



Estimating Combined Effect of Multiple Treatments

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Outline

- Problem at Hand
- Practical Guidance
- Example Application
- Future Research



PROBLEM AT HAND

How to estimate combined effect?

- 3000+ CMFs in CMF Clearinghouse
 - Most related to single treatment

CMF
CRASH MODIFICATION FACTORS CLEARINGHOUSE

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**Research Meets Practice:
Identifying and Applying CMFs**

Join us for a webinar on Monday, Dec. 16 to learn about Clearinghouse updates and CMF application. [Click here for more!](#)

1 2 3 4

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. Using this site, you can search to find CMFs or [submit](#) your own CMFs to be included in the clearinghouse.

Recently Added CMFs

Improve pavement friction (increase skid resistance)	Install raised median	Convert minor-road stop control to all-way stop control
CMF: 0.866	CMF: 0.61	CMF: 0.319
CRF: 13.4	CRF: 39	CRF: 68.1
Crash type: Rear end	Crash type: All	Crash type: All
Crash severity: All	Crash severity: All	Crash severity: All


How to estimate combined effect?

- Develop CMFs for combinations of treatments
 - Expensive and not feasible for all combinations



How to estimate combined effect?

- Develop guidance for applying multiple CMFs
 - Current research is limited or in-progress

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About TRB Annual Meeting Calendar Committees & Panels Programs Projects	
NCHRP 17-63 [Active]	
Guidance for the Development and Application of Crash Modification Factors	
Staff Responsibility:	Mark S. Bush
Research Agency:	University of North Carolina
Principal Investigator:	Daniel L. Carter
Effective Date:	8/1/2013
Completion Date:	2/1/2016

PRACTICAL “INTERIM” GUIDANCE

Be Mindful of Issues

- Added Benefit versus Additive Effects
- Assumption of Independence
- Applicability of CMFs

Be Mindful of Issues

- Added Benefit versus Additive Effects
 - Additional treatment may have added benefit, but effects of treatments are not additive

$$20\% + 20\% \neq 40\%$$

Be Mindful of Issues



- Assumption of Independence
 - Safety effects of treatments may overlap





Be Mindful of Issues

- Applicability of CMFs
 - CMFs may apply to different scenarios
 - Roadway conditions
 - Crash types
 - Crash severities

Install Traffic Signal at Unsignalized Intersection

CMF	Crash Type	Crash Severity	Area Type
0.85	All	All	Rural
0.83	All	All	Urban
1.15	All	Property damage only (PDO)	All
0.62	Angle	All	All
0.62	All	Fatal	All
1.48	Rear end	All	All

Opportunities to Overcome Challenges

Added Benefit versus Additive Effects

- Use multiplicative form when necessary
 - $CMF_{\text{Combined}} = CMF_1 * CMF_2$

20% + 20% ≠ 40%

0.8 * 0.8 = 0.64 (36% reduction)

Opportunities to Overcome Challenges

Assumption of Independence

- Is assumption of independence valid?
 - Use engineering judgment

Treatment #1



- Head On
- Rear End
- Right Angle
- Left Turn
- Right Turn
- Run Off Road
- Pedestrian
- Bicycle

Treatment #2



- Head On
- Rear End
- Right Angle
- Left Turn
- Right Turn
- Run Off Road
- Pedestrian
- Bicycle

Opportunities to Overcome Challenges

Assumption of Independence

- Temper effects of additional treatment(s) if necessary

$$CMF_{\text{Combined}} = CMF_1 * CMF_{2,\text{Reduced}}$$

Assumes both CMFs
apply to the same crash
type and severity

$$CMF_{2,\text{Reduced}} = CMF_2 + (1-CMF_2)/2$$

Be consistent!

