

Fostering rigorous science and credible evidence in vision zero planning

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How might we foster rigorous science and credible evidence in Vision Zero Programs?

- NCHRP Project 17-18(5)
“Integrated Safety Management Processes”
proposed methodologies for
“identifying crash concerns and developing an effective combination of strategies to support jurisdictional goals”.
- Significantly, research was led by Canadians!

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 501

Integrated Safety Management Process

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SUBJECT AREAS
Safety and Human Performance

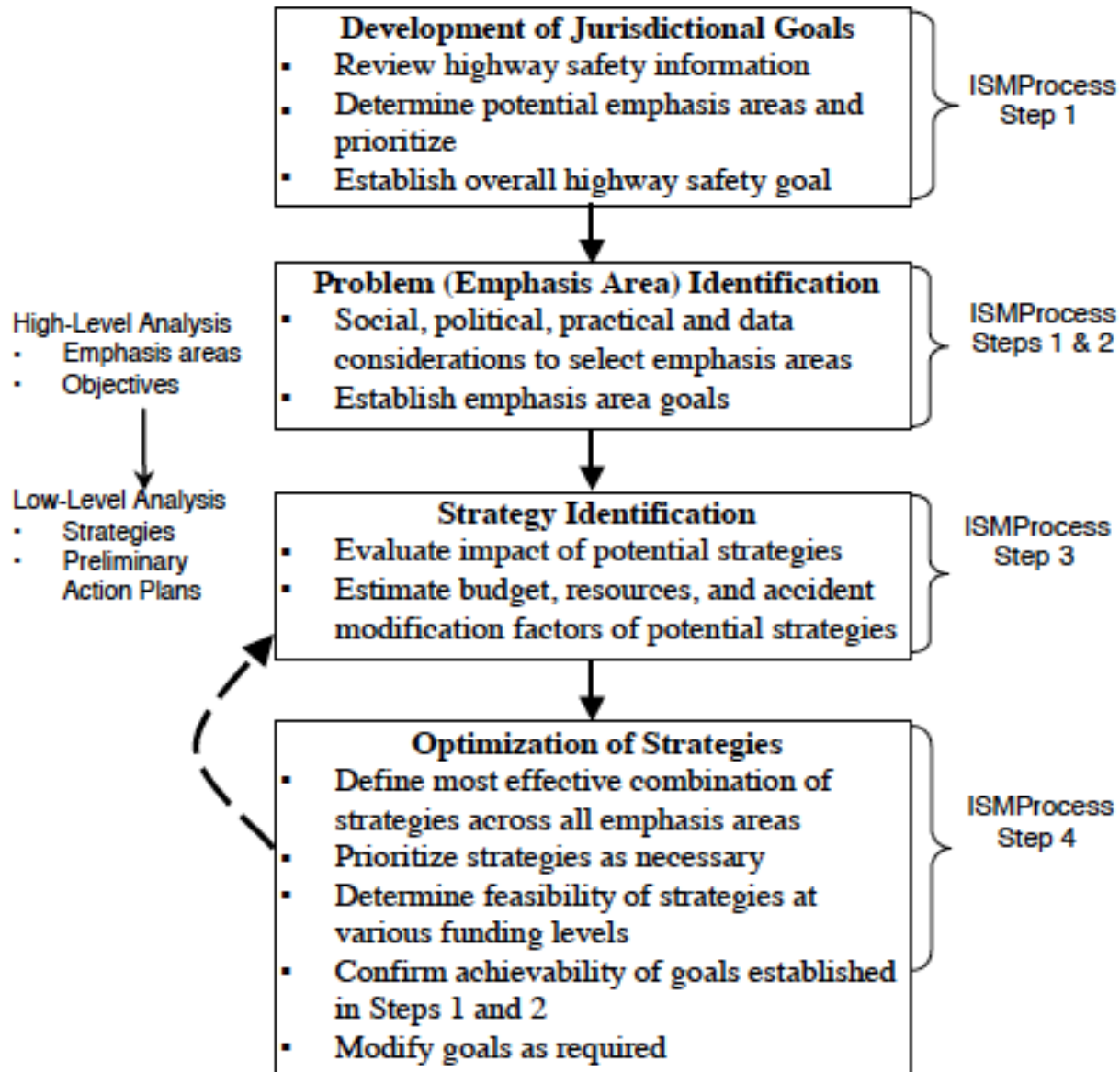
Research Sponsored by the American Association of State Highway and Transportation Officials
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TRANSPORTATION RESEARCH BOARD

