Planning Level CMFs

Data Driven Safety Analysis

presented to
Annual Statewide Traffic Engineers Meeting

presented by
Adriane McRae, PE
DOTD - Highway Safety

July 2016
CM-WHAT?!
Multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site.

<table>
<thead>
<tr>
<th>HSM Part</th>
<th>Supporting Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART B: Roadway Safety Management Process</td>
<td>Safety Analyst (AASHTO Ware)</td>
</tr>
<tr>
<td>PART C: Predictive Method</td>
<td>IHSDM &amp; ISATe</td>
</tr>
<tr>
<td></td>
<td>HSM &amp; ISATe spreadsheets</td>
</tr>
<tr>
<td>*PART D: Crash Modification Factors (NOTE: will be eliminated with HSM 2nd Edition)</td>
<td>FHWA CMF Clearinghouse</td>
</tr>
</tbody>
</table>
www.CMFclearinghouse.org

HSM Stamp of Approval – coming soon!
What is a CMF?

CMF = \frac{\text{Expected crashes with treatment}}{\text{Expected crashes without treatment}}

Where,

- CMF > 1 - expected to increase crashes
- CMF < 1 - expected to decrease crashes
- CMF = 1 - no effect on crash frequency

- **Low** CMF values mean a **High** Reduction in crashes
- CMFs are developed using HSM methods on real projects
- Anyone can submit an evaluation study for a new CMF
What is a CMF?

EXAMPLE

» An intersection is experiencing 100 angle crashes and 500 rear end crashes per year.

» If you apply a countermeasure that has a CMF of 0.80 for angle crashes, then you can expect to see 80 angle crashes per year following implementation.

\[
100 \text{ angle crashes } \times 0.80 \text{ CMF } = 80 \text{ angle crashes}
\]

» If the same countermeasure also has a CMF of 1.10 for rear-end crashes, then you would expect to also see 550 rear end crashes per year following implementation.

\[
500 \text{ rear-end crashes } \times 1.10 \text{ CMF } = 550 \text{ rear end crashes}
\]

CMFs are the reverse of Crash Reduction Factor

\[
\text{CMF } = 0.8 \text{ then CRF } = 0.2 \text{ for same countermeasure}
\]

CMFs developed using HSM methods on real project
Critical components of a CMF

- Evaluation Study Quality ★★★★★
- Standard Error
- Crash Type
- Crash Severity
- Area Type (rural, urban, suburban, # of lanes, etc.)
- Roadway characteristics (arterial, freeway, etc.)
- AADT
- Best Available!
Quality of CMFs

**Evaluation Study**

<table>
<thead>
<tr>
<th>Score</th>
<th>Star Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 (maximum)</td>
<td>⭐⭐⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>11-13</td>
<td>⭐⭐⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>7-10</td>
<td>⭐⭐⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>3-6</td>
<td>⭐⭐⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>1-2</td>
<td>⭐⭐⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
</tr>
</tbody>
</table>

HIGHEST QUALITY
## Quality of CMFs

### Evaluation Study

<table>
<thead>
<tr>
<th>Relative Rating</th>
<th>Excellent</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Design</td>
<td>Statistically rigorous study design with reference group or randomized experiment and control</td>
<td>Cross sectional study or other coefficient based analysis</td>
<td>Simple before/after study</td>
</tr>
<tr>
<td>Sample Size</td>
<td>Large sample, multiple years, diversity of sites</td>
<td>Moderate sample size, limited years, and limited diversity of sites</td>
<td>Limited homogeneous sample</td>
</tr>
<tr>
<td>Standard Error (SE)</td>
<td>Small compared to CMF</td>
<td>Relatively large SE, but confidence interval does not include zero</td>
<td>Large SE and confidence interval includes zero</td>
</tr>
<tr>
<td>Potential Bias</td>
<td>Controls for all sources of known potential bias</td>
<td>Controls for some sources of potential bias</td>
<td>No consideration of potential bias</td>
</tr>
<tr>
<td>Data Source</td>
<td>Diversity in states representing different geographies</td>
<td>Limited to one state, but diversity in geography within state (e.g., California)</td>
<td>Limited to one jurisdiction in one state</td>
</tr>
</tbody>
</table>
Quality of CMFs

CMF / CRF Details

CMF ID: 4194

Conversion of signalized intersection into single- or multi-lane roundabout

Description:

Prior Condition: Signalized intersection

Category: Intersection geometry

Study: Safety Effectiveness of Converting Signalized Intersections to Roundabouts, Gross et al. 2008

Score Details

Study Design Score: Excellent
Sample Size Score: Excellent
Standard Error Score: Excellent
Potential Bias Score: Fair
Data Source Score: Excellent

Star Quality Rating: ★★★☆☆ [View score details]