Opportunities to Overcome Challenges

Applicability of CMFs

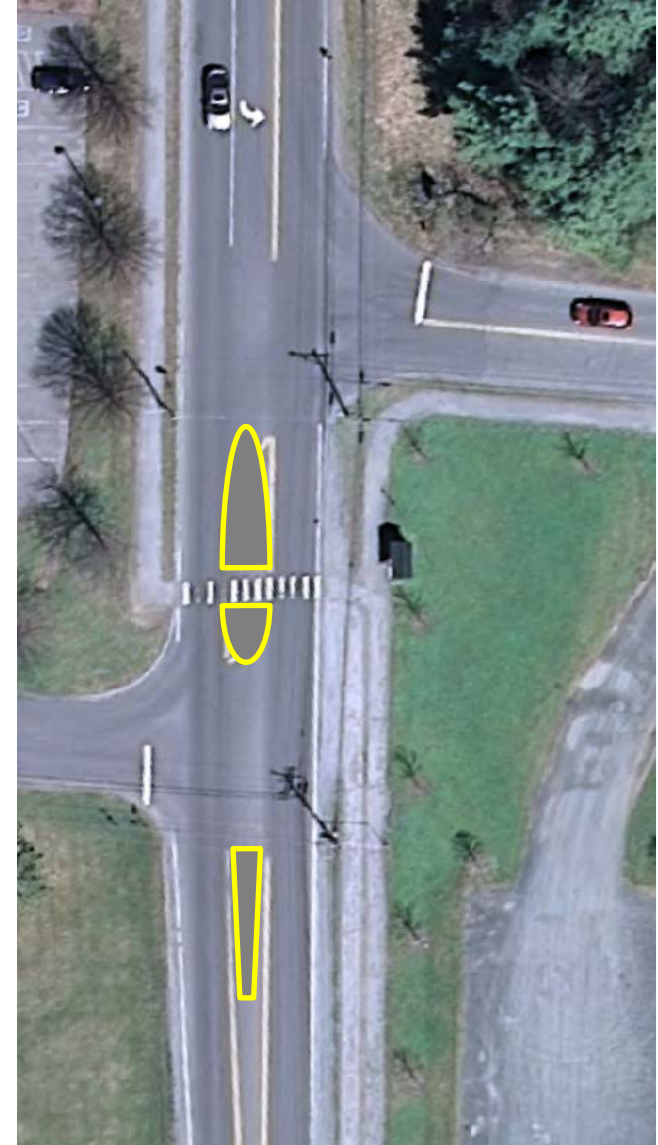
- Only multiply CMFs if they apply to the same crash type and severity
- Estimate impacts independently and then combine results



EXAMPLE APPLICATION

What is the impact?

- Site Characteristics
 - 2-lane, urban minor arterial
 - Two-way stop-control
 - Pedestrian crossing
 - Bus stops
- Safety Issues
 - Pedestrian exposure
 - Vehicle speed
 - Driver awareness
 - Driver behavior



What is the impact?

Strategies	CMF	Target Crashes	Total Crashes (5 years)	Expected Crashes WITHOUT	Expected Crashes WITH	Crashes Reduced
Enhance awareness of pedestrians by installing a pedestrian refuge island.	0.54	Pedestrian	1	0.20	0.11	0.09
Install raised median island to discourage drivers from using painted median and reduce speeds through the intersection (i.e., traffic calming).	0.68	All crashes	11 includes pedestrian crash	2.2	1.50	0.7
Install raised median island to discourage drivers from using painted median and reduce speeds through the intersection (i.e., traffic calming).	0.68	All crashes	10 Excludes pedestrian crash	2.0	1.36	0.64



What is the impact?

Strategies	Crashes Reduced	Average Crash Cost	Annual Benefit	Service Life	Present Value
Enhance awareness of pedestrians by installing a pedestrian refuge island.	0.09	\$158,866 (pedestrian)	\$14,298	10	\$110,405
Install raised median island to discourage drivers from using painted median and reduce speeds through the intersection (i.e., traffic calming).	0.7	\$32,236 (total)	\$20,631	10	\$159,307

\$269,712



FUTURE RESEARCH

Research Needs

- Guidance on “adjustment” for overlapping effects
- Guidance on estimating standard error for combined effect

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Thank You!

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Questions?

