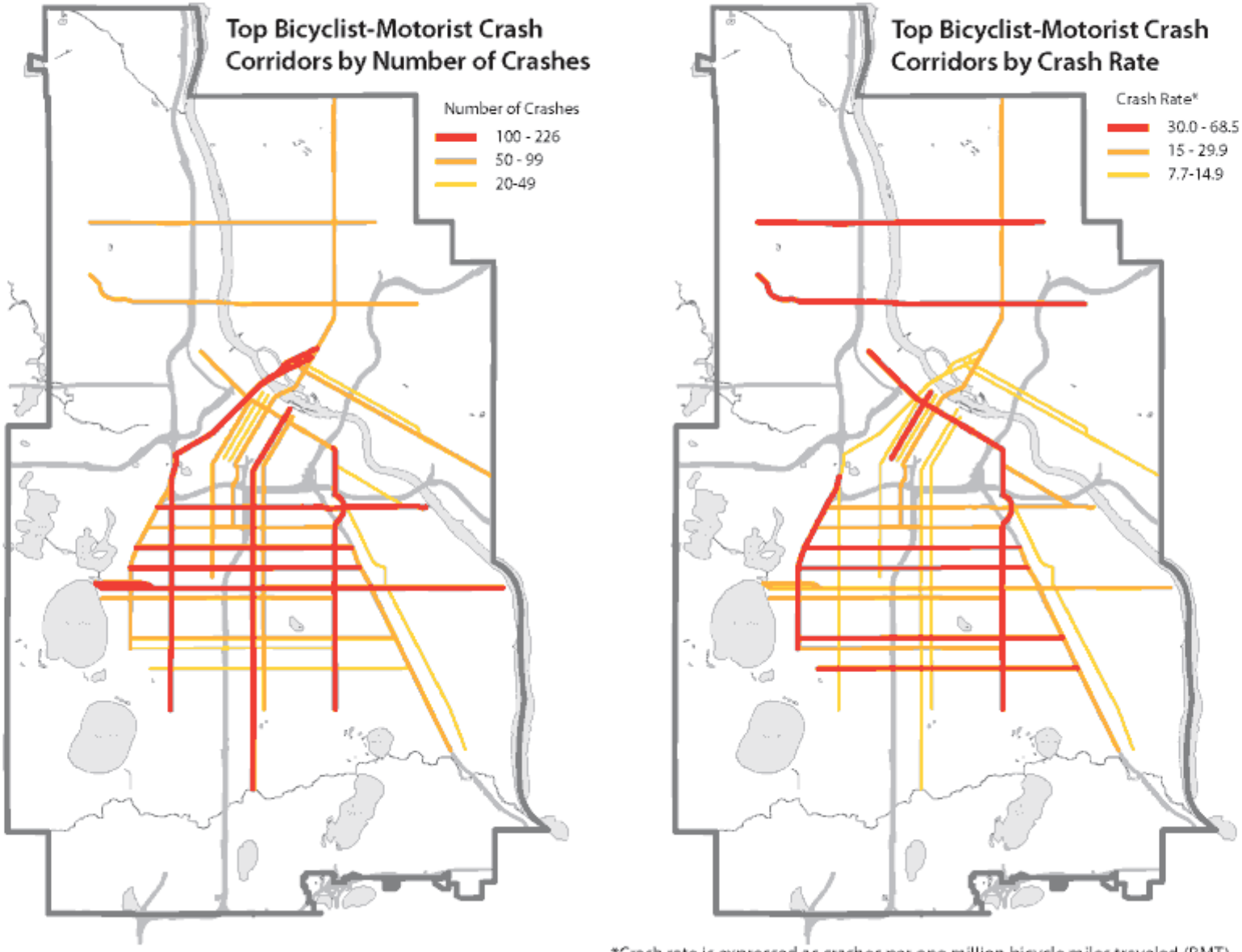
2,973 reported bicyclist-motorist crashes from 2000-2010



www.minneapolismn.gov/bicycles/data



Number of Crashes vs. Crash Rate



*Crash rate is expressed as crashes per one million bicycle miles traveled (BMT)

