Crash Prediction Method for Pedestrian Crashes at Roundabouts

A crash prediction method for motor-vehicle crashes at roundabouts was developed in NCHRP Project 17-70 and is being incorporated in the forthcoming second edition of the AASHTO *Highway Safety Manual* (HSM). However, there is no comparable method for predicting the frequency and severity of pedestrian crashes at roundabouts as a function of traffic volumes and roundabout design and traffic control features. Most available information about pedestrian crashes at roundabouts is anecdotal, rather than quantitative, in nature. Where quantitative research has been conducted the results are conflicting and inconclusive.

There is a clear need to develop a crash prediction method for pedestrian crashes at roundabouts, including both SPFs and CMFs, suitable for incorporation in a future edition of the HSM. The SPFs should quantify the effect of both motor-vehicle and pedestrian volumes on crash frequency and severity. The CMFs should quantify the effects of geometric design and traffic control features on crash frequency and severity, including: the effects of the radius, number of lanes, and width of the circulating roadway and approaches; the distance of crosswalks from the circulating roadway; and the crossing distances and types of traffic control provided at crosswalks. Distinctions should be made among specific types of roundabouts including single-lane roundabouts, multilane roundabouts, turbo roundabouts, and roundabouts at ramp terminals. Distinctions should be made between crashes involving pedestrians crossing at the crosswalks and pedestrians walking or crossing at other locations. The crash prediction method should be suitable for comparing the frequency and severity of pedestrian crashes at roundabouts to the frequency and severity of pedestrian crashes at conventional intersections serving similar motor-vehicle and pedestrian volumes.

American Association of State Highway and Transportation Officials
Special Committee on Research and Innovation

FY2024 NCHRP PROBLEM STATEMENT TEMPLATE

1. PROBLEM TITLE

Developing and Validating Safety Performance Functions that Combine Multiple Existing Safety Performance Functions

2. RESEARCH OBJECTIVE

The Objective of this research is to develop Safety Performance Functions (SPF) that combine existing SPFs in order to leverage the products from past research, and to ease the task of practitioners when applying predictive methods in the HSM.

The research should provide guidance on the use and combination of multiple SPFs, as well as the appropriateness of the use of such combined SPFs with existing CMFs.

3. URGENCY AND POTENTIAL BENEFITS

Currently, there exist multiple SPFs that safety practitioners could incorporate in their safety work. Similarly, a large and ever growing number of CMFs are available and easily accessible in the CMF clearinghouse. In some instances, it might be desired to combined crash types or severity in order to correctly apply available CMFs. Having the framework to confidently combine prediction methods for multiple crash types or severities could allow practitioners more flexibility to adapting HSM crash prediction methods to their work, from facilitating the prefer use of higher quality CMFs, to combining their existing SPFs based on limited data with reference SPFs (such as the ones in the HSM) that are expected to be more robust, to producing an overarching SPF that is sensitive to a combined set of predictors of interest that would not be available from the individual SPFs.

4. BACKGROUND INFORMATION AND NEED FOR RESEARCH

In some cases, multiple SPFs might be available for a single crash type, and even national level work is often based on a limited number of states (typically 3 or less). In these cases, a state might be interested in combining their existing state SPFs with other multistate SPFs (such as the products from NCHRP research), in order to produce a more robust crash prediction at a fraction of the cost of developing a larger database for estimating new state SPFs.

In other cases, practitioners might have an interest in using crash predictions at a aggregated level than the available SPFs (for example, an agency might be interested on predictions for KAB crashes but might have SPFs for K, A, and B crashes separately). In these cases, the properties of the resulting combination of SPFs are unknown. Therefore, it is unknown if the use of such combined SPFs is appropriate for network screening, EB correction, variance of estimates, etc. This research should provide guidance as to where the practice of combining SPFs is appropriate and recommended, as well as the expected benefits or costs of using these combinations of predictions.

This research will investigate and document scenarios of appropriate use for combinations of SPFs and will provide practitioners with a sense of when it is appropriate to borrow and adapt research results. The research should be based on the analysis data from multiple states and the results and recommended practice should be applicable to transportation agencies across the U.S.