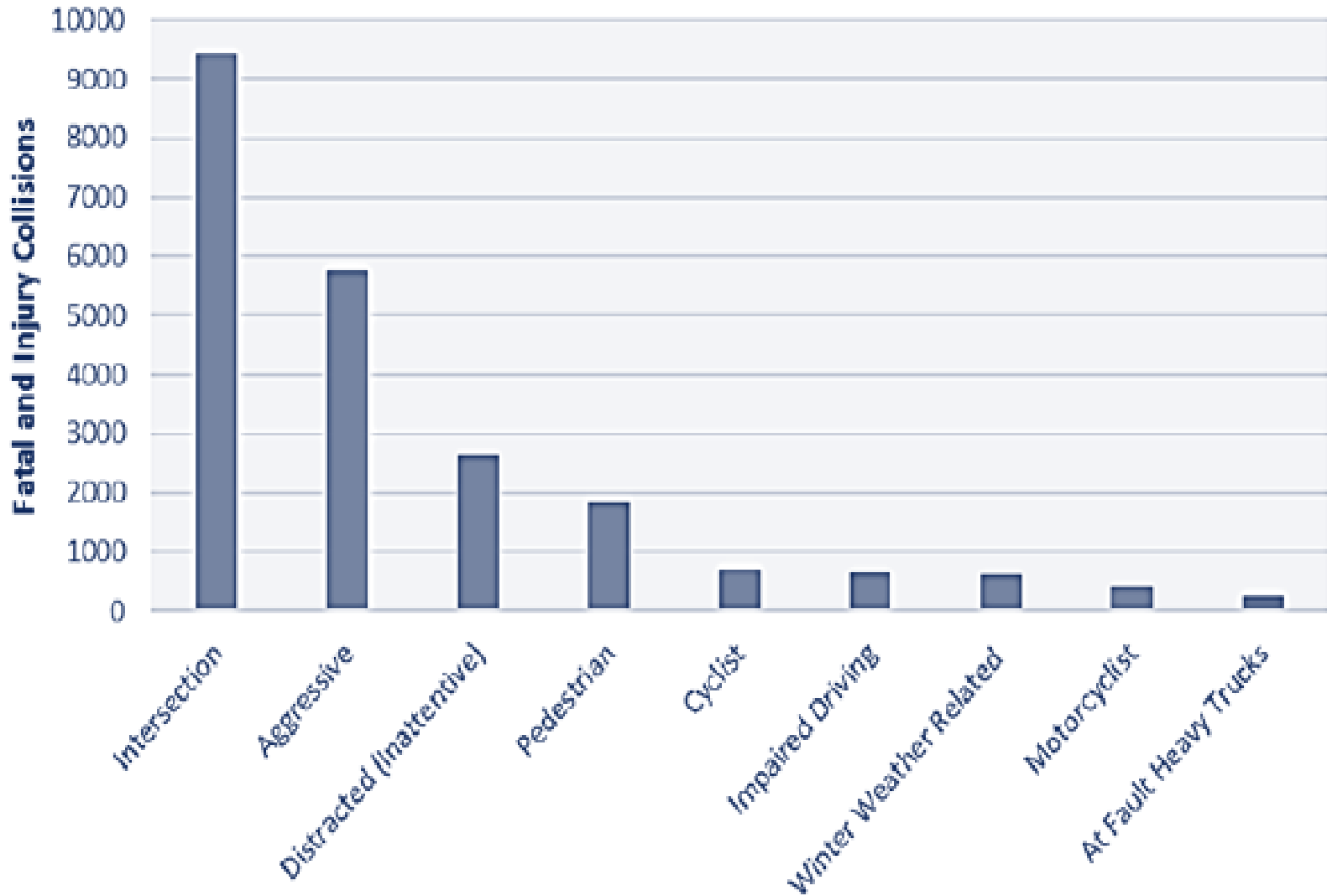
WASHINGTON, D.C.
2003
www.TRB.org

- “An integrated management (Vision Zero?) process comprises the necessary steps for advancing from crash data to integrated action plans:
 - (1) review highway safety information;
 - (2) establish emphasis area goals;
 - (3) develop objectives, strategies, and preliminary action plans to address the emphasis areas;
 - (4) determine the appropriate combination of strategies for identified emphasis areas;
 - (5) develop detailed action plans; and
 - (6) implement the action plans and evaluate performance”
- Process includes methodologies to aid the practitioner in problem identification, resource optimization, and performance measurements

Procedure for determining an effective combination of strategies to achieve a jurisdiction's safety vision.



Identifying Emphasis Areas – Typical Approach



Source: 2018 Vision Zero Advocate Conference Presentation by Pedram Izadpanah

City	Emphasis Areas	
City of London	<ul style="list-style-type: none"> ● Intersections ● Distracted and Aggressive Driving ● Young Drivers 	<ul style="list-style-type: none"> ● Pedestrians ● Cyclists ● Red Light Running
City of Hamilton	<ul style="list-style-type: none"> ● Aggressive Driving ● Intersections ● Vulnerable Road Users 	<ul style="list-style-type: none"> ● Older Drivers ● Hills ● Young Drivers
City of Ottawa	<ul style="list-style-type: none"> ● Distracted Driving ● Vulnerable Road Users ● Aggressive Driving 	<ul style="list-style-type: none"> ● Young & Older Drivers ● Emergency Response ● Metrics & Evaluation
City of Calgary	<ul style="list-style-type: none"> ● Intersections ● Mid-block ● Vulnerable Road Users 	<ul style="list-style-type: none"> ● Impaired & Distracted Driving ● Speeding
City of Toronto	<ul style="list-style-type: none"> ● Aggressive Driving ● Intersections ● Distracted Driving 	<ul style="list-style-type: none"> ● Pedestrians ● Cyclists ● School Zones

Source: 2018 Vision Zero Advocate Conference Presentation by Pedram Izadpanah

**IDENTIFYING AND EXPLORING EMPHASIS AREAS
– ILLUSTRATION OF THE NCHRP 501 APPROACH**

IDENTIFYING AND EXPLORING EMPHASIS AREAS – ILLUSTRATION OF THE NCHRP 501 APPROACH

- Uses crash records
- Identifies subsets of crashes that provide potential emphasis areas
- Evaluates these potential emphasis areas by comparing them to their complementary subsets on a rate or percentage basis
- A statistical test ensures observed differences are real and not by chance
- **Output leads to identifying objectives and strategies for all emphasis areas**
- *Analysis can be performed with free software*

CARE

CRITICAL ANALYSIS REPORTING ENVIRONMENT



A data analysis software package originally designed for problem identification and countermeasure development in traffic safety applications.

