Variability in CMFs

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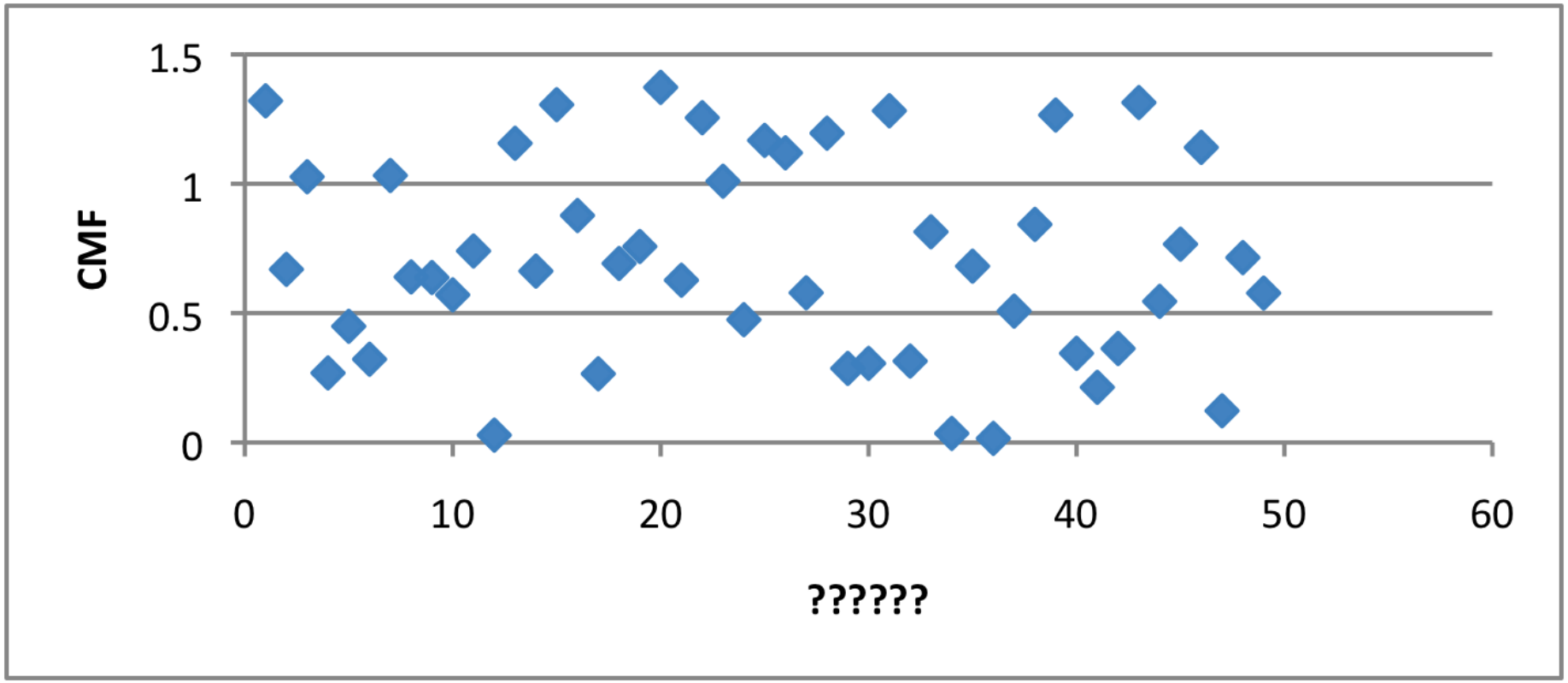


Who Works at a Workshop?

- A workshop is … an educational seminar or series of meetings emphasizing interaction and exchange of information among a usually small number of participants.

