



## INTRODUCTION TO CRASH MODIFICATION FACTORS

**DEFINITION** A crash modification factor (CMF) is a measure of the safety effectiveness of a particular treatment or design element.

**APPLICATION** CMFs are applied to the estimated crashes *without* treatment to compute the estimated crashes *with* treatment, as shown by Equation 1.

$$\text{Estimated Crashes WITH Treatment} = \text{CMF} * \text{Estimated Crashes WITHOUT Treatment} \{1\}$$

A CMF less than 1.0 indicates that a treatment has the potential to reduce crashes.

*Example: A CMF for total crashes for installing centerline rumble strips on rural major collector roads has been estimated to be 0.86 (1). This CMF indicates that the frequency of total crashes with the treatment is estimated to be 86 percent of the estimated crash frequency without the treatment. In other words, the CMF indicates that there will be a 14 percent reduction in total estimated crash frequency.*

A CMF greater than 1.0 indicates that a treatment has the potential to increase crashes.

*Example: A CMF for total crashes for converting an urban four-lane cross-section to a five-lane cross-section has been estimated to be 1.11 (2). This CMF indicates that there will be an 11 percent increase in the estimated total crash frequency.*

The application of an appropriate CMF can influence the decision to implement a particular project, and the misapplication of CMFs can lead to misinformed decisions. Key factors to consider when applying CMFs include: 1) selection of an appropriate CMF, 2) estimation of crashes without treatment, 3) application of CMFs by type and severity, and 4) estimation of the combined effect for multiple treatments.

### *Selecting an Appropriate CMF*

The CMF selection process involves several considerations, including the availability of related CMFs, the applicability of available CMFs, and the quality of applicable CMFs. The key to selecting an appropriate CMF is to identify the CMF that best matches the scenario at hand.

Availability: The *Highway Safety Manual (HSM)* (3) and *CMF Clearinghouse* (4) are the two primary sources of CMFs.

Applicability: Several variables can be used to match a CMF to a given scenario including treatment type, roadway type, area type, segment or intersection geometry, segment or intersection traffic control, traffic volume, and state from which the CMF was developed. The HSM and CMF Clearinghouse provide information to help users identify applicable situations.

Quality: If multiple applicable CMFs exist for a given treatment, then the quality or standard error can be used to differentiate the results. The CMF Clearinghouse provides quality ratings for CMFs which may be used for this purpose. In the absence of a quality rating, CMFs may be compared by their



standard error where a smaller standard error indicates a greater level of certainty for a CMF estimate.

Ultimately, CMFs should be applied to situations that closely match those from which the CMF was developed. However, it is critical for practitioners to use engineering judgment when a CMF is not available for the situations encountered as there are some cases for which a CMF that was developed for different conditions might be the best available.

#### *Estimating Crashes without Treatment*

The CMF is applied to the estimated crashes *without treatment* to estimate crashes *with treatment* (assuming the countermeasure of interest is implemented). Hence, the safety performance *without treatment* has to be estimated before applying CMFs. The HSM presents several methods for estimating the safety performance of a roadway or intersection. The most simplistic method to estimate crashes without treatment is to compute the long-term (i.e., 5+ years) average crash frequency before treatment. In this method, it is assumed that the crash history before treatment will represent the future safety performance in the absence of changes. The Empirical Bayes method, described in the HSM, is a more rigorous method for estimating crashes without treatment as it combines information from the site of interest with information from other similar sites.

#### *Applying CMFs by Type and Severity*

CMFs may apply to total crashes or to target crash types and severities. It is often useful to estimate the change in crashes by type and severity, but this should only be done when there are CMFs available for the specific crash types and severities in question. The crash type associated with a CMF defines the crashes for which the related CMF is applicable. Crash severity is defined by the most severe outcome of those involved in the crash. It is not appropriate to apply a CMF for a specific crash type or severity to other crash types and severities because a countermeasure may reduce certain crash types or severities while increasing other crash types and severities.

#### *Estimating the Effects of Multiple Treatments*

There are relatively few studies that estimate CMFs for combinations of countermeasures. It is far more common for studies to estimate CMFs for individual countermeasures. Consequently, it is difficult to accurately estimate the effects of combinations of countermeasures. Methods have been proposed for combining the CMFs developed from individual countermeasures to approximate the effect of multiple countermeasures, but there has been little research to support any specific method. The current practice for many agencies is to assume that CMFs are multiplicative; this is the current method presented in the *HSM (3)* and posted on the *CMF Clearinghouse (4)*. In brief, this proposed approach (and many of the alternatives) is problematic in the sense that applying the combined CMF may overestimate or underestimate the true crash effects, particularly if the countermeasures target similar crash types. More information regarding the application of multiple CMFs is available in recent articles (5, 6).

Readers can refer to the CMF Clearinghouse for more information ([www.cmfclearinghouse.org](http://www.cmfclearinghouse.org)). The CMF Clearinghouse includes a web-based database of CMFs along with supporting documentation to help users identify the most appropriate countermeasure for their safety needs.

## **REFERENCES**

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