Corridor level crash rate

Minneapolis crash analysis

Crashes ÷ Exposure = Crash Rate

Corridor level crash rate

Minneapolis crash analysis

Crashes ÷ Exposure = Crash Rate

$$\frac{\textbf{Crashes}\ \text{(Total crashes along corridor from 2000-2010)}}{\textbf{Exposure}\ \text{(Bicycle miles traveled)}} = \textbf{Crashes per million BMT}$$

Corridor level crash rate

Minneapolis crash analysis

Crashes ÷ Exposure = Crash Rate

Crashes (Total crashes along corridor from 2000-2010)

Exposure (Bicycle miles traveled)

= **Crashes per million BMT**

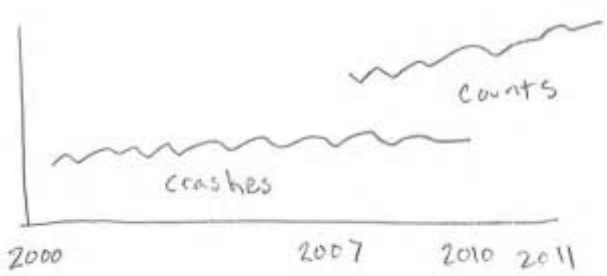
(**1** Conduct screenline count(s) → **2** Extrapolate to 11-year period) X **3** Multiply by length of corridor (miles)

NBPDP Count Extrapolation Factors

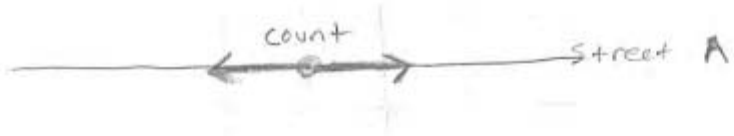
4-6pm to Daily	5.00
Daily to Weekly	7.69
Weekly to Monthly	4.29
Monthly to Annual	9.09
Annual to 11-year	11.00
Daily to 11-year	3,298.68

Assumptions and Notes

> Recent traffic is representative of historic traffic.



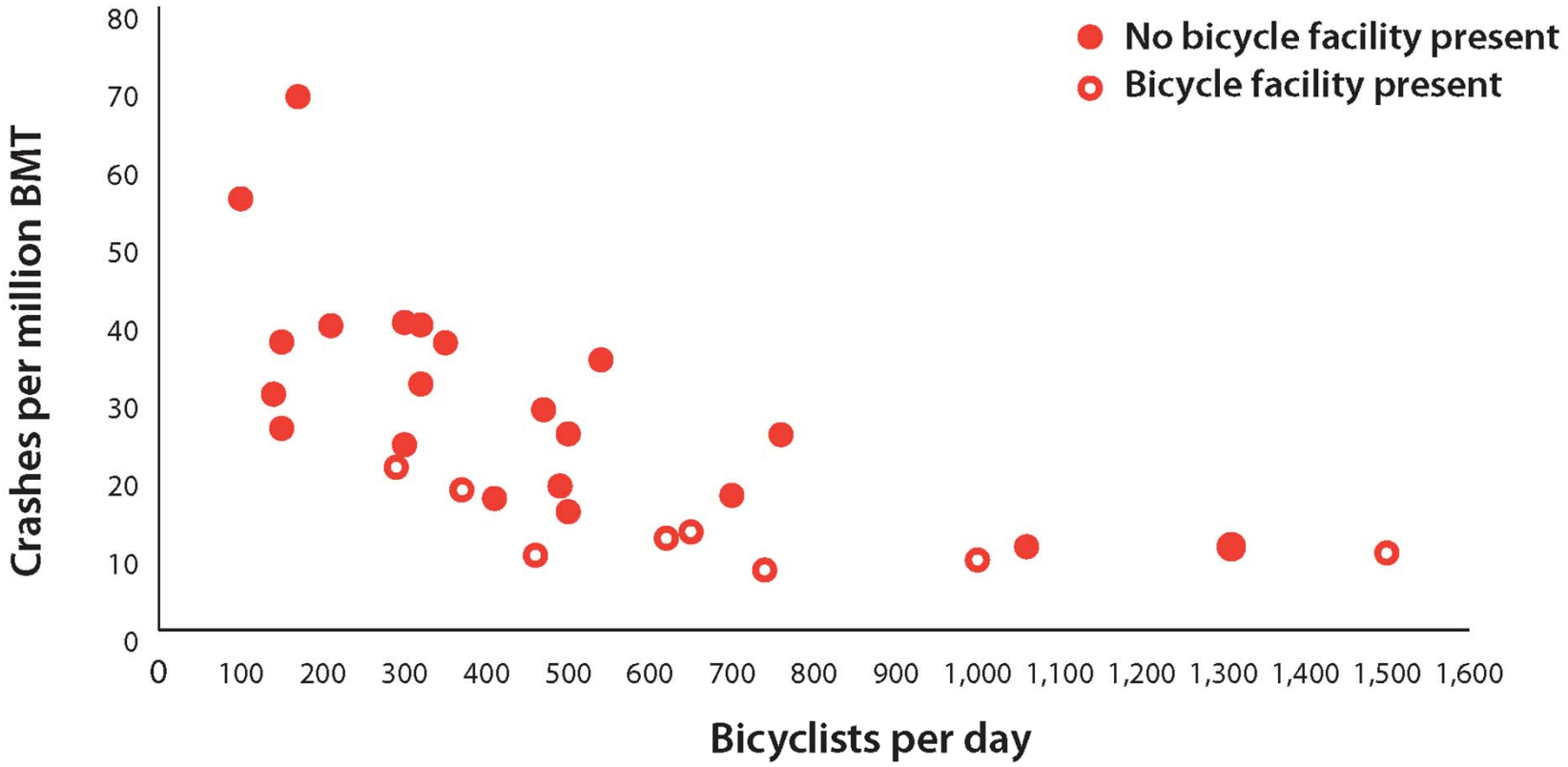
> Counts at 1 or 2 points are representative of whole corridor.