.. The American Heritage Dictionary of the English Language

TOPICS (Focus is on before-after studies)

a. Theoretical and Practical Issues in CMF development

   - Why different results can be obtained in different studies even with the best methods.

b. Examples of variability in the recent CMF development.

c. Accounting for variability in application

Theoretical and Practical Issues in CMF development from EB before-after studies

-- Accounting for regression to the mean (RTM)

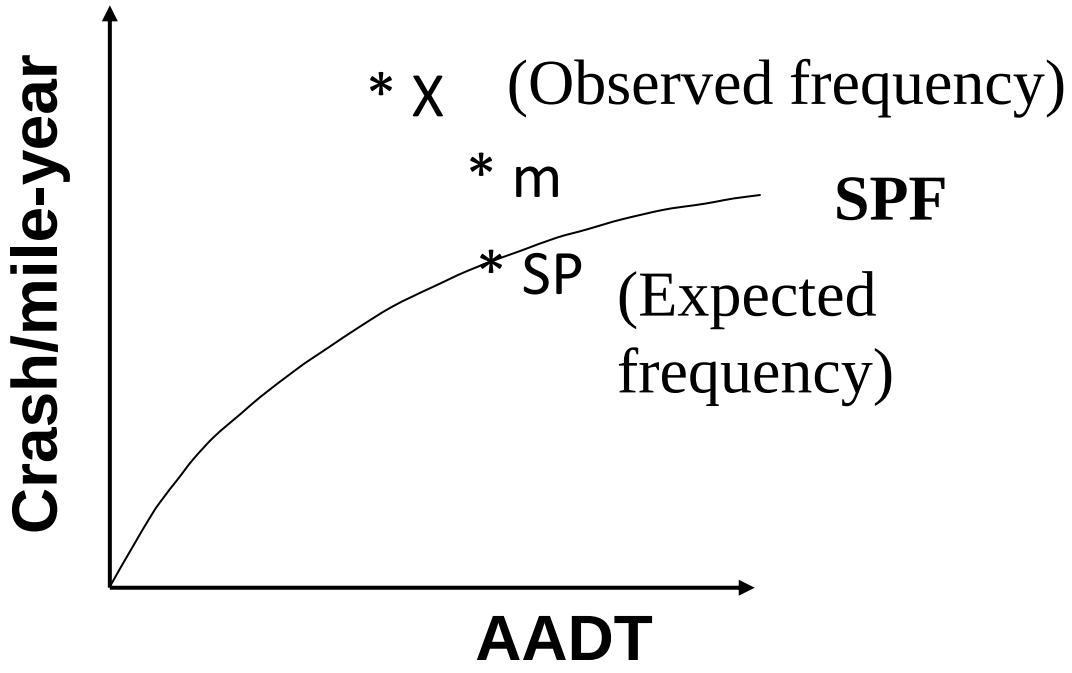
– Accounting for traffic volume changes

– Accounting for non-treatment effects

– Accounting for behavioural adaptation

Critical Elements of the Empirical Bayes Method

- Use safety performance functions to estimate expected (long term) accident frequency, *m*.
  - *m* is a weighted average of the safety performance function estimate (SP) and the observed accident frequency (*X*) of a site
  - Estimating SP is critical, especially if traffic volume or SPF changes or is sensitive to the choice of reference group used to estimate SPF
  - SPF should be used to account for non-treatment effects – HOW?



Discussion Points

- How important is the SPF in EB evaluations?
  - For RTM correction?
  - For accounting for AADT changes
  - For accounting for time trends
- How many EB studies use SPFs for all 3 purposes?
- What to do if SPFs are weak?

SIMPLE vs COMPLEX SPFs FOR EB STUDIES

(*CMF depends on the Safety Performance Function used in EB analysis)*

- Simple SPFs
  - Typically have AADT as the only independent variable
    - Crashes/year = α $(AADT)^{\beta}$
  - Typically are estimated for different entity types and environments
    - 4 leg vs 3 leg
    - Urban vs rural
    - 2-lane, multilane, freeway
  - Typically are estimated with annual multipliers

- Complex SPFs ….