On-line analysis with Alabama sample data at <https://safety.aladata.com>

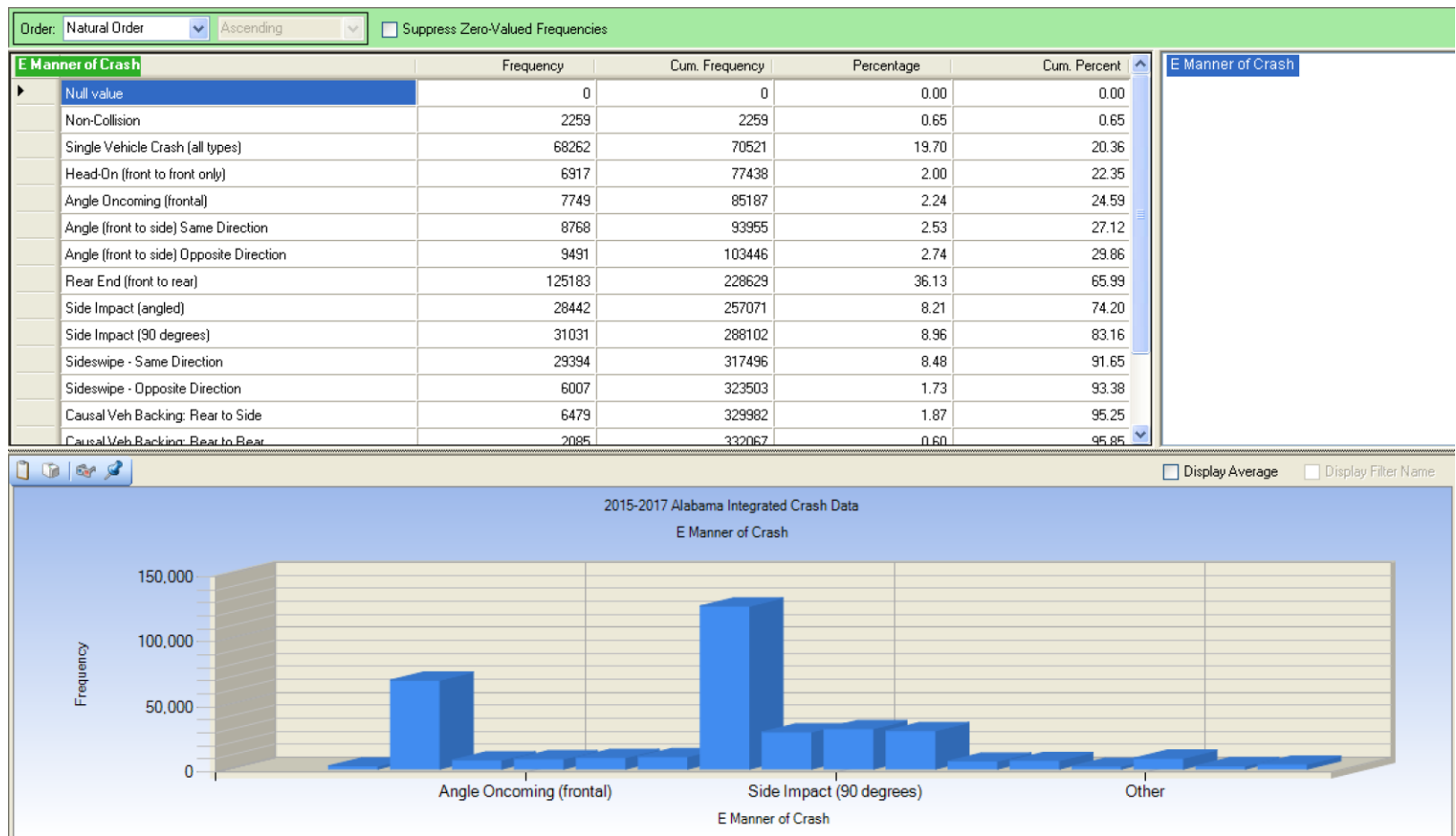
Desktop software download at

<http://www.caps.ua.edu/analytics/downloads/datasets/>

Basic procedures can be implemented in a spreadsheet

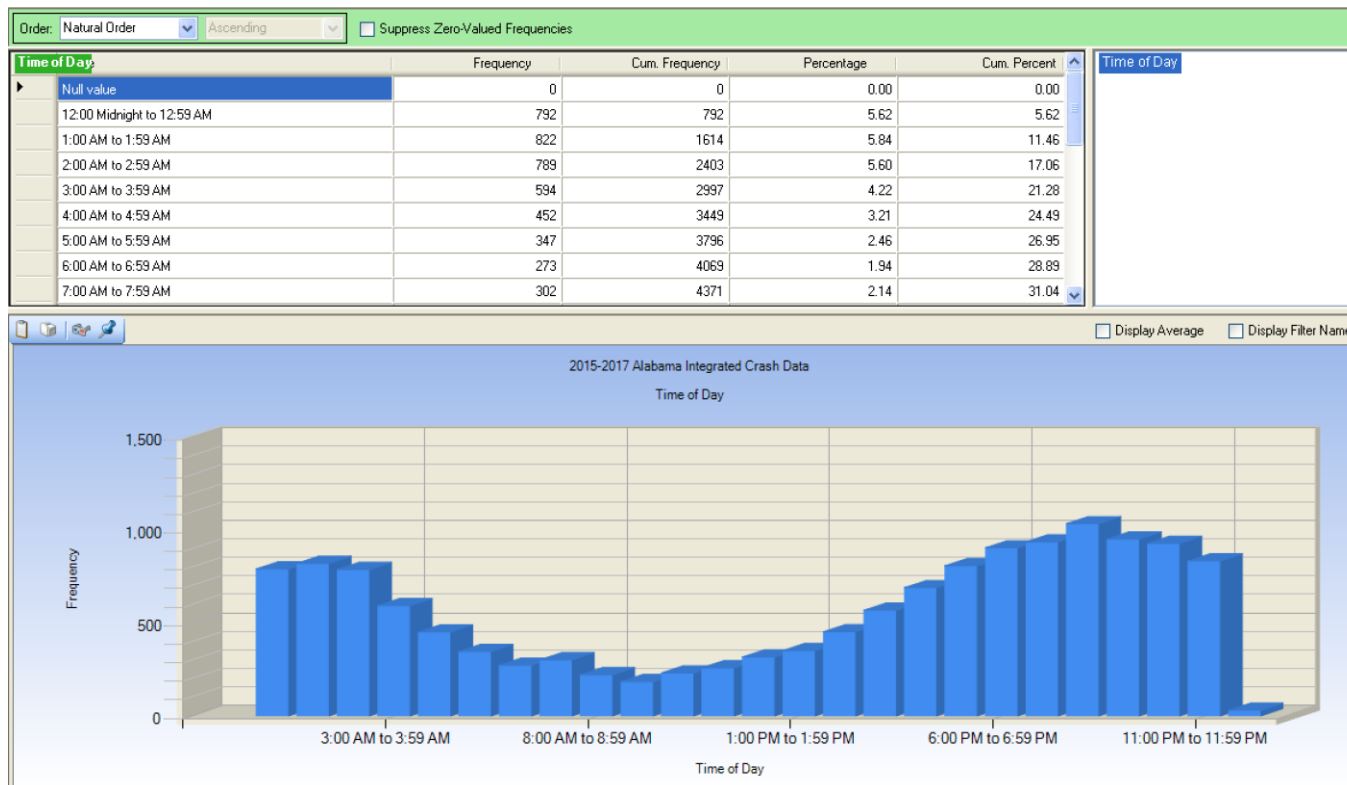
IDENTIFYING AND EXPLORING EMPHASIS AREAS – ILLUSTRATION OF THE NCHRP 501 APPROACH

