HSIP

U.S. Department of Transportation
Federal Highway Administration

HSIP Noteworthy Practice Series

HSIP Project Evaluation

About the HSIP Noteworthy Practice Series

The Highway Safety Improvement Program (HSIP) is a core Federal-aid highway program with the primary purpose of achieving a significant reduction in fatalities and serious injuries on all public roads. Many states and local agencies are successfully implementing innovative approaches to HSIP planning, implementation, and evaluation. The HSIP Noteworthy Practices Series presents case studies of these successful practices organized by specific HSIP topics. The individual case studies provide summaries of each practice, key accomplishments, results, and contact information for those interested in learning more.

HSIP Project Evaluation

Evaluation is critical to determine if a project or group of projects is achieving the desired results and to ensure investments are cost-effective. Evaluation provides a quantitative estimate of the effects on safety, which is valuable information for future planning. Evaluation results enable a state to determine if appropriate countermeasures were used at particular locations, whether any adverse impacts occurred, if corrective action is necessary, and how effective those countermeasures would be for similar sites in the future.

Various methods exist for evaluating projects, but any evaluation should consider a minimum of three to five years of before and after crash data, the target crash type of the improvement, and crash severity (a countermeasure may increase the total number of crashes, but reduce the crash severity). Ideally, project evaluation should incorporate more advanced techniques (e.g., safety performance functions (SPFs), Empirical Bayes (EB) method) to account for natural fluctuations in crashes from year to year and other changes potentially impacting evaluation results.

The majority of states are conducting project evaluations based on a simple before-after analysis, and a few are using evaluation results to develop state-specific crash modification factors (CMFs) for various countermeasures. While simple before-after evaluations are rather easy to perform and may provide a basic understanding of safety changes, they assume any change was due solely to the safety improvement at the site and may misrepresent the true effectiveness of a project due to the effects of regression-to-the-mean.[1] The EB method can be incorporated into project evaluations to reduce the effects of regression-to-the-mean. However, very few states have been able to use the EB method since it requires calibrated SPFs. Many states do not have the training, resources, tools, manpower, or necessary data to calibrate SPFs.

Another challenge is that individual states may not have enough installations of a particular countermeasure to develop quality CMFs. The Evaluations of Low Cost Safety Improvements Pooled Fund Study (ELCSI PFS) combines the implementation efforts of multiple states to develop reliable estimates of countermeasure effectiveness. States can independently initiate similar efforts.

[1] Regression-to-the-mean bias describes a situation in which crash rates are artificially high (or low) during the before period and would have decreased (or increased) even without an improvement to the site.

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Noteworthy Practices

The following cases demonstrate noteworthy practices four states are using in HSIP project evaluations:

- The Colorado DOT developed SPFs for all roadway facility and intersection types in the State, which enabled the DOT to institutionalize the EB method into all safety project evaluations and reduce the effects of regression-to-the-mean. (read more)
- The Florida DOT developed an on-line database application of safety improvement projects that automates the processes for conducting benefit-cost analysis to compare different countermeasures and for conducting safety project evaluations to develop crash reduction factors (CRF). The application has also enabled Florida to develop and continue to refine state-specific CRFs for several countermeasures based on the project evaluation results. (read more)
- The North Carolina DOT created a safety project evaluation group to conduct evaluations on all spot safety projects in the State. The project evaluations provided field engineers with valuable feedback on the effectiveness of safety projects and countermeasures. (read more)
- The University of Wisconsin Traffic Operations and Safety (TOPS) Laboratory, under contract to Wisconsin DOT, developed a project evaluation process incorporating EB analysis into all HSIP project evaluations. The TOPS Laboratory compared benefit-cost analysis using simple before-after analysis results and EB to demonstrate the importance of using statistical evaluations to reduce the overestimation of safety benefits due to regression-to-the-mean. (read more)

To access these full case studies, click on the individual links above or visit the FHWA Office of Safety on-line at: http://safety.fhwa.dot.gov/hsip.