COMPLEX SPF

- Crashes that would have occurred without treatment

$$(\pi) = \alpha\,(Volume)^{b}\,(Speed)^{c}\,(Yellow)^{d}\,(Trucks)^{e}$$
$$(Through\ lanes)^{f}\,(Left\ lanes)^{g}$$

- where α= calibration parameter associated with a specific year
- *b, c, d, e, f, g* = calibration parameter associated with a geometric or operational variable
- *Volume* = ADT for the major road or the major plus minor road
- *Speed* = speed limit on major road in miles per hour
- *Yellow* = difference between yellow interval recommended by ITE and actual yellow
- interval
- *Trucks* = percentage of trucks in major road traffic stream
- *Through lanes* = number of lanes on major road approach
- *Left lanes* = total number of left-turn lanes from both major approaches.

CMF estimation must consider changes in AADT – Case of roundabouts

Accident type	Expected after without treatment		Recorded After	*Apparent* reduction	*Actual* reduction
	Naïve	EB			
All (with AADT change)	553	455	275	278 (50%)	180 (40%)
All (without AADT change)	436	354	275	161 (37%)	79 (22%)
Injury (with AADT change)	84	58	12	72 (86%)	46 (79%)
Injury (without AADT change)	68	48	12	56 (82%)	36 (75%)

Accounting for behavioral adaptation

- Problem of spillover
  - Effects underestimated if spillover sites used for comparison/reference group
  - E.g., red light cameras; speed control treatments; raised pavement markers

- Problem of migration
  - Effects underestimated if migration sites used for comparison/reference group
  - e.g., Speed control treatments; all-way stops