5. LITERATURE SEARCH SUMMARY

Most commonly, SPFs are developed from statistical models that assume a negative binomial (NB) distribution of crashes. The SPF Development Guide from FHWA (Raghvasan and Bauer, 2013) mentions a gamut of SPF developing alternatives, one of which is the traditional NB generalized linear model. Although the statistical properties of some simple combinations of NB variables are straight forward (e.g., SPFs with the same dispersion parameter), most generally, the properties of the combination of SPFs are undetermined (e.g., combining NB and non-NB SPFs, combining NB variables different dispersions, etc.).

6. LINK TO 2021-2026 AASHTO STRATEGIC PLAN

This project would support transportation practitioners in their decision making and practice of safety, and it relates with Safety in general, a value explicitly stated in AASHTO's strategic plan. Specifically, it connects to the goals of advancing a safe, multimodal transportation system; improving asset performance; and aligning transportation interests across partners and regions.

7. IMPLEMENTATION CONSIDERATIONS AND SUPPORTERS

Communication and Implementation Funding:

Communication and Implementation Period:

8. RECOMMENDED RESEARCH FUNDING AND RESEARCH PERIOD

Research Funding:

Research Period:

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American Association of State Highway and Transportation Officials
Special Committee on Research and Innovation

FY2024 NCHRP PROBLEM STATEMENT TEMPLATE

1. PROBLEM TITLE

Development and Refinement of Motorcycle Crash Modification Factors & Functions

2. RESEARCH OBJECTIVE

The development of new and refinement of existing motorcycle CMFs for inclusion in the FHWA CMFClearinghouse.org. These CMFs could include both behavioral countermeasures and infrastructure countermeasures; however, the research would focus primarily on built environment countermeasures that could be included within infrastructure improvement/maintenance projects. Human factors influencing motorcycle crashes should be considered, such as the effects of traffic signing and/or traffic signals.

3. URGENCY AND POTENTIAL BENEFITS

Motorcycle riders continue to be overrepresented in fatal traffic crashes. In 2020, 5,579 motorcyclists died in crashes in the U.S. As fuel costs increase, there tends to be the movement to use more fuel-efficient vehicles, including motorcycles and scooters. In 1981, NHTSA undertook a study, Motorcycle Accident Cause Factors and Identification of Countermeasures (DOT-HS-5-01160), commonly called the Hurt Study after the lead researcher H. H. Hurt, Jr. Although somewhat dated; it still has sound findings; a sample of the safety issues identified include: (a) three-fourths of crashes involved another vehicle, (b) one-fourth involved a collision with the roadway or a fixed object, (c) vehicle failure was rare, (d) single-vehicle crashes most often involved over braking or running wide on a curve, (e) roadway defect crashes were rare, (f) conspicuity was a common factor, (g) weather as a crash factor was rare, and (h) intersections were the most commonplace for a motorcycle related crash. Planners, designers, and safety professionals' understanding of available safety countermeasures to address motorcycle/scooter crashes is limited by the absence of research on motorcycle/scooter-related crashes. Appropriate motorcycle safety countermeasure implementation is limited due to understanding how current and proposed safety countermeasures affect motorcycle and scooter crash potential and severity. Therefore, motorcycle and scooter safety countermeasures are not considered or implemented in everyday practice.

4. BACKGROUND INFORMATION AND NEED FOR RESEARCH

Currently, there are limited CMFs related to motorcycle crashes available to guide planners, designers, and safety engineers on infrastructure elements to reduce the likelihood and severity of motorcycle/scooter-related crashes. The CMFClearinghouse provides a handful of CMFs specific to motorcycles, including horizontal alignment, the number of lanes, intersection configuration, photo enforcement, and turn lanes. Other research focuses on the motorcyclists themselves and ways to improve conspicuity, training, restricting younger riders and passengers, power restrictions, and personal safety equipment. Some infrastructure-related items with limited research and CMF development include modification to roadside hardware to reduce the severity of crashes, alternative roadway marking types to improve friction, and effects of uneven pavement conditions (manholes, steel plates, brick pavers). NCHRP Report 500 identified several infrastructure countermeasures, many where determined in the Hurt study to be less of an issue, but two, in particular, would address some of the issues noted in the Hurt study, in particular paved shoulders and improved roadside barriers. However, available CMFs for these two types of improvements are not available.