Project Evaluations Using Empirical Bayes

Colorado

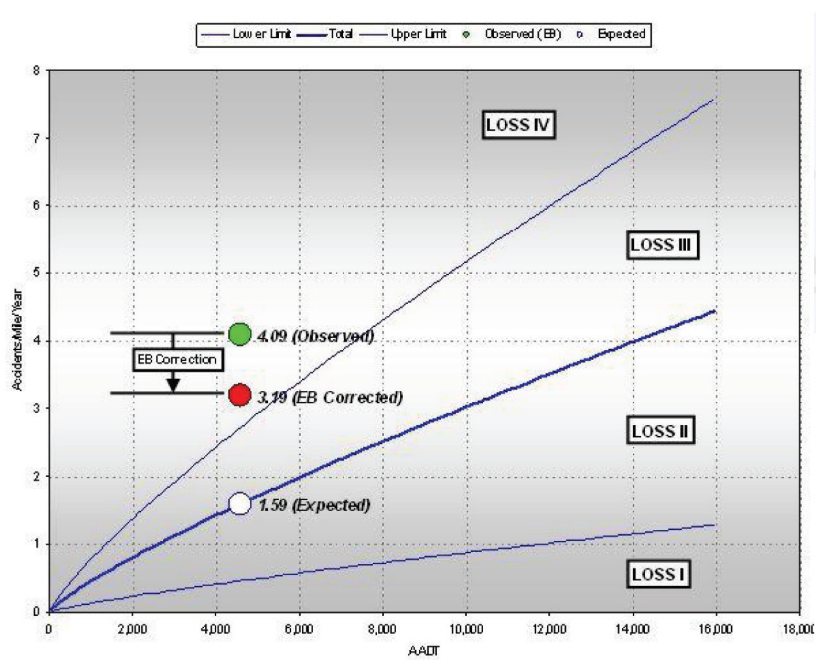
Incorporating the Empirical Bayes (EB) method into project evaluations reduces the potential overestimation of safety benefits due to regression-to-the-mean. While the EB method is not difficult in itself, it requires safety performance functions (SPF) for the type of facilities on which projects are being evaluated.

Key Accomplishments

- Developed SPFs for all roadway facility and intersection types in the state.
- Institutionalized the use of the Empirical Bayes method as a standard procedure for safety evaluation analysis to reduce effects of regression-to-the-mean.

SPFs were originally developed by Colorado Department of Transportation (CDOT) for use in the network screening process. While crash rates are commonly used to measure safety, the crash rate implies a linear relationship between safety and exposure, which can often be misleading since rates change with Annual Average Daily Traffic (AADT). To capture how this rate change takes place, design engineers at the CDOT started to calibrate SPFs in the late 1990s, as part of the development of the Level of Service of Safety (LOSS) concept. LOSS is used to identify locations with potential for safety improvement and reflects how a roadway segment is performing in regard to its expected crash frequency and severity at a specific level of AADT, based on the SPF. By 2001, CDOT had calibrated SPFs for all public roadways (state and local) in Colorado, stratified by the number of lanes, terrain, environment, and functional classification. In 2009, CDOT in collaboration with consultants developed SPFs for all intersection types.

The development of SPFs has not only advanced CDOT's network screening process, it also has enabled CDOT to institutionalize the use of the EB method as a standard procedure for safety evaluation analysis. Colorado has traditionally used a simple spreadsheet with three to five years of before and after data to conduct project evaluations. CDOT is currently working on applying an EB correction to evaluate sites on an SPF graph as shown. The use of the EB method is particularly effective when it takes a long time for a few crashes to occur, as is often the case on Colorado rural roads.



Results

CDOT developed SPFs for all state and local roadway facilities and intersection types. The development of the SPFs has enabled CDOT to fully institutionalize the EB method for all safety analysis at CDOT and reduce the effects of regression-to-the-mean.

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The Focus is Results

Crash Reduction Analysis System Hub

Florida

Crash reduction factors (CRF) provide agencies with an estimate of the expected crash reduction and/or benefits associated with various countermeasures. However, since local conditions (e.g., roadway, driver, traffic, weather, crash investigation techniques) may vary from agency to agency, state specific CRFs provide a more accurate indication of the effectiveness of various countermeasures. Prior to the development of the Crash Reduction Analysis System Hub (CRASH), the Florida Department of Transportation (FDOT) did not have a central database that combined crash data and safety project data to determine CRFs, or a mechanism in place to provide FHWA with a report on the effectiveness of safety projects in reducing crashes. The individual districts maintained the historical data for their safety improvement projects, which were in various formats and were not easily accessible for developing CRFs. In an effort to systematically maintain statewide safety improvement project data and facilitate a continual process of developing and updating state specific CRFs, the FDOT funded a research project with the Lehman Center for Transportation Research to develop the CRASH application.