Examine frequency distributions for each variable in crash records, looking for high poles, this will identify potential emphasis areas



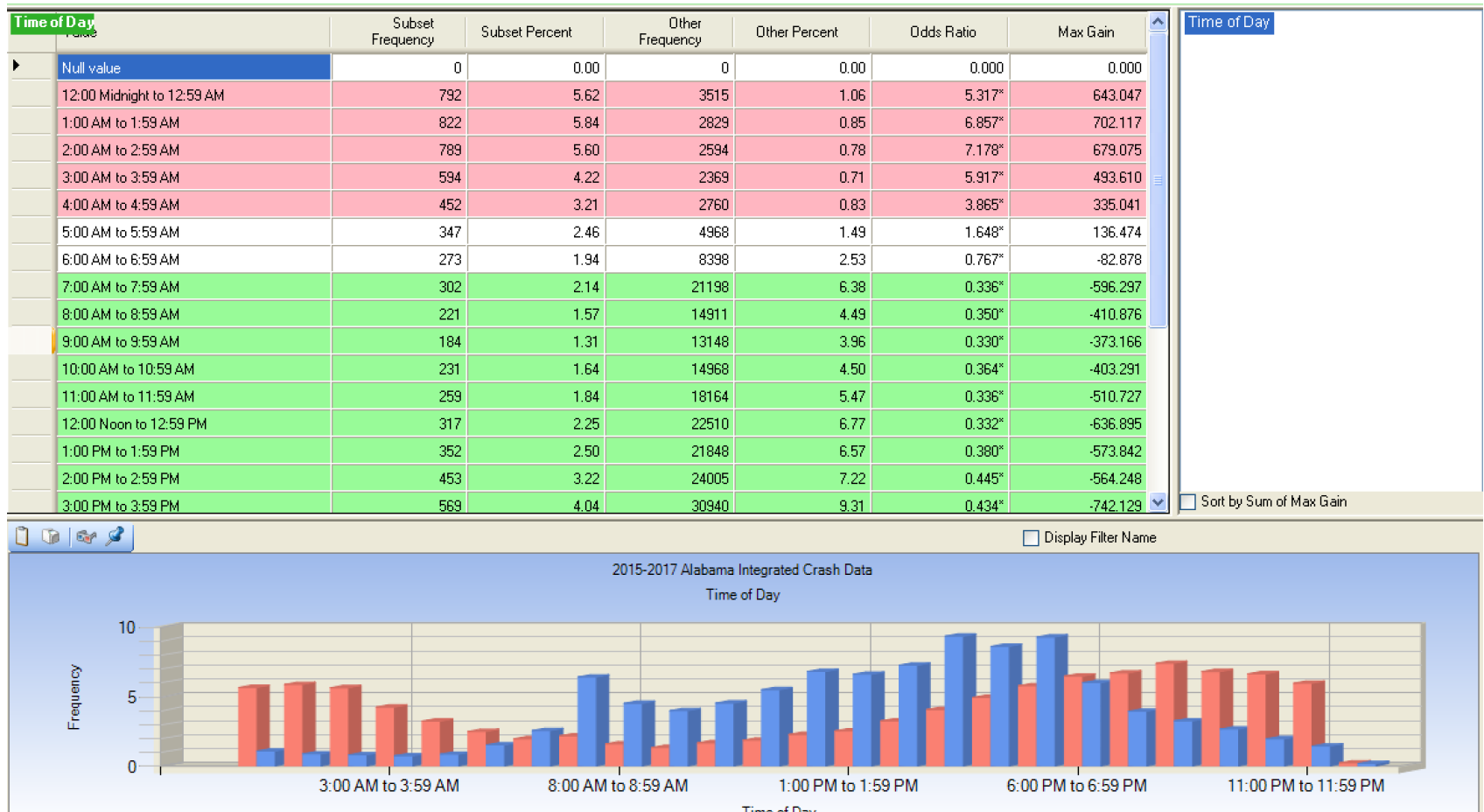
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Emphasis areas can be further explored to more specifically define the subset of crashes, e.g. time-of-day for alcohol-related



