Overview of CMF Guidebook

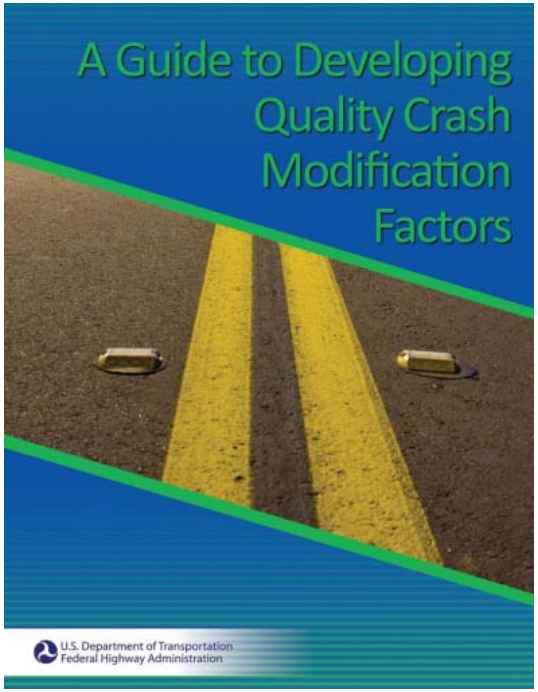
A Guide for Developing Quality CMFs

TRB International Workshop on CMFs

January 23, 2011

Objective

- Provide overview of various methods for developing CMFs
  - General applicability
  - Strengths
  - Weaknesses
- Review flow chart to select appropriate method

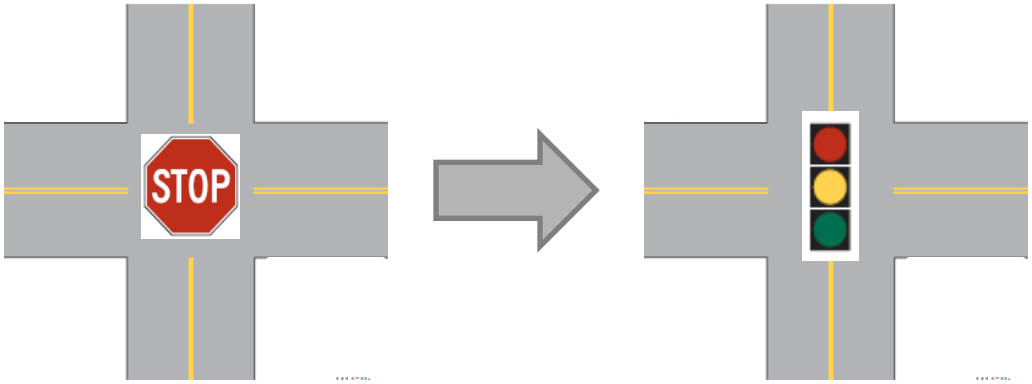


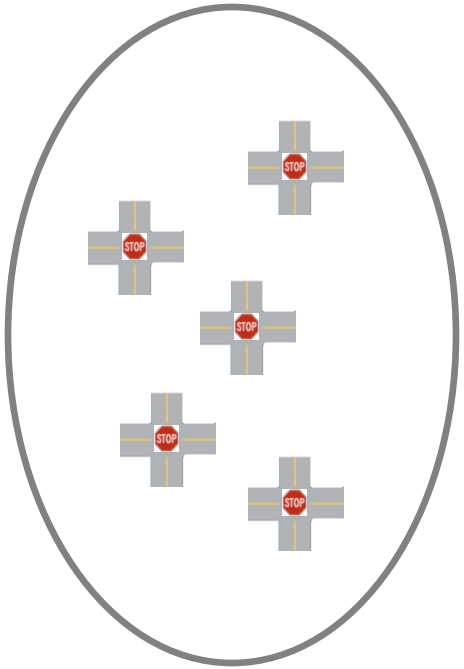
Methods

- Before-After
  - Comparison Group
  - Empirical Bayes
  - Full Bayes
- Cross-Sectional
- Case-Control
- Cohort
- Alternative Approaches

Before-After – Comparison Group

- General applicability
  - Treatment is similar among treatment sites
  - Before and after data are available for treated and untreated sites
  - Untreated sites used to account for changes other than the treatment