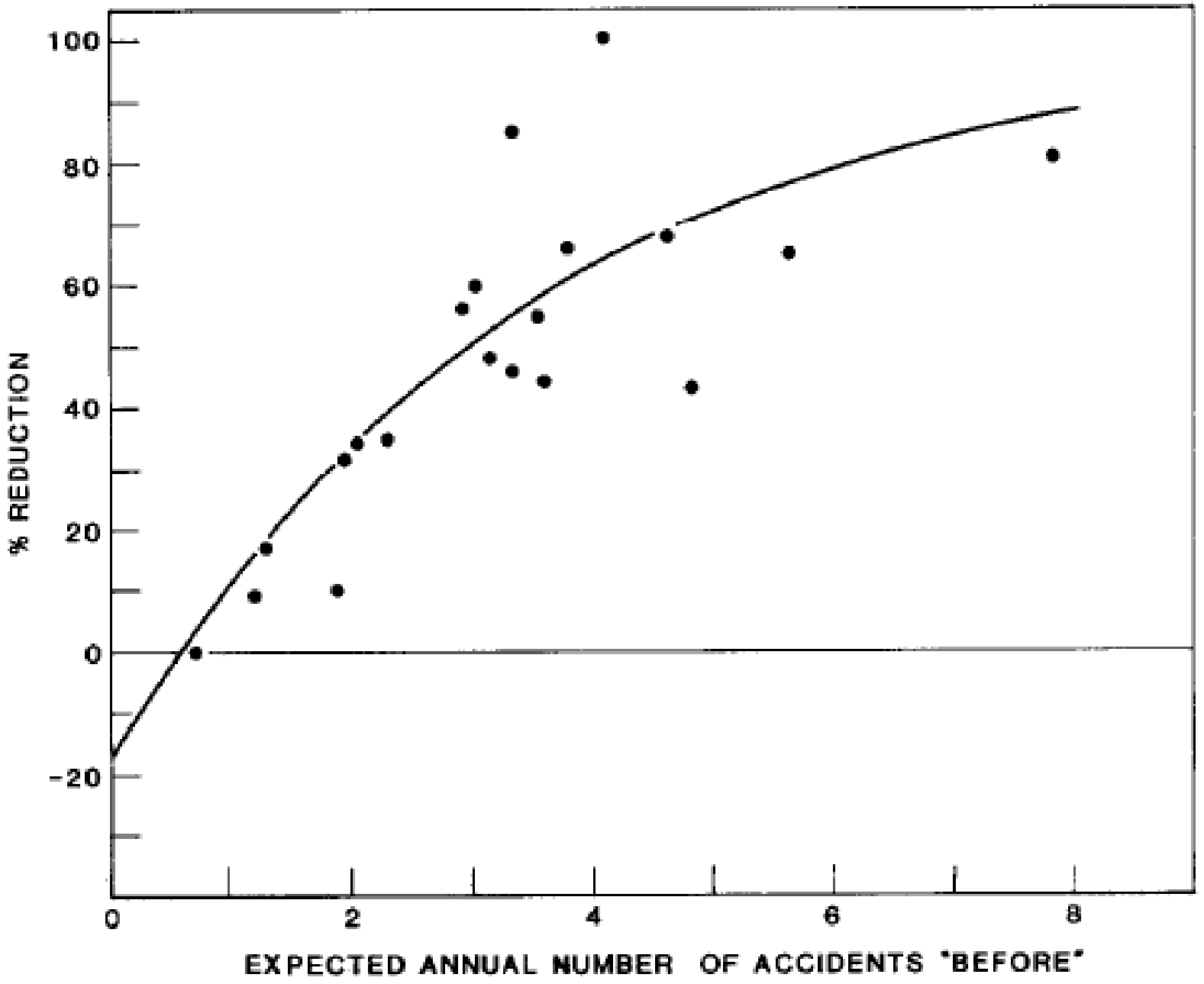
Discussion Points

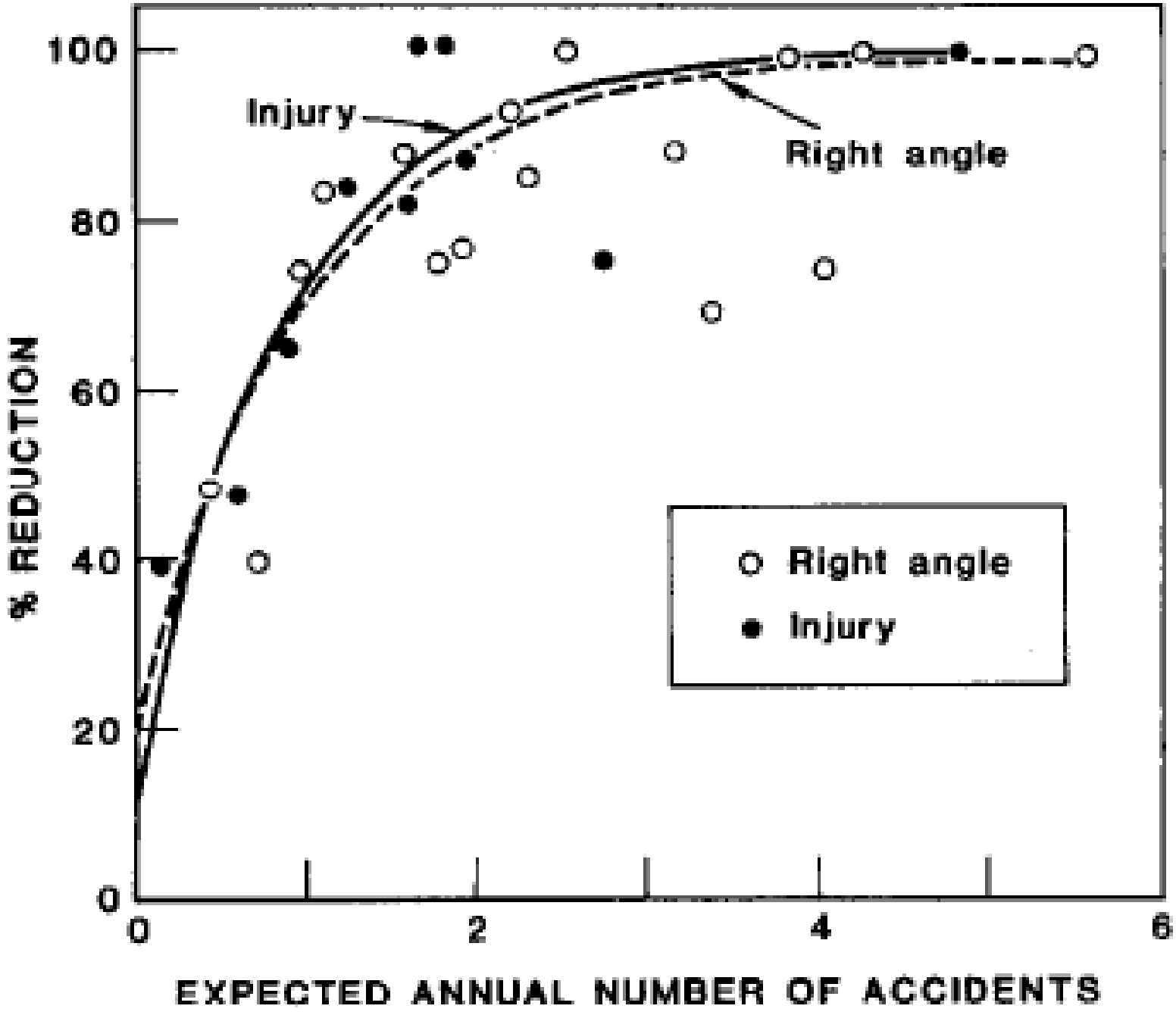
- What other treatments may be affected by spillover?
- What other treatments may be affected by migration?
- What existing CMFs may be affected?