Crash Modification Factor (CMF)

Value: 0.81

Adjusted Standard Error:

Unadjusted Standard Error: 0.06

Crash Reduction Factor (CRF)

Value: 19 (This value indicates a decrease in crashes)
Add 3 inch yellow retro-reflective sheeting to signal backplates

Install dynamic signal warning flashers

Install a traffic signal

Remove unwarranted signal
Guidance for Using Crash Modification Factors (CMF)

What is a CMF?
A Crash Modification Factor (CMF) is a value that quantifies the expected change in crash frequency at a site as a result of implementing a specific countermeasure or treatment.

\[
\text{CMF} = \frac{\text{Expected crashes with treatment}}{\text{Expected crashes without treatment}}
\]

Where,
- CMF > 1 - expected to increase crashes
- CMF = 1 - expected to decrease crashes
- CMF = 1 - no effect on crash frequency

The following table illustrates a CMF (HSM Table 13-31) for increasing the distance to roadside features for rural two-lane roads and freeways:

<table>
<thead>
<tr>
<th>CMF Resources</th>
<th>Setting (Road Type)</th>
<th>Traffic Volume</th>
<th>Crash Type (Severity)</th>
<th>CMF</th>
<th>Standard Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased distance to roadside features from 16.7 feet to 20.7 feet</td>
<td>Rural two-lane roads and freeways</td>
<td>Unspecified</td>
<td>0.78</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Increased distance to roadside features from 3.3 feet to 16.7 feet</td>
<td>Rural two-lane roads and freeways</td>
<td>All types (All severities)</td>
<td>0.50</td>
<td>0.00</td>
</tr>
</tbody>
</table>

CMFs can be found in several different resources, but two of the main resources include the FHWA CMF Clearinghouse (www.cfmclearinghouse.com) and the AASHTO Highway Safety Manual (HSM). While the HSM provides the best available research-based CMFs, the CMF Clearinghouse is a comprehensive database of available CMFs, including all of the CMFs listed in the HSM. The CMF Clearinghouse is updated regularly, with new CMFs from researchers and state agencies.

Key Considerations in Selecting CMFs
When selecting CMFs, it is imperative to consider the evaluation study used to develop the CMF, the quality of the CMF, and the applicability to the site of interest.

Evaluation Study Design
The evaluation study design (i.e., how the study was conducted) is a critical component of the CMF and should be considered when evaluating CMFs. Depending on the evaluation study design used to develop a CMF, the CMF could over- or underestimate the effectiveness of a safety treatment. When a study period has a comparatively high crash frequency, a CMF derived from such a study could overestimate or underestimate the effectiveness of a countermeasure. On the other hand, CMFs derived from studies with a lower crash frequency may not adequately account for the effects of a safety treatment.

Most agencies currently use the simple (or serial) before-After study to estimate changes in crash frequency due to a specific change (safety treatment) at a site. However, this method does not account for regression to the mean or other changes (e.g., traffic volumes, weather, or driver behavior) that may have impacted the site. The simple regression method relies on statistical methods that address these issues. However, the methods are observational and do not account for the effects of multiple safety treatments at a site.

Highway Safety Manual Project Applications

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Highway Safety Manual Project Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicator Method</td>
<td>Part C - Chapters 80-82p</td>
</tr>
<tr>
<td>Crash Modification Factors</td>
<td>Part D - Chapters 83-87p</td>
</tr>
<tr>
<td>Benefit Cost Analysis</td>
<td>Part B - Chapters 7 &amp; 8</td>
</tr>
</tbody>
</table>

The change in expected crash frequency or severity (safety impact) of various alternatives determined using the predicator method or CMFs can be summarized into monetary costs and benefits and incorporated into a benefit-cost analysis. Chapter 5 of the HSM outlines the steps for doing this. Chapter 6 then provides information to help identify potential contributing factors in the crashes and outlines steps for selecting countermeasures.
WHY USE CMFS?
Louisiana Statistics

Fatalities per 100 MVMT (2014)*
- Louisiana = 1.53
- US = 1.08
- Best State = 0.57

Fatalities per 100,000 Pop (2014)*
- Louisiana = 15.85
- US = 10.25
- Best State = 3.49

*Per National Highway Traffic Safety Admin. (NHTSA)
Purpose of CMFs

- Select potential countermeasures
- Obtain the expected effectiveness of countermeasures (HSM Part D)
- Compare alternative treatments
- Assist with benefit cost analysis
Challenges with CMFs

- Many, many to choose from
- Consistency is difficult across large agency
- Studies include roadways with various features
- Various studies of similar countermeasures have various results
- Finding the “perfect” CMF takes time & expertise
Louisiana Specific - Planning Level CMFs