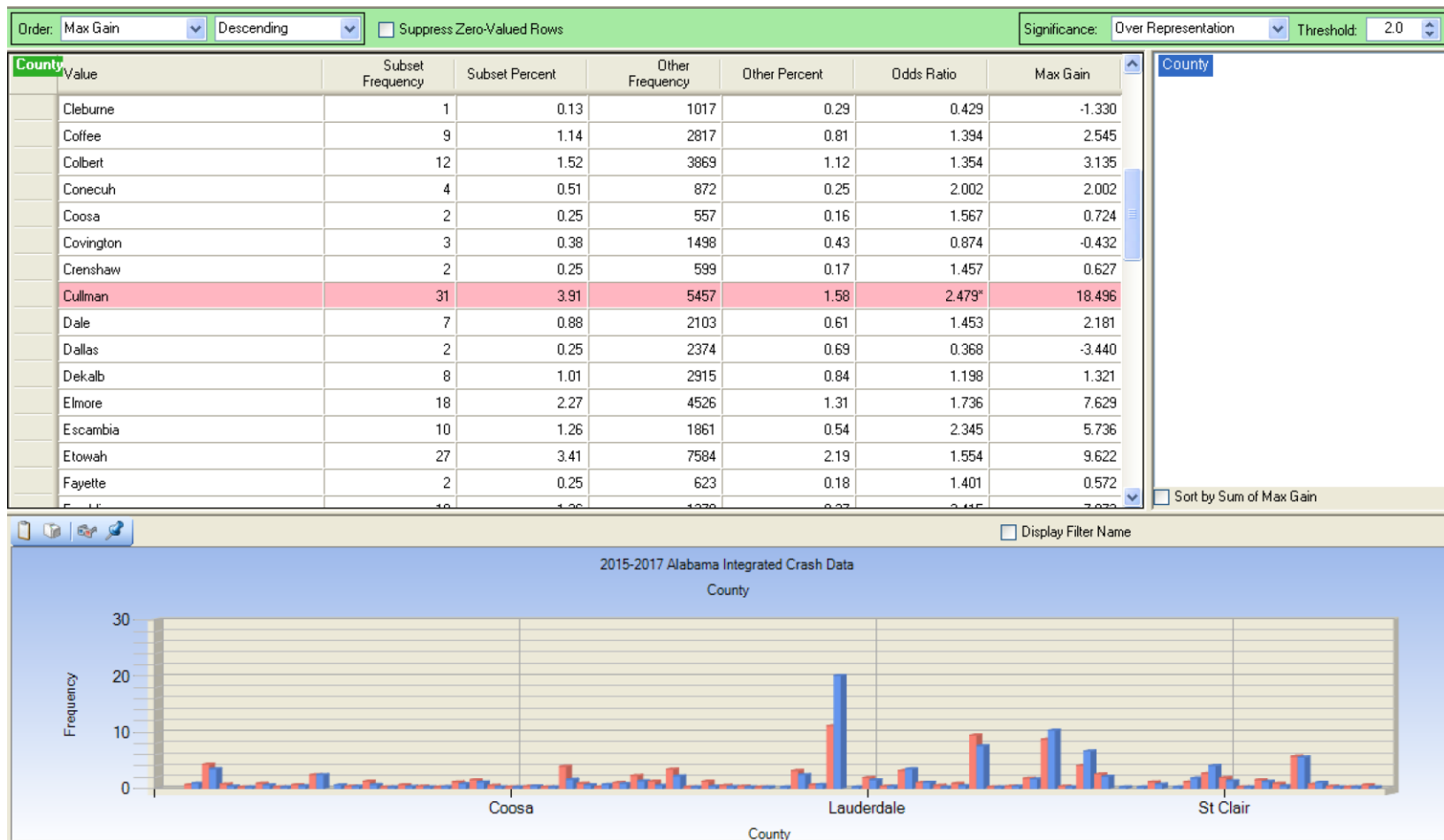
IDENTIFYING AND EXPLORING EMPHASIS AREAS – ILLUSTRATION OF THE NCHRP 501 APPROACH

Emphasis areas can be compared to their complement to confirm over-representation



IDENTIFYING AND EXPLORING EMPHASIS AREAS – ILLUSTRATION OF THE NCHRP 501 APPROACH

Emphasis areas can be further targeted using other crash-related variables



IDENTIFYING AND EXPLORING EMPHASIS AREAS – ILLUSTRATION OF THE NCHRP 501 APPROACH

Example – Head-On vs non-Head-On crashes by roadway curvature

Curvature	Subset Freq	Subset %	Other Freq	Other %	Over-Representation	Maximum Gain
None	1 000	58.8	16 000	80.0	0.74	0
Slight	500	29.4	3 000	15.0	1.96	244.80
Sharp	200	11.8	1 000	5.0	2.36	115.60

Over-representation is evaluated using appropriate statistical test

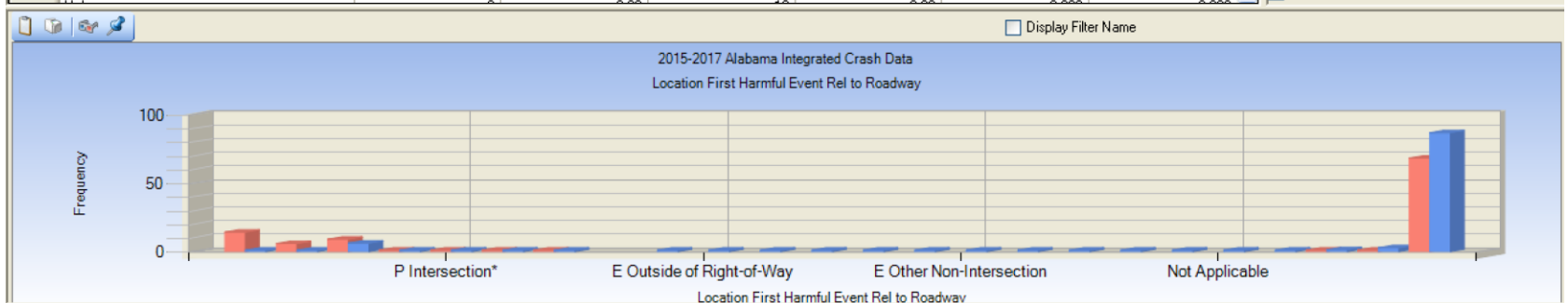
$$MaximumGain = \left(\frac{SubsetPercentage_i - OtherPercentage_i}{100} \right) \sum_{i=1}^n SubsetFrequency_i$$

