ARIZONA TRANSPORTATION RESEARCH CENTER

RESEARCH NOTES:

Project SPR 558

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High Risk Crash Analysis

Research Need

In agencies with jurisdiction over extensive road infrastructure it is common practice to select and rectify locations with significantly higher than average crash counts. Improving these 'sites with promise' or high risk locations may arise as a result of safety management activities, during maintenance activities, or as a result of political pressures and/or public attention. Commonly a two-stage process is used. In the first stage the past accident history of all sites is reviewed to screen a limited number of high risk locations for further examination. In the second stage the selected sites are studied in greater detail to devise cost-effective remedial actions or countermeasures for a subset of correctable sites.

Due often to limited time and resources constraints and the extensive number of candidate sites typically considered in such endeavors, it is impractical for agencies to examine all sites in detail. The current Arizona Local Government Safety Project Analysis Model (ALGSP), which was developed by Carey (2001) with funding from the Arizona Department of Transportation (ADOT), is intended to facilitate conducting these procedures by providing an automated method for analysis and evaluation of motor vehicle crashes and subsequent remediation of 'hot spot' or 'high risk' locations. The software is user friendly and can save lots of time for local jurisdictions and governments such as Metropolitan Planning Organizations (MPOs), counties, cities, and towns. However, its analytical core is based on the simple ranking of crash statistics, where the user is offered choices of crash frequency, crash rate, crash severity, or crash cost (severities associated with average costs per crash severity type). Although this method has the benefit of straightforwardness, the efficiency of identifying truly high-risk sites leaves some room for improvement.

Research Goals

This research, funded by ADOT, aimed to justify and recommend improvements to the analytical algorithms within the ALGSP model, thus enhancing its ability to accurately identify high risk sites. Specifically, the study goal was to provide recommendations that will lead to improvement in the accuracy and reliability of the ALGSP software for identifying true 'hot spots' within a transportation system or network, be they road segments, ramps, or

intersections, with the intent to serve the state of Arizona.

Key Results

The research resulted in 1) a survey of past and current hot spot identification (HSID) approaches, 2) evaluation of HSID methods and exploration of optimum duration of before-period crash data under simulated scenarios, 3) development of safety performance functions (SPFs) for various functional road sections within Arizona, 4) extended comparisons of alternative HSID methods based on SPFs by using real crash data, and 5) recommendations for improving the identification ability of current ALGSP model. These results are found in the full report in the following chapters:

- Literature review of HSID methods (Chapter II): Through tracing the historical and conceptual development of various HSID techniques, the strengths and weaknesses associated with alternative approaches are assessed, and appropriate directions of future research on HSID methods are explored and proposed. Detailed description of Bayesian approaches is also provided.

- Experimental design for evaluation of HSID methods and exploration of accident history (Chapter III): In this experiment, "sites with promise" are known *a priori*. Real intersection crash data from six counties within Arizona were used to simulate crash frequency distributions at hypothetical sites. A range of real conditions was manipulated to quantify their effects. Various levels of confidences were explored, false positives (labeling a safe site as high risk) and false negatives (labeling a high risk site as safe) were compared across three methods, the simple ranking method, the confidence interval method, and the Empirical Bayesian (EB) method. Finally, the effect of crash history duration in these approaches is quantified.

- Safety performance functions for Arizona road segments (Chapter IV): The SPFs for nine functional classifications of road sections in Arizona were created based on the crash data of Year 2000 provided by ADOT. Due to the existence of overdispersion of accidents, Negative Binomial models are utilized to develop these SPFs.

- Comparison of HSID methods based on real crash data of Arizona road segments (Chapter V): On the basis of SPFs for Arizona road sections, five tests were implemented to evaluate the performances of the EB, accident reduction potential, accident frequency and the accident rate methods. Two levels of confidences were explored under each test. In addition, the similarity of identification results of the alternative HSID methods was explored as well.

- HSID in current ALGSP model and recommended software changes (Chapter VI): The algorithms for conducting HSID in the current ALGSP model are first reviewed, and the recommended software changes to enhance their accuracy are recommended. These recommendations include incorporating functional classification as an additional

selection parameter, data interface improvements, accident history requirement, embedding the relationships between exposure and safety for various roadway functional classes, incorporation of the EB techniques to compute the expected crash count, incorporation of accident reduction potential as an additional weighting method, and incorporation of EB techniques to calculate the expected crash costs.

Conclusions and Recommendations

Based on the analysis of both real and simulated data, the results in the report show significant advantages of the EB methods over other HSID methods across various confidence levels and different statistical tests. Specifically, the research reveals that the Empirical Bayes approach yields:

- A higher percentage of truly high risk sites are identified as 'high risk'
- A higher percentage of truly safe sites are identified as 'safe'
- Overall misclassifications are reduced using a Bayesian approach compared to alternative methodologies.
- The best site consistency and method consistency among the alternative methodologies.

Although it is shown that incorporation of Bayesian techniques into the ALGSP will provide model users with more accurate prediction of hot spots, improvements are contingent upon the provision of accurate safety performance functions, which are currently unavailable in the ALGSP. A Safety performance function—the relationship between traffic volumes, road section lengths, and crashes—are provided in Appendix C of the full report for various roadway functional classifications in the state of Arizona. Thus, the research provides both the analytical tools and the necessary 'look up' tables to support the incorporation of the EB method into the ALGSP model. These safety performance functions will support all of the software enhancements needed to improve the ALGSP and accommodate Empirical Bayes' procedures.

Ref: Carey, J. Arizona Local Government Safety Project Analysis Model. Final Report 504, Arizona Dept. of Transportation, Phoenix, AZ., 2001.

The full report: *High Risk Crash Analysis* by Simon Washington and Wen Cheng, Department of Civil & Environmental Engineering, Arizona State University (Arizona Department of Transportation, report number FHWA-AZ-05-558, published December 2005) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 S. 17 Ave., MD 075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies through ADOT's Engineering Records Section.