Traffic demand has increased as population increased. The US population reached 313,914,040 in 2012 (US Census Bureau, 2015). Increased travel demand may have potential impact on roadway safety and the operational characteristics of roadways. Total crashes and injury crashes at intersections accounted for 40% and 44% of traffic crashes, respectively, on US roadways in 2007 according to the Intersection Safety Issue Brief (FHWA, 2009). Traffic researchers and engineers have developed a quantitative measure of the safety effectiveness of treatments in the form of crash modification factors (CMF). Based on CMFs from multiple studies, the Highway Safety Manual (HSM) Part D (AASHTO, 2010) provides CMFs which can be used to determine the expected number of crash reduction or increase after treatments were installed.

Even though CMFs have been introduced in the HSM, there are still limitations that require to be investigated. One important potential limitation is that the HSM provides various CMFs as fixed values, rather than CMFs under different configurations. In this dissertation, the CMFs were estimated using the observational before-after study to show that the CMFs vary across different traffic volume levels when signalizing intersections. Besides screening the effect of traffic volume, previous studies showed that CMFs could vary over time after the treatment was implemented. Thus, in this dissertation, the trends of CMFs for the signalization and adding red light running cameras (RLCs) were evaluated. CMFs for these treatments were measured in each month and 90- day moving windows using the time series ARMA model. The results of the signalization show that the CMFs for rear-end crashes were lower at the early phase after the signalization but gradually increased from the 9th month. Besides, it was also found that the safety effectiveness is significantly worse 18 months after installing RLCs.

Although efforts have been made to seek reliable CMFs, the best estimate of CMFs is still widely debated. Since CMFs are non-zero estimates, the population of all CMFs does not follow normal distributions and even if it did, the true mean of CMFs at some intersections may be different than that at others. Therefore, a bootstrap method was proposed to estimate CMFs that makes no distributional assumptions. Through examining the distribution of CMFs estimated by bootstrapped resamples, a CMF precision rating method is suggested to evaluate the reliability of the estimated CMFs. The result shows that the estimated CMF for angle+left-turn crashes after signalization has the highest precision, while estimates of the CMF for rear-end crashes are extremely unreliable. The CMFs for KABC, KABC, and KAB crashes proved to be reliable for the majority of intersections, but the estimated effect of signalization may not be accurate at some sites.

In addition, the bootstrap method provides a quantitative measure to identify the reliability of CMFs, however, the CMF transferability is questionable. Since the development of CMFs requires safety performance functions (SPFs), could CMFs be developed using the SPFs from other states in the United States? This research applies the empirical Bayes method to develop CMFs using several SPFs from different jurisdictions and adjusted by calibration factors. After examination, it is found that applying SPFs from other jurisdictions is not desired when developing CMFs.

The process of estimating CMFs using before-after studies requires the understanding of multiple statistical principles. In order to simplify the process of CMF estimation and make the CMFs research reproducible, this dissertation includes an open source statistics package built in R (R, 2013) to make the estimation accessible and reproducible. With this package, authorities are able to estimate reliable CMFs following the procedure suggested by FHWA. In addition, this software package equips a graphical interface which integrates the algorithm of calculating CMFs so that users can perform CMF calculation with minimum programming prerequisite.
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The public is welcome to attend.