IDENTIFYING AND EXPLORING EMPHASIS AREAS – ILLUSTRATION OF THE NCHRP 501 APPROACH

Definition of subsets and their comparison is important.

Here, pedestrian vs non-pedestrian crashes at intersections are compared, evaluating location of first harmful event.

Location First Harmful Event Rel to Roadway	Subset Frequency	Subset Percent	Other Frequency	Other Percent	Odds Ratio	Max Gain
E Intersection with Crosswalk and Pedestrian Sig...	49	14.16	684	0.86	16.533*	46.036
E Intersection with Crosswalk no Pedestrian Sig...	20	5.78	450	0.56	10.257*	18.050
E At Intersection no Crosswalk	31	8.96	4889	6.12	1.463	9.816
E Off Roadway - Location Unknown	2	0.58	188	0.24	2.455	1.185
P Intersection*	1	0.29	39	0.05	5.918	0.831
Other	1	0.29	53	0.07	4.355	0.770
Off Roadway	1	0.29	226	0.28	1.021	0.021
Null value	0	0.00	0	0.00	0.000	0.000
Median	0	0.00	446	0.56	0.000	0.000
E Outside of Right-of-Way	0	0.00	197	0.25	0.000	0.000
E In Parking Lane or Zone	0	0.00	60	0.08	0.000	0.000
E Gore	0	0.00	12	0.02	0.000	0.000
E Separator	0	0.00	18	0.02	0.000	0.000
E Non-Intersection Crosswalk	0	0.00	29	0.04	0.000	0.000
E Other Non-Intersection	0	0.00	5	0.01	0.000	0.000
E Driveway Access Crosswalk	0	0.00	1	0.00	0.000	0.000
E Sidewalk	0	0.00	16	0.02	0.000	0.000

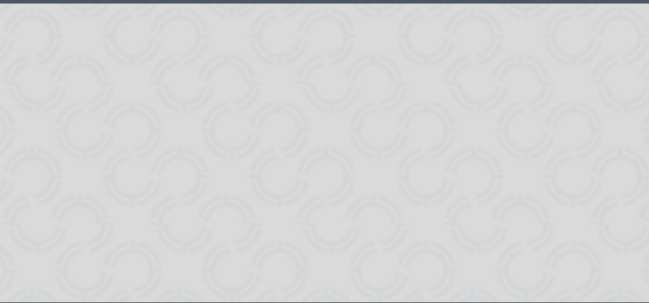


IDENTIFYING AND EXPLORING EMPHASIS AREAS – A SMALL SAMPLE OF POSSIBILITIES

- **Fatal crashes**
 - Identify age groups, location types, manner of crashes
 - Leads to focussed education, engineering and enforcement strategies
- **Speeding-Related**
 - Identify road/intersection types, geographic areas and time of day to focus strategies on
- **Bicycle Crashes**
 - Over-represented for certain types of infrastructure?
 - Requires linked data on volumes and type of infrastructure for meaningful insights

USING RIGOROUS SCIENCE AND CREDIBLE EVIDENCE TO DETERMINE APPROPRIATE STRATEGIES FOR IDENTIFIED EMPHASIS AREAS

- *Needs to be based on credible evidence*
- *Assessing credibility of evidence is not trivial*
 - *Methodological Issues*
 - *Applicability/transferability of results*
- *Challenges due to road user adaptation – our focus here*



All

1. Vision Zero Overview

2. Traffic Safety Research

3. Engineering

Countermeasures



Inventory of Proven and Promising Traffic Safety Countermeasures »

The Canadian Council of Motor Transport Administrators (CCMTA) has developed a comprehensive inventory of proven and promising countermeasures for traffic safety that support the Vision Zero focus of their Road Safety Strategy 2025.

April 25, 2017

Road Safety Measures

Road Safety Strategy 2025 provides Canadian jurisdictions and road safety stakeholders with an inventory of road safety initiatives which can be adopted or adapted to address their specific road safety challenges. Some of these have been **proven** effective and for others, measured effectiveness is not yet available and these are considered **promising**. The inventory supports the concept of a safer systems approach to road safety to address: the road user, road infrastructure and vehicle safety concerns.

Evidence provided for the initiatives in the inventory is the outcome of independent research and the initiatives should not be construed in any way as being policies adopted by CCMTA or by its members. The initiatives may, however, be used by CCMTA and its member jurisdictions and other stakeholders as a reference for the development of policy and programs. The assessment tool used to evaluate initiatives is available **here**.