**PRIORITY CATEGORIES**

» Roadway Segments
» Intersections
» Non-Motorized Users

**POTENTIAL CATEGORIES FOR FUTURE**

» Bridges
» Interchanges
Louisiana Specific - Planning Level CMFs

- Roadway Segments
  - Rumble Strips/stripes
  - Safety edge
  - Enhanced Delineation of Horizontal Curves
  - High Friction Surface Treatment
  - Shoulder/Curve widening
  - Tree Removal
  - Fixed object removal
  - Guardrail
  - Cable Median Barrier
  - Access Management Improvements
  - Road diets
Louisiana Specific - Planning Level CMFs

Intersections

» Enhanced striping/signing
  – Backplates, signal head per lane

» Signal upgrades/modifications
  – Flashing yellow arrow

» New signal installation

» Modifications to stop control

» Add/New Turn lanes

» Improve skew angle

» Sight Distance improvements

» Lighting

Roundabouts

» Signal vs Stop controlled

» Single vs multi-lane

» Rural vs. urban/suburban

Super streets (J-turns)
Louisiana Specific - Planning Level CMFs

- Non-motorized users
  - Crosswalks
  - Pedestrian signals
  - Pedestrian hybrid beacons
  - Bike lanes
  - Shoulder widening
  - Sidewalks
For treatments with multiple CMF’s, countermeasures will be combined into broader CMF values.

The process of combining CMFs will result in a single CMF and standard error for treatments using the following process:

1. Determine estimate of CMF from literature/CMF clearinghouse.
2. Adjust for regression to the mean (RTM) and traffic volume bias.
3. Determine ideal standard error of safety effect.
4. Apply method correction factor to adjust for study characteristics such as the analytical method used.
5. Adjust ideal standard error for RTM and traffic volume bias.
6. Combine CMFs using weighted sums based on std. error.
<table>
<thead>
<tr>
<th>Countermeasure Name</th>
<th>Description</th>
<th>Crash Types</th>
<th>CMF</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1A- Centerline Rumble Strips</td>
<td>Installation of rumble strips along undivided road centerlines.</td>
<td>All</td>
<td>0.85</td>
<td>0.02</td>
</tr>
<tr>
<td>R1B- Edgeline Rumble Strips</td>
<td>Installation of rumble strips along the edge of roadways.</td>
<td>Fatal, Serious Injury, Minor Injury</td>
<td>0.68</td>
<td>0.19</td>
</tr>
<tr>
<td>R2A- Wide Edge Lines</td>
<td>Increase the width of the pavement edgeline markings.</td>
<td>All</td>
<td>0.87</td>
<td>0.05</td>
</tr>
<tr>
<td>R2B- Curve Chevron Signing</td>
<td>Installation new chevron signs on horizontal curves.</td>
<td>All</td>
<td>0.86</td>
<td>0.08</td>
</tr>
<tr>
<td>R2C- Pavement Markers</td>
<td>Install new permanent raised pavement markers along segments and curves.</td>
<td>All</td>
<td>1.10</td>
<td>0.03</td>
</tr>
<tr>
<td>R3- HFST</td>
<td>Installation of a high friction surface treatment pavement course at intersections, along straight roadway segments, and along curves.</td>
<td>All</td>
<td>0.25</td>
<td>0.02</td>
</tr>
<tr>
<td>R4- Curve Widening</td>
<td>Increase horizontal curvature by one degree.</td>
<td>All</td>
<td>1.04</td>
<td>0.01</td>
</tr>
<tr>
<td>R6- Fixed Object Protection</td>
<td>Remove or relocate fixed object outside of clear zone.</td>
<td>All</td>
<td>0.62</td>
<td>0.16</td>
</tr>
<tr>
<td>R7- Guardrail Installation</td>
<td>Install new guardrail.</td>
<td>All</td>
<td>0.89</td>
<td>0.02</td>
</tr>
<tr>
<td>R8- Cable Median Barrier</td>
<td>Installation of new cable median barrier.</td>
<td>All</td>
<td>0.59</td>
<td>0.09</td>
</tr>
<tr>
<td>R9- Access Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R10- Road Diet</td>
<td>Reduce the number of travel lanes in a variety of conditions.</td>
<td>All</td>
<td>0.78</td>
<td>0.01</td>
</tr>
<tr>
<td>R11- Safety Edge</td>
<td>Installation of new safety edge along existing pavement edge.</td>
<td>All</td>
<td>0.93</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Next Steps

- Finalize list of countermeasures & target crashes
- Prioritize list & focus on highest priority
  - Roadway Segments – Roadway Departure
  - Intersections – High severity crashes
  - Non-Motorized Users
- Compile category values from CMF clearinghouse
- Combine CMFs where necessary
- Present preliminary list - Fall 2016
- Publish final list
- Periodically update
QUESTIONS?