Examples of Variability in Recent CMF Development

- Modifying the signal change interval
- Converting signals to roundabouts
- Offset lefts
- Two-way to all-way stop conversion
- Lane width/shoulder width
- Raised pavement markers

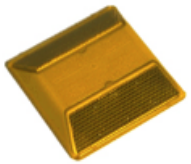
Conversion of intersections to all-way stop




100
80
60
40
20
0
% REDUCTION
Injury
Right angle
Right angle
Injury
0
2
4
6
EXPECTED ANNUAL NUMBER OF ACCIDENTS

Safety Evaluation of Raised Pavement Markers

- *Previous comparison group studies had found an increase in crashes*
  - *Used daytime crashes for comparison*



- % Reduction in crashes (EB Study)

	Night	Wet
New Jersey Non-Selective 174 miles	0.9	3.2
New York Selective 82 miles	12.7	20.2

Pavement markers: disaggregate effects (% reduction)

- Two Lane roads

	Flatter curves	**Sharper curves**
ADT <5000	-16%	-43%
5001-15000	No change	-26%
15001-20000	24%	-3%

- Freeways

	All sites
ADT <20,000	-13%
20001 to 60,000	6%
>60,000	33%

Improve skid resistance at targeted locations

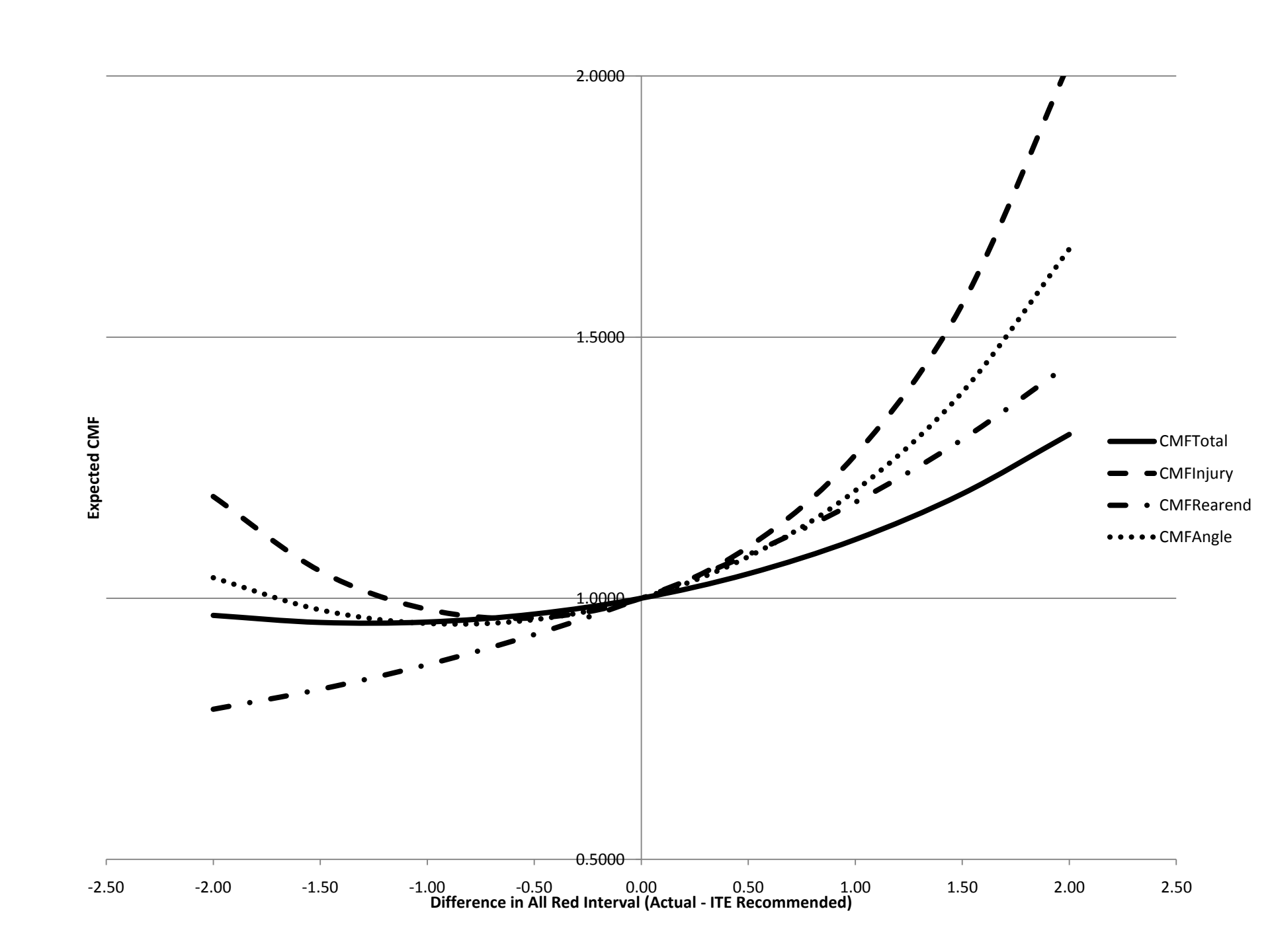
- Previous research suggested that crashes could increase if drivers increase speed

- % reduction in crashes at locations with high skid numbers and wet weather accident frequency – applicability of CMF

Location Type	All Crashes	Wet-road	Rear-end Wet-road
Segments	23%	56%	43%
Intersection approaches	20%	57%	68%

Increase Signal Change Interval

Group	CMF for Total Crashes (SE)	CMF for Injury Crashes (SE)
Increase Change Interval (< ITE)	0.728 (0.077)	0.662 (0.099)
Increase Change Interval (> ITE)	0.922 (0.089)	0.937 (0.114)


2.0000
1.5000
1.0000
0.5000
Expected CMF
-2.50
-2.00
-1.50
-1.00
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
Difference in All Red Interval (Actual - ITE Recommended)
CMFTotal
CMFInjury
CMFRearend
CMFAngle

HSM CMFs for lane and shoulder width

Figure 2.2.4.6 Collision Modification Factor for Various Shoulder Widths versus Annual Average Daily Traffic [10]