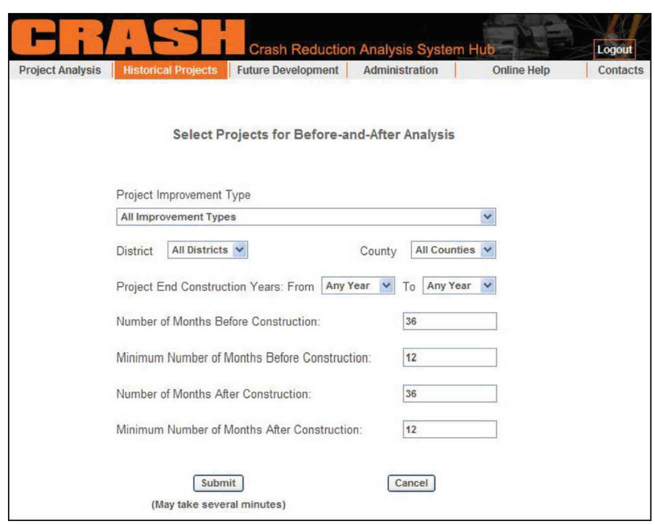
The CRASH application is a web database of safety improvement projects on the FDOT intranet. The District Safety Engineers (DSE) input all Highway Safety Improvement Program (HSIP) funded projects into CRASH, which stores individual safety improvement projects and crash data. The application uses before and after crash counts to evaluate the CRFs for the countermeasures implemented in the safety improvement projects entered in the system. The State Safety Engineer (system administrator) updates the CRFs annually; although they can be updated at any time. The CRFs are typically calculated based on five years of before and after data, but the system administrator may specify a time period for the calculation.

Key Accomplishments

- Developed an online database of safety improvement projects and state-specific CRFs.
- Automated processes for benefit-cost analysis and safety project evaluations.

The CRASH application enables the DSEs to easily evaluate different countermeasures and conduct a benefit-cost analysis by inputting project limits and selecting crash data years. CRASH currently includes 135 different improvements types. When the user selects a proposed countermeasure, the application provides a range of CRFs for crashes in various categories based on historical crash reductions or increases associated with past projects. The user can select the standard CRF or input a user defined value in cases where no sufficient studies in Florida exist to develop a state specific CRF.

The CRASH system enables easy performance tracking of safety efforts. It provides various functions for data retrieval and exportation for other analysis and reporting purposes, including the annual HSIP report.



Results

The CRASH application has enabled Florida to develop state-specific CRFs for several countermeasures based on the evaluation results of implemented HSIP projects. The system has also reduced the level of effort required to conduct benefit-cost analyses and project evaluations by automating the processes.

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Safety Evaluation Group

North Carolina

HSIP Noteworthy Practice Series *HSIP Project Evaluation*

In 1999, the North Carolina Department of Transportation (NCDOT) created a permanent group of employees to focus on safety project evaluation. The purpose for the group was to establish a formal project evaluation process to verify the success of the state's efforts in safety.

In the first four years following its formation, the group established a process for conducting project evaluation and identified what results would be most useful to the field engineers. The group's initial efforts were more research and technically oriented but, to better serve the needs of the field engineers, the results of the evaluation studies were simplified (the field engineers were most interested in the before and after crash diagrams and changes in crash patterns). Originally, the group conducted about 50 project evaluations a year with one supervisor and six engineers, but now the group completes approximately 200 evaluations a year with reduced staff (one supervisor, four engineers, and one technician).

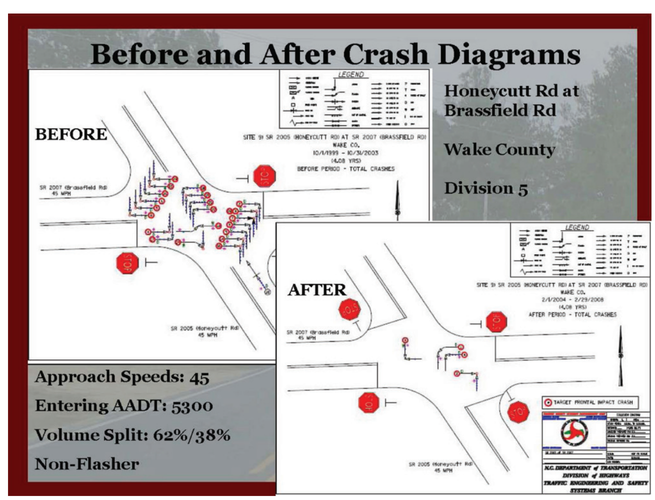
The safety evaluation group conducts simple before-after studies on all spot safety projects once a minimum of three years of before and after data are available (the same time periods are used for both the before and after periods). For each project, the group prepares an evaluation report including before and after crash type and severity data, collision diagrams, photos, and discussion of the study results. After an evaluation report is completed, it is submitted to the field engineer who originally developed the project to provide feedback on whether the project successfully mitigated the previously identified safety issue. For projects unsuccessfully mitigating the safety issue or resulting in a different crash pattern, the evaluation report provides the field engineer with an opportunity to reassess the conditions and identify a different countermeasure. NCDOT