5. LITERATURE SEARCH SUMMARY

Beyond the Hurt study, in 2018 FHWA further undertook a study (FHWA-HRT-18-062) to identify infrastructure countermeasures to focus on motorcycle crashes. The study identified five areas: (1) high friction surface treatments, (2) limited sight distance signing, (3) pavement change warning, (4) curve speed warning, and (5) prohibitive signing, e.g., turn prohibitions. Additionally, NCHRP Report 500 A Guide for Addressing Collisions Involving Motorcycles which included several safety countermeasures; however, most were related to the motorcyclist driver, e.g., clothing, safety equipment, and training. For infrastructure elements, NCHRP Report 500 included: (a) Provide full paved shoulders to accommodate roadside motorcycle recovery and breakdowns, (b) Consider motorcycles in the selection of roadside barriers, (c) Identify pavement markings, surface materials, and other treatments that reduce traction for motorcycles and treat or replace with high-traction material, (d) Maintain the roadway to minimize surface irregularities and discontinuities, (e) Maintain roadway surfaces in work zones to facilitate safe passage of motorcycles, (f) Reduce roadway debris – such as gravel, shorn treads, snow and ice control treatments (sand/salt), and that resulting from uncovered loads – from the roadway and roadside, (g) Provide advance warning signs to alert motorcyclists of reduced traction and irregular roadway surfaces, (h) Incorporate motorcycle safety considerations into routine roadway inspections, and (i) Provide a mechanism for notifying highway agencies of roadway conditions that present a potential problem to motorcyclists. However, CMFs were not developed or identified for any of the focus areas noted in NCHRP 500.

6. LINK TO 2021-2026 AASHTO STRATEGIC PLAN

7. IMPLEMENTATION CONSIDERATIONS AND SUPPORTERS

Communication and Implementation Funding:

Communication and Implementation Period:

8. RECOMMENDED RESEARCH FUNDING AND RESEARCH PERIOD

Research Funding:

Research Period:

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Effect of Type of Jurisdiction in Crash Prediction Modeling

The AASHTO Highway Safety Manual provides tools for predicting the safety performance of a roadway facility. These tools include safety performance functions (SPFs) which incorporate geometric and other conditions to predict the crashes expected on a facility. States can develop jurisdiction-specific SPFs using their own state data, allowing analyses that more closely represent the individual states' experiences. Although the development of customized SPFs is generally considered more accurate for crash predictions, it involves a higher level of data needs, expertise, and cost. Many states have opted to use SPFs from the HSM and developed calibration factors that would adjust the crash predictions for their state. Although developing calibration factors is less costly than developing jurisdiction-specific SPFs, both of these approaches require some amount of expenditure. Additionally, some states may not be able to develop SPFs or calibration factors for some types of facilities because they do not have any in their state.

State practitioners have questions about whether SPFs or SPF calibration factors are transferable from other states. If so, this would represent a cost savings to states and increase the availability and usefulness of SPFs. This research should address the following questions:

- Under what conditions it is valid for one state to use SPFs or SPF calibration factors from another state?
- Are there certain types of SPFs that transfer from one state to another with more reliable results? For example, do intersection models transfer more reliably that segment models?
- Is it possible to use area-wide characteristics as adjustment factors to increase the reliability of transferred SPFs or calibration factors? Such characteristics may include vehicle miles traveled, average AADT, population density, or distribution of road class.

A synthesis topic statement has been submitted to NCHRP on this same topic (State Customization of Highway Safety Manual Methods, submitted February 2022). It was intended to develop a compilation of calibration factors and SPFs that states have developed. If funded, the synthesis work should be leveraged for this research project.