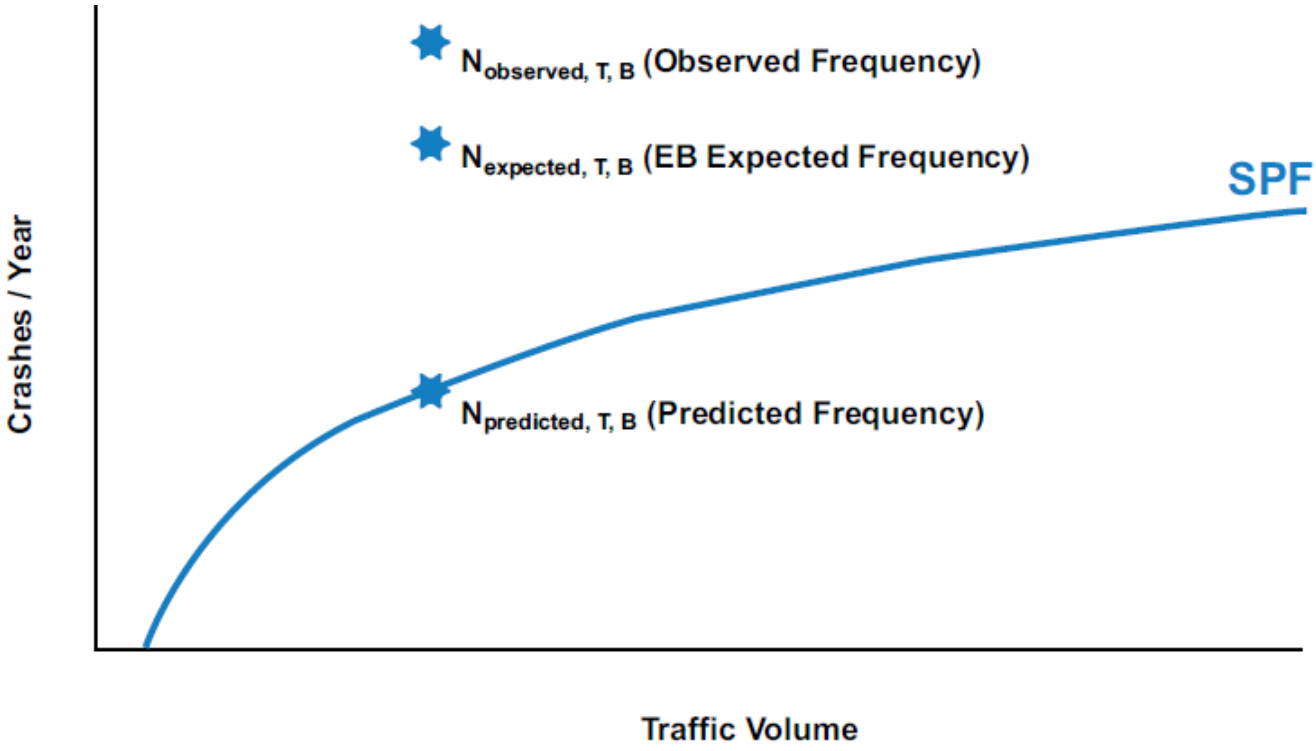


Before-After – Comparison Group

- Strengths
  - Simple
  - Accounts for time trends and traffic volume changes
- Weaknesses
  - Difficult to account for RTM
  - Difficult to confirm RTM is not an issue

Before-After – Empirical Bayes

- General applicability
  - Treatment is similar among treatment sites
  - Before and after data are available for treated and untreated reference group



Before-After – Empirical Bayes

- Strengths
  - Properly accounts for changes in crashes due to:
    - Regression-to-the-mean
    - Traffic volume and time trends
- Weaknesses
  - Relatively complex
  - May require separate comparison group if treatment impacts reference group
  - Cannot consider prior knowledge
  - Cannot account for spatial correlation
  - Cannot specify complex model forms

Before-After – Full Bayes

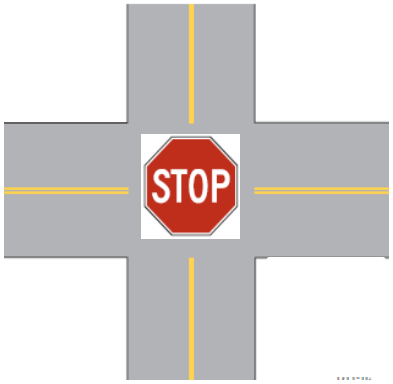
- General applicability
  - Useful for before-after or cross-sectional studies
- Before-After
  - Distribution is used instead of point estimate
    - Estimate expected crash frequency, variance, and variance of estimated CMF
- Cross-Sectional
  - Relate geometric and operational characteristics with expected crash experience