> Traffic travels along corridor rather than across the corridor.

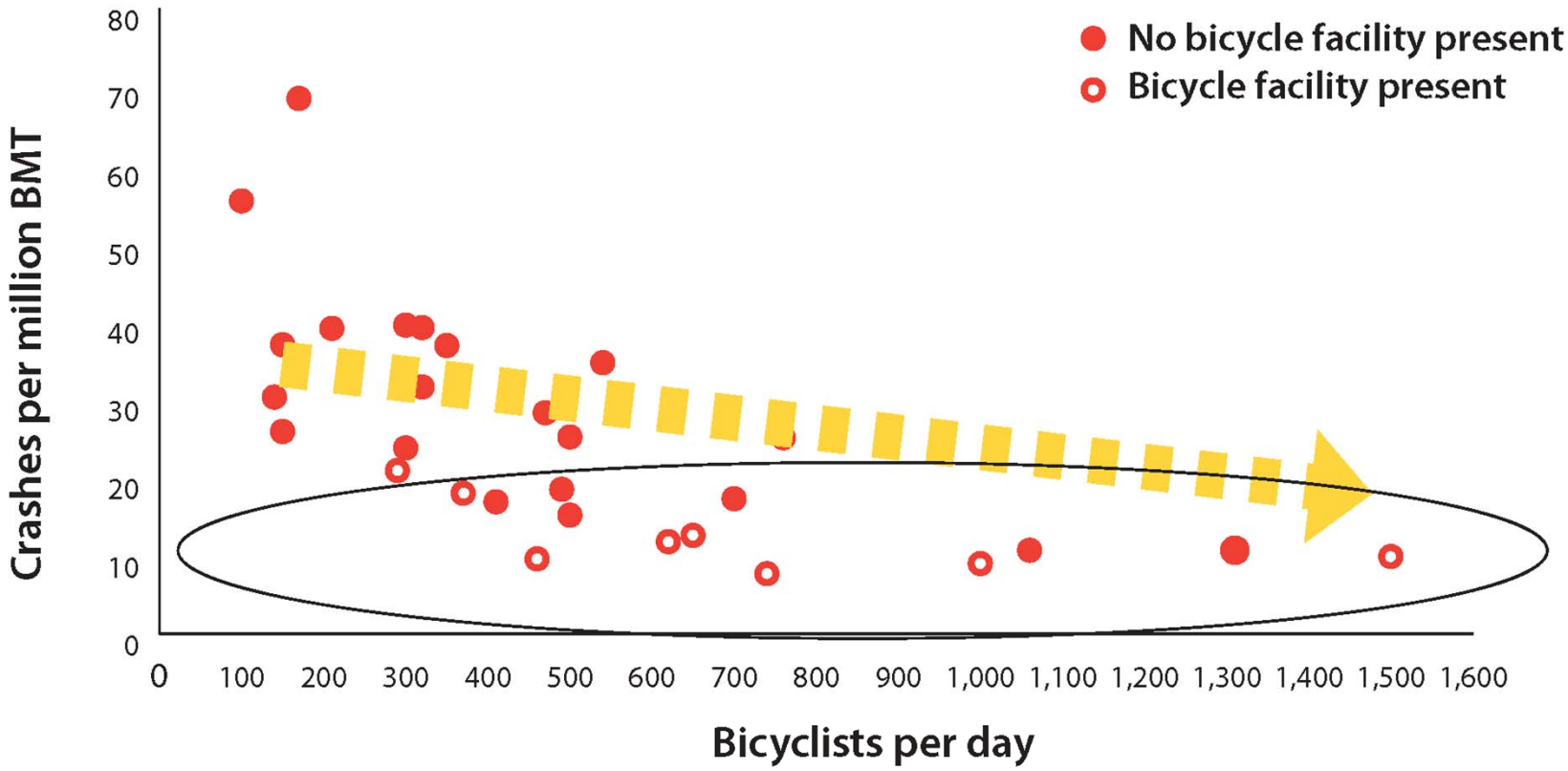
> Crash rate did not account for motor vehicle, transit, or pedestrian traffic.