Research Topic: "Effects of Signalization on the Safety of Intersections and Ramp Terminals"

Background Information

The predictive method tools in the AASHTO's 1st Edition Highway Safety Manual (HSM) [(1)(2)] includes crash predictive methods for a host of intersections on rural two-lane highways, rural multilane highways, urban/suburban arterials, and ramp terminals [(3)]. Predictive methods intended for inclusion in the future HSM Second Edition (HSM2) were later developed under NCHRP 17-58 (Safety Prediction Models for Six-Lane and One-Way Urban and Suburban Arterials) [(4)] and NCHRP 17-68 (Intersection Crash Prediction Methods for the Highway Safety Manual) [(5)]. Thus, the HSM contains predictive methods for predicting crashes at a wide range of intersections and ramp terminals on various facility types. Many agencies use the results of these methods to inform and support decisions related to planning, design, and operations; and specifically the evaluation of appropriateness of traffic control devices at intersections – often the decision entails whether a given intersection should be stop-controlled (ST) or signalized (SG).

To help address the struggles that some agencies have faced in applying HSM results to make such decisions, the Federal Highway Administration's (FHWA) Office of Safety and Operations Research and Development recently performed an initial analysis of HSM models for intersections and ramp terminals. Expectations were either that SG intersections would experience fewer crashes than ST intersections for all AADTs (and especially at "higher" AADTs) or perhaps that ST intersections would have fewer crashes than SG intersections at "lower" AADTs (where signals are not usually warranted), while SG intersections would have fewer crashes than ST intersections at "higher" AADTs (where signalization is warranted). The expectation for SG intersections having fewer crashes is particularly true for fatal and injury crashes. However, as agencies applying HSM models have discovered, neither pattern is consistently found. An extension of FHWA's investigation to include some state agency-developed SPFs and calibration factors for HSM intersection models developed by various agencies similarly found mixed results.

Bonneson et al. (2014) [(6)] noted that crash modification factors (CMFs) generally show a tendency for intersections undergoing conversion from stop-control to signalization to experience a reduction in crash frequency. However, the wide variation in CMF values and the fact that several CMFs exceed 1.0 (i.e., converting to a signal increases crashes) is not particularly helpful when practitioners need to establish what the safety performance change would be in a STOP to signal conversion.

Need for Research

Research is needed to determine the safety performance change for a STOP to signal control conversion. This is particularly important as agencies need higher levels of confidence when doing this analysis.

Research Objective

Based upon a review of past studies, the evidence seems inconclusive on the safety effect of adding a traffic control signal (where no other changes are made at the intersection). Therefore, it is appropriate to undertake a data-based investigation to determine which of the following characterizations applies for each intersection and ramp terminal type:

- The CPM or CMF function is biased.
- The data collection methods/approaches for CPM or CMF development are biased.
- The expectation or judgment is biased.
- There are additional factors that need to be considered which would explain the conditions under which the CPM or CMF is accurate and the conditions under which the expectation is correct.

The objective of the research is then to develop crash modification factors or functions that describe the change in safety associated with the installation of a traffic control signal at an intersection that is currently controlled by Stop sign. The research should recognize that other changes are often made at the intersection when it is signalized and (1) isolate the safety effect of signal installation and (2) develop additional factors or functions that describe the safety effect of common combinations of changes made in conjunction with signal installation (e.g., add signal and add through lane, left-turn bay, protected-permissive left-turn operation).

The study would focus on the various 3-leg and 4-leg intersections and freeway ramp terminal configurations represented in the HSM Predictive Methods (Part C), for both rural and urban/suburban areas (and/or for the expanded functional classification system documented in NCHRP Research Report 855 [(7)]: rural, rural town, suburban, urban, urban core). Research questions to be addressed include:

- Under what conditions are SG intersections expected to provide a safety performance benefit compared to ST intersections, particularly when considering crash severity?
- How does the safety performance effect vary by intersection type? By facility type? By intersection entering AADT? By distribution of major vs. minor road AADT? By directions traveled on the major and minor road (i.e., one-way or two-way)?
- Is the effect on higher severity crashes different than for total crashes; in other words, how do the severity of crashes change?
- Is the effect of signalization universal or are there differences by jurisdiction?