Before-After – Full Bayes

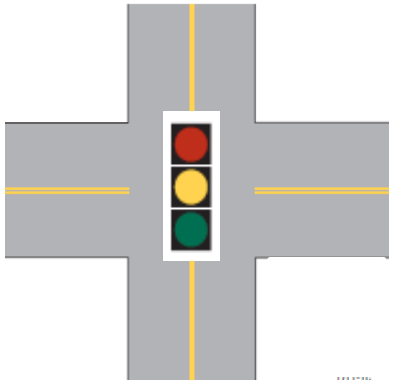
- Strengths
  - More flexible modeling tool
    - Complex model forms
    - Considers spatial correlation
    - Incorporate prior knowledge
    - Estimation of valid models with small sample size
- Weaknesses
  - Requires a high degree of statistical training

Cross-Sectional

- General applicability
  - Compare with and without rather than before-after
  - Useful when limited before-after data
  - Sites that are similar except for treatment of interest



$$CMF = \frac{2.9}{3.4} = 0.85$$



3.4 crashes/year

2.9 crashes/year

Cross-Sectional

- Strengths
  - Possible to develop CMFunctions
  - Allows estimation of CMFs when conversions are rare
- Weaknesses
  - Difference in crashes can be due to other factors (both known and unknown)
  - Difficult to account for unknown, or known but unmeasured, factors
  - Inappropriate functional form, omitted variable bias, or correlation of variables

Case-Control

- General applicability
  - Select sites based on outcome status and then determine prior treatment status
  - Assess whether exposure to treatment is disproportionately distributed
    - Estimate odds ratio
    - Indicates likelihood of actual benefit

Treatment	# of Cases	# of Controls
With	A	B
Without	C	D

$$Odds\ Ratio\ (OR) = CMF = \frac{A/B}{C/D} = \frac{AD}{BC}$$

Case-Control

- Strengths
  - Useful for studying rare events
  - Can investigate multiple treatments per sample
- Weaknesses
  - Cannot demonstrate causality
  - Can only investigate one outcome per sample
  - Does not recognize differences between locations with multiple crashes

Cohort

- General applicability
  - Select sites based on treatment status and then determine outcome status over time
  - Assess whether exposure (time until event) is disproportionate between cohorts
    - Estimate relative risk
    - Direct estimate of CMF