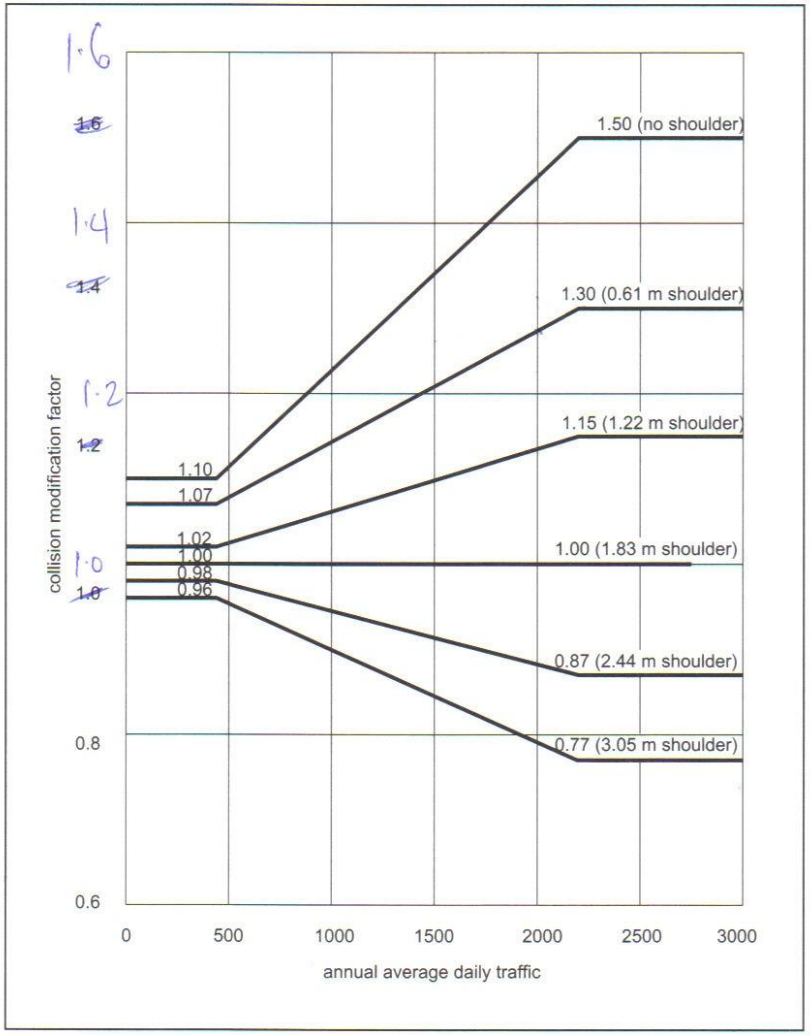
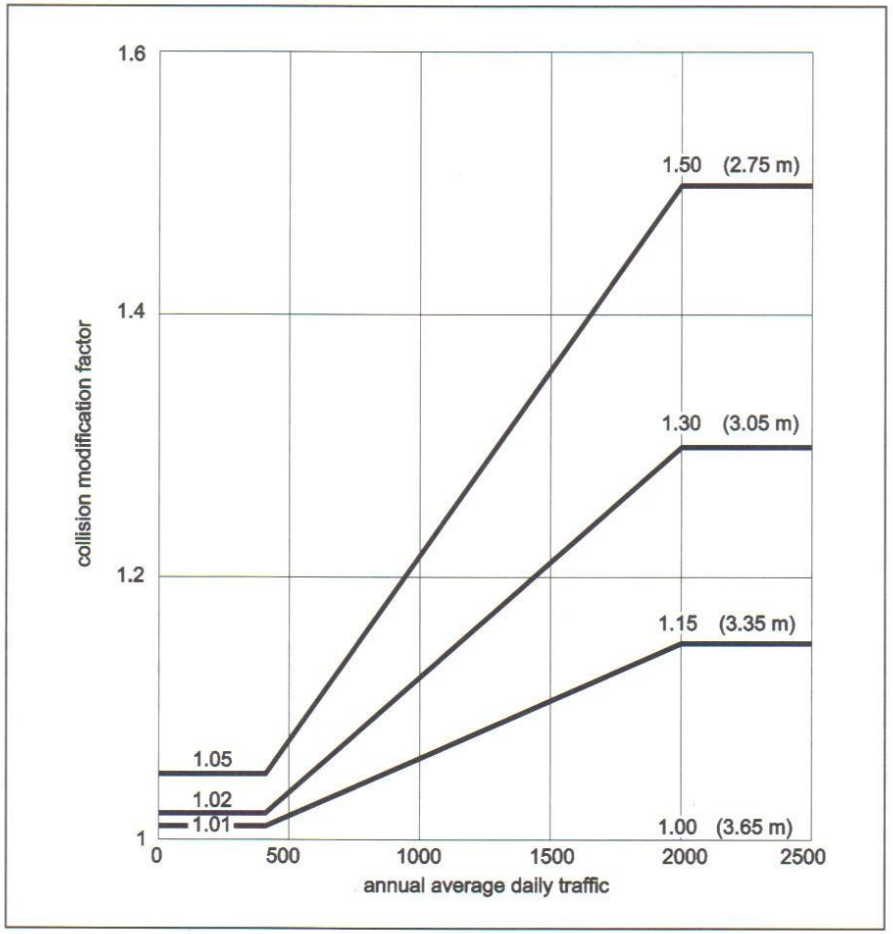