Findings from this proposed research could also be useful in addressing other areas where there are seeming inconsistencies in current predictive models and CMFs. For example, models developed under NCHRP Project 17-70 [(8)] for the safety performance of roundabouts compared to HSM models for signalized intersections can yield “unexpected” results (i.e., that a roundabout is sometimes predicted to experience more crashes), particularly when compared to the CMFs in the HSM Interim Predictive Method for Roundabouts (HSM section 12.9) [(1)].

Research Approach

A before-after study design is likely to provide the most reliable results. The research approach could be similar to that by Srinivasan et al. (2014) [9], but expanded to include national representation, larger sample size (especially in urban area), and closer agreement with the scope of this research topic. (http://www.cmfclearinghouse.org/study_detail.cfm?stid=444)

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Equity Considerations and Application of Socioeconomic Factors in Safety Management

What socio-economic factors affect ability and what affects choice (nature vs. nurture)? Are race, gender, and age just arbitrarily chosen due to the availability of data and are these correlation rather than causation? How are socio-economic factors related to equity and how do we apply these relationships to transportation decision-making?

These questions are overarching and philosophical but underpin policy and how tax dollars are spent due to the recent focus on equity, including safety funding (see SS4A Underserved Communities Census Tracts (Historically Disadvantaged Communities) (arcgis.com)). Is it possible to investigate these questions on a deeper level to determine what socio-economic factors impact outcomes?

The Department of Transportation identifies communities with a high percentile of persons (age 5+) who speak English "less than well" as having an equity disadvantage (CDC Social Vulnerability Index). How can this be more data-driven? Socio-economic factors should be defined by lifestyle components and measurements of both financial viability and social standing, which directly influence social privilege and levels of financial independence. Factors such as health status, income, environment, and education are studied by sociologists in terms of how they each affect human behaviors and circumstances.

For the purposes of this problem statement, the goal of proposed research would be to determine socio-economic factors that are statistically significant in safety outcomes as related to human behaviors and circumstances. Secondly, how could this data be used in directing safety investments to populations more vulnerable to death or injury on our public transportation networks and how could the data influence policy at the federal level to offer guidance to state, local, and tribal agencies on how to consider equity in their project selection processes.

Problem Statements C2, D1, and D3 in the Transportation Research Circular Number E-C270: Opportunities for Research on Transportation and Equity are closely related. A similar problem statement was submitted to the AASHTO Committee on Safety.

Other resources reviewed included:

An Equity-Driven Approach To School Zone Safety To Inform Safe Routes To School (SRTS) Programs - Center for Transportation Equity, Decisions & Dollars (uta.edu)

Justice40 Initiative | US Department of Transportation

SS4A Underserved Communities Census Tracts (Historically Disadvantaged Communities) (arcgis.com)

TITLE: HSM Predictive Method Definitions Picture Book

With the increased emphasis nationally and with many local agencies in highway safety, more individuals are look towards the Highway Safety Manual for guidance on how to improve safety and reduce fatalities on our roadways. It is difficult for new users of the Predictive Method found in Part C of the HSM to understand all the various definitions, facility types, overall input features that are required to use the many Safety Performance Functions (SPFs) and their associated Crash Modification Factors (CMFs). This lack of understanding can lead to the improper application of the HSM predictive models and inaccurate crash prediction results. It is proposed that a HSM Predictive Method Definitions Picture Book (HSM Picture Book) be developed to help existing and future safety practitioners better understand the definitions, facility types, facility features, and input values required to perform a predictive analysis.

The initial concept for the HSM Picture Book is to provide a companion document to the HSM2 that contains clear and easy to understand photos along with brief definitions for each of the various input values for the many SPFs and CMF found within Part C of the HSM. It is intended that the document would focus on providing real world picture examples for as many features as possible in an effort to help practitioners see what the various prediction models are look at. It is anticipated that the HSM Picture Book would follow a similar style and layout as the HSM2.