Search for Road Safety Measures

Criteria (you can select more than one)

Type

Road Users Road Infrastructure Vehicles

Risk Group(s)

Young/Novice Drivers Medically at-risk Drivers Vulnerable Road Users Commercial Drivers High-risk Drivers General Population

Contributing Factor(s)

Drugs Alcohol Distraction Fatigue Speed and Aggressive Driving Unrestrained Occupants Environmental Factors Road Infrastructure Vehicle Factors

Road Safety Interventions

Education/Training Communication/Awareness Policy/Legislation/Regulation Enforcement Road Infrastructure Technology Information/Data/Research

Limit marked crosswalks to roads with average daily traffic of 12,000 or less

Type: Road Infrastructure

Risk Group(s): Vulnerable Road Users

Contributing Factor(s): Speed and Aggressive Driving Environmental Factors Road Infrastructure

Strategy Type(s): Road Infrastructure



Zegeer et al. (2005) carried out a study to determine whether marked crosswalks at uncontrolled locations are safer than unmarked crosswalks under various traffic and roadway conditions and to recommend ways to make crossing safer for pedestrians. Five years of pedestrian crash data from 1,000 marked crosswalks and 1,000 matched unmarked comparison sites were included in the study. None of the sites in the study had a traffic signal or stop sign on the approaches. Detailed data were collected on traffic volume, pedestrian exposure, number of lanes, median type, and speed limit. The results of the study showed that on two-lane roads and on multilane roads (roads with three to eight lanes) with average daily traffic (ADT) below 12,000, there was no difference in pedestrian crash rates between a marked crosswalk alone at an uncontrolled location and an unmarked crosswalk. However, on multilane roads with ADT volumes greater than 12,000 vehicles and no raised median and on multilane roads with ADT above 15,000 vehicles and with a raised median, marked crosswalks alone had significantly higher pedestrian crash rates than unmarked crosswalks.

The authors cited the findings of research by Knoblauch et al. (2001) which suggested that while marked crosswalks in themselves may not increase measurable unsafe pedestrian or motorist behaviour, the installation of a marked crosswalk may increase the number of at-risk pedestrians (particularly children and older adult pedestrians) who choose to cross there instead of at the nearest signal-controlled crossing. The authors suggested that crosswalk enhancements should be added to the marked crosswalks rather than removing or failing to install them. Some suggested improvements included providing raised medians on multilane roads, installing traffic and pedestrian signals when warranted, adding curb extensions, providing adequate lighting, and designing intersections with tighter to turn radii.

Protected Left Turn movement

Type: Road Infrastructure

Risk Group(s): Vulnerable Road Users General Population

Contributing Factor(s): Speed and Aggressive Driving Environmental Factors Road Infrastructure

Strategy Type(s): Road Infrastructure



Left-turning traffic is over-represented in conflicts at intersections. An estimated 27% of all intersection-related crashes in the United States are associated with left turns, with more than two-thirds of these crashes occurring at signalized intersections (U.S. Department of Transportation, 2009).

When a driver has a protected left turn signal, a solid green arrow gives the driver the complete right of way in a left-turn lane, with no pedestrian movement or vehicular traffic conflicting with the left turn. Protected left turn signals are introduced to eliminate conflict between left-turning vehicles and crossing pedestrians as well as through traffic. When a protected left turn signal is used, the time to provide that phase must be taken from the through phase or the cycle length must be extended. Criteria that are frequently used to implement left turn phasing include traffic volume of left-turning vehicles, delays to left-turning vehicles, and left-turn collision experience.

Recent (2017) research for FHWA indicated that pedestrian crashes increase where left turn protected phase for vehicles is provided and pedestrian volumes are lower than 5000 per day

“Pedestrians not respecting “don’t walk” signal during the protected left-turn phase”

Search for Road Safety Measures

Criteria (you can select more than one)

Type

Road Users Road Infrastructure Vehicles

Risk Group(s)

Young/Novice Drivers Medically at-risk Drivers Vulnerable Road Users Commercial Drivers High-risk Drivers General Population

Contributing Factor(s)

Drugs Alcohol Distraction Fatigue Speed and Aggressive Driving Unrestrained Occupants Environmental Factors Road Infrastructure Vehicle Factors

Road Safety Interventions

Education/Training Communication/Awareness Policy/Legislation/Regulation Enforcement Road Infrastructure Technology Information/Data/Research

Linkages

Keywords (optional) 

delineation

Enhanced delineation and friction for horizontal curves

Type: Road Infrastructure

Risk Group(s): General Population

Contributing Factor(s): Road Infrastructure

Strategy Type(s): Road Infrastructure



Horizontal curves are a change in the roadway alignment that creates a more demanding environment for the driver, vehicle, and pavement. Recent analysis of US crash data indicated that 28% of fatal crashes occurred on horizontal curves. In addition, three times as many crashes occurred on curves as on tangential sections of roadways (Federal Highway Administration, 2012).

The installation of larger chevron signs with enhanced retroreflectivity, curve warning signs, sequential flashing beacons, advisory speed signs, and the application of high friction surface treatments can have a positive effect on reducing the number of vehicles that leave the roadway on horizontal curves (Federal Highways Administration, 2010).

The United States Federal Highways Administration's FHWA Clearinghouse cited the effectiveness of the several treatments or 'crash modification factors' that contribute to safer travel on horizontal curves. Montella (2009) and Srinivasan et al. (2009) demonstrated that installing chevron signs, curve warning signs, and/or sequential flashing beacons can result in a 38%-43% reduction in all fatal and injury crashes; installing chevron signs on horizontal curves can produce a 16% decrease in non-intersection fatal and injury crashes; installing new fluorescent curve signs or upgrading existing curve signs to fluorescent sheeting can result in a 25% reduction in non-intersection fatal and injury crashes; installing static combination horizontal alignment/advisory speed signs can contribute to a 13% decrease in all injury crashes; and refinishing pavement on curved sections of roadways with high numbers of serious crashes with microsurfacing treatment can result in an approximate 43% decrease in all fatal and serious injury crashes.