Figure 2.2.2.1 Collision Modification Factor for Various Lane Widths and Traffic Levels versus Annual Average Daily Traffic[3]



CMFs for Lane-Shoulder Combinations on 2-lane roads

Pavement Width (ft)	10-ft Lanes	11-ft Lanes	12-ft Lanes
26	1.00	0.99	0.96
28	1.00	0.99	0.97
30	1.00	0.99	0.97
32	1.00	0.95	0.94
34	1.00	0.78	0.81
36	1.00	0.95	0.95

- CMFs for 4 ft shoulders are shaded
- Interaction between lane and shoulder width is important

% reduction in crashes from offset improvements for left-turn lanes

	Total	Injury	Left-Turn Opposing	Rear-End
Nebraska (Paint)	-0.5	**6.2**	**-45.0**	**-6.9**
Wisconsin Major construction)	**33.8**	**35.6**	**38.0**	**31.7**

Note: A negative sign indicates an increase in crashes.

- If > 9 crashes/year Nebraska installations have 8% reduction and are highly cost-effective!!
- CMF depends on intensity of treatment and on whether there is a crash problem

Economic Analysis (Nebraska)

- **COST**
  - $200 per approach (8-10 year service life);
- **BENEFIT:COST**
  - Reduction of 0.64 crashes/year for 2:1 benefit cost ratio
  - Achievable if 9 or more crashes expected per year, for which the crash reduction factor is at least 8%

Accounting for Variation in CMFs

- Major Design Change
- Minor improvements

Accounting for CMF Variation in Estimating Safety Consequence of Major Design Changes

- E.g.
  - Roundabouts
    - New FHWA Roundabout Guide
    - Recent MTO/Transport Canada Research
  - Traffic Signals
    - NCHRP491
  - Adding lanes to segment
  - Add lanes to intersection

- Method:
  - Estimate (I) expected crashes without change (Use EB Method)
  - Estimate (II) expected crashes with change
    - Use a Safety Performance Function for facility with the change
  - Compare (i) and (II)

Estimating Safety Without Major Design change

- Account for variation in applications – need to always do disaggregate analysis in EB studies
  - Research needs are different from agency needs

- Use CMFunctions

  Recent example: Conversion of signals to roundabouts:

  CMFunction = (4E-05)*AADT + 0.303

DiscussionPoints

- What are the implications for international transferability of CMFs?

- What messages can we take to the afternoon session

Summary ➔Segue

- CMF Variability impacts transferability
- CMF variability can be due to application circumstance
  - Level/intensity of application
  - Level of existing safety problem
  - Traffic, geometry, other
- CMF variability can be due to methodological issues – even if EB is used
  - Quality of reference group used to develop SPFs
  - Quality of SPF development
  - How AADT and other non-treatment effects are accounted for