Cohort	Outcomes	Non-Outcomes	Total At-Risk
With	A	B	A + B
Without	C	D	C + D

$$Relative\ Risk = CMF = \frac{A/(A+B)}{C/(C+D)}$$

Cohort

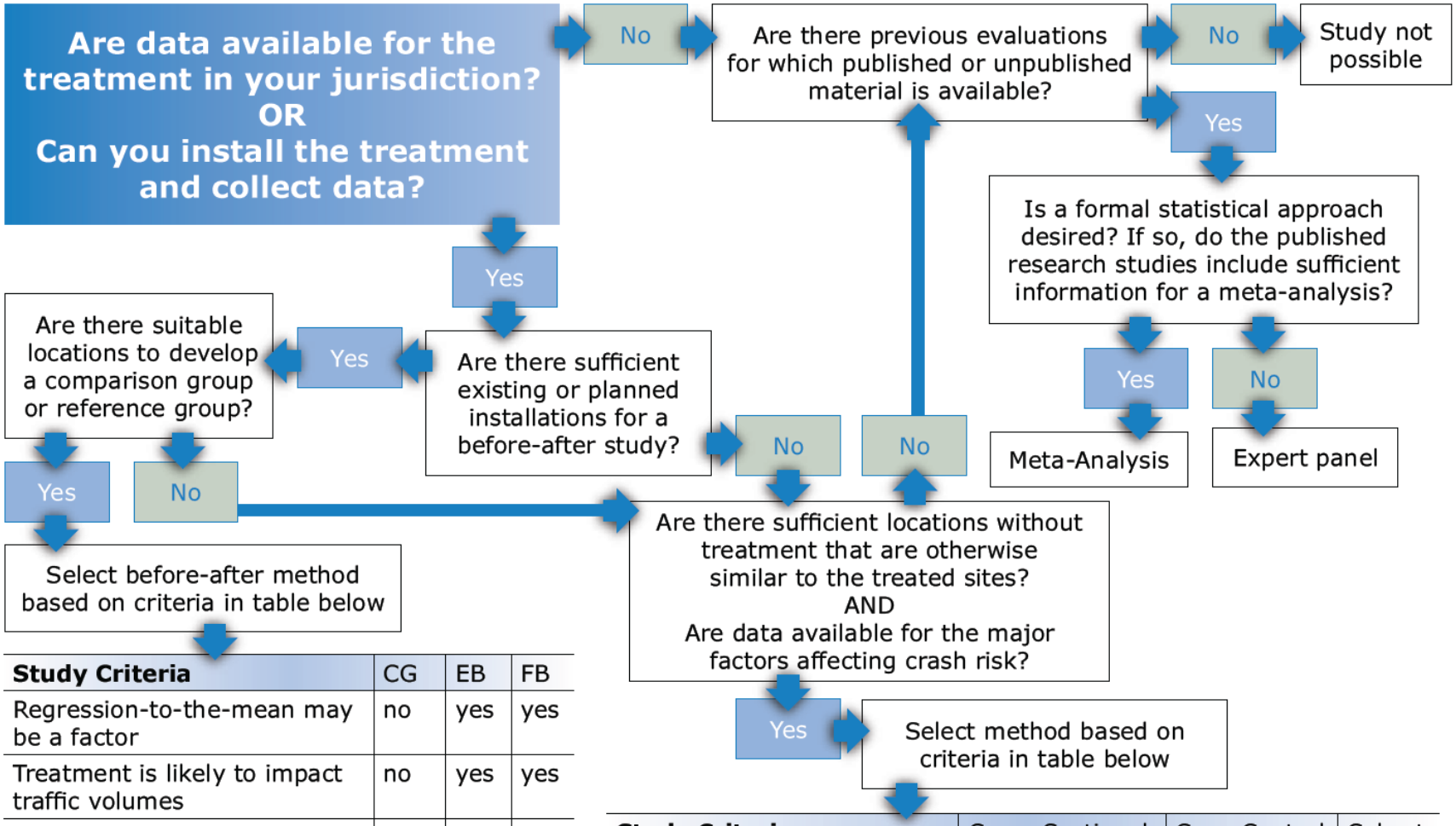
- Strengths
  - Useful for studying rare treatments
    - Sample is selected based on treatment status
  - Can demonstrate causality
- Weaknesses
  - Large samples are often required (expensive)
  - Site characteristics are subject to change
  - Does not recognize differences between locations with multiple crashes

Alternative Approaches

- Meta-analysis
  - Aggregate analysis of past research
  - Systematically combine knowledge on CMFs
- Expert panels
  - Critically evaluate findings of published and unpublished research
  - Derive CMFs through consensus
- Surrogates
  - Derive a CMF indirectly using data other than crash data
    - E.g., vehicle speeds, traffic conflicts, etc

Which Method is Preferred?

- Before-after
  - Comparison group
  - Empirical Bayes
  - Full Bayes
- Cross-sectional
- Case-control
- Cohort
- Alternative methods
- **It depends!**



Study Criteria	CG	EB	FB
Regression-to-the-mean may be a factor	no	yes	yes
Treatment is likely to impact traffic volumes	no	yes	yes
Include spatial correlation (either among treated sites or among treated and comparison or reference sites)	no	no	yes
A complex model form is required	no	no	yes
Include prior knowledge of model or CMF estimates in the analysis	no	no	yes

Study Criteria	Cross-Sectional	Case-Control	Cohort
Crash type is rare	no	yes	no
Treatment is rare	no	no	yes
Accounts for locations with multiple crashes (rather than first occurrence)	yes	no	no
CMFunction desired	yes	no	no

Scenario 1

- Jurisdiction implemented a 1.5 second all-red phase at 16 traffic signals in CBD
  - Blanket treatment
  - All 4-legged intersections
  - No other signalized intersections in vicinity
  - Several 2-way stop-controlled intersections along same two routes
  - Reasonable to believe that treatment does not impact safety at stop-controlled intersections
- **Before-after with comparison group**

Contact

Frank Gross, VHB

fgross@vhb.com