Curve Delineation

Srinivasan et al. (2012)



Crash Type	AADT Range	CMF* (standard error)
Lane departure crashes	< 3,800	1.206 (0.136)
	> 3800	0.731 (0.067)
Crashes during dark	< 3,800	1.192 (0.136)
	> 3800	0.678 (0.085)
Lane departure crashes during dark	< 3,800	1.200 (0.138)
	> 3800	0.712 (0.093)

***“Treatment should be targeted where it is likely to be effective;
Otherwise speed mitigation measures could be implemented”***

Raised Pavement Markers

Persaud et al. (2004)



Two lane roads

AADT	CMF for Flatter curves	CMF for Sharper curves
<5000	1.16	1.43
5001-15000	No change	1.26
15001-20000	0.76	1.03

- *“.. could encourage drivers to increase speed, especially where traffic volumes were low – can be dangerous on sharper curves”*
- *Treatment should be targeted where it is likely to be effective, e.g., at sites with a high frequency of wet weather night crashes*
- *Despite credible evidence of driver adaptation*

NCHRP

REPORT 600

2012

Human Factors Guidelines for Road Systems

Second Edition

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page 6-11 notes: "*Raised reflective pavement markers are highly effective at improving curve visibility and reducing crashes, especially when used in combination with centerlines and edge lines.*" Statement is referenced to "Nemeth, Z.A., Rockwell, T.H., and Smith. G.L. (1986) "Recommended Delineation Treatments at Selected Situations on Rural State Highways

Using rigorous science and credible evidence in performance evaluation to revisit/refine/update a vision zero plan -- challenges

- Why evaluate? Who evaluates?
 - Crash-based evaluation is not trivial
 - Accounting for RTM, crash trends, traffic volume changes
 - Separating/accounting for effects of multiple strategies
 - CMF Clearinghouse has CMFs ranging from 1 to 5 stars
 - Barriers to performance evaluation
- Evaluation of pilot programs
 - May require application of surrogate measures
 - Surrogate measure must have an established relationship to crashes
 - Statistical rigour still required
 - Example from a CARSP 2017 conference presentation

Impact of Curb Radius Reduction on Pedestrian Safety: A Before-After Surrogate Safety Study in Toronto

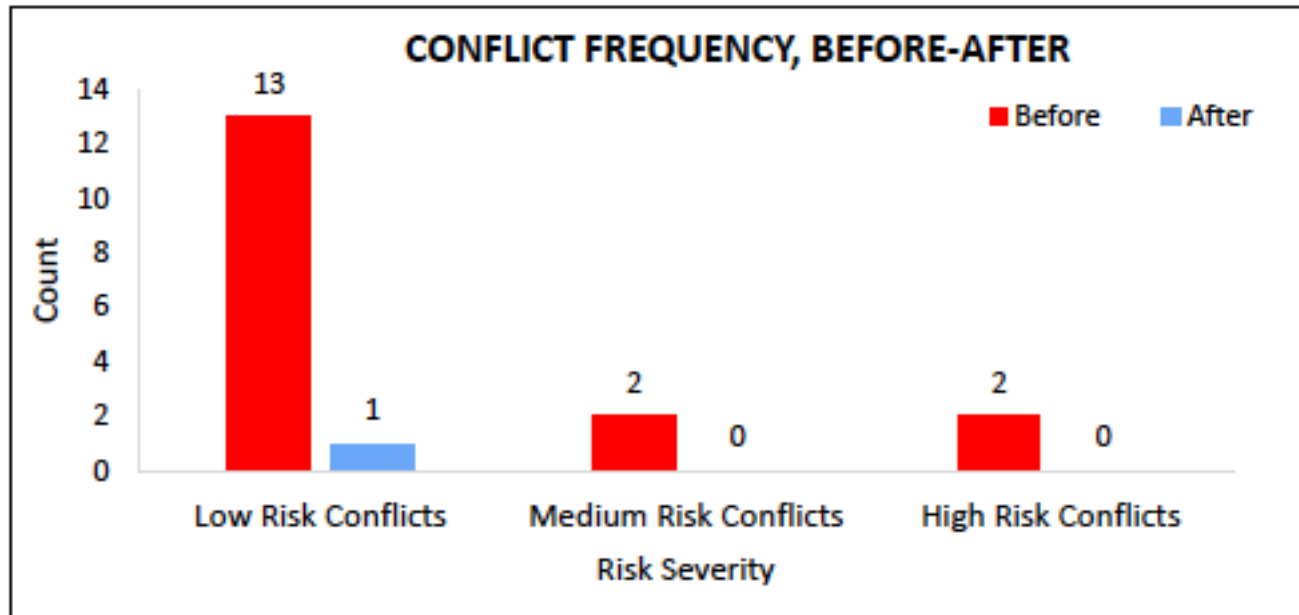
Methodology

- 3 days of video for before study and 3 days for after study
- Video data were recorded on weekdays from 7am to 7pm
- Total of 144 hours for 2 intersections

Davenport / Christie		Yorkwoods / Driftwood	
Before	After	Before	After
August 2 nd , 2016	November 8 th , 2016	September 13 th , 2016	May 9 th , 2017
August 3 rd , 2016	November 9 th , 2016	September 14 th , 2016	May 10 th , 2017
August 4 th , 2016	November 10 th , 2016	September 15 th , 2016	May 11 th , 2017

Results - Conflict Rates

Yorkwoods / Driftwood



- Low Risk Conflict Rate was reduced by 90%
- Medium Risk Conflict Rate was reduced by 100%
- High Risk Conflict Rate was reduced by 100%

Extracted from a CARSP 2017 presentation by Sohail Zangenehpour

So, should the City of Toronto continue to invest in curb radius reduction?

-- *Questions to ask*

- Was evaluation sample large enough?
- Were results statistically significant?
- Would use of a comparison group change the results?
- Would reduction in conflicts translate into reduction in pedestrian crashes? How much?

Food for thought in closing

- So, can we/should we better foster rigorous science and credible evidence in vision zero planning?
- If so, what will it take?