Generally: more bicyclists, lower crash rate



Source: Crashes as reported Minneapolis Public Works by the MPD and Minneapolis Park Police, Minneapolis Public Works Non-Motorized Traffic Counts 2007-2013.

Generally: more bicyclists, lower crash rate



Source: Crashes as reported Minneapolis Public Works by the MPD and Minneapolis Park Police, Minneapolis Public Works Non-Motorized Traffic Counts 2007-2013.

E 28th St - 170 bicyclists per day

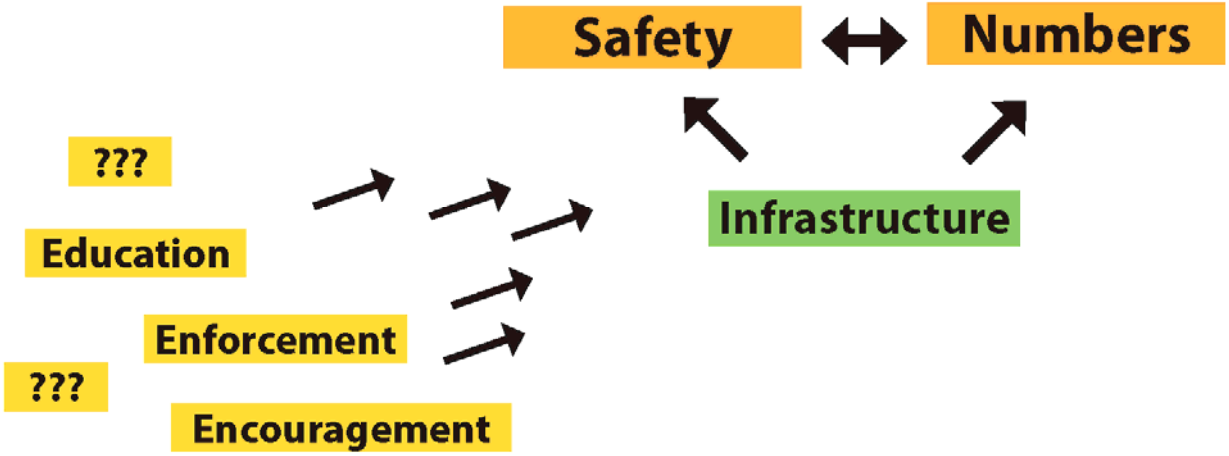
Relatively high crash rate

15th Ave SE - 4,330 bicyclists per day

Relatively low crash rate

Is there Safety in Numbers for Cyclists?

- In Minneapolis, "numbers" have a positive relationship with safety.
- Observed at the city-wide level over time and across different corridors.
- Corridors with more bicyclists tend to have lower crash rates.
- Other factors may be at play - some of the safest corridors also have bicycle facilities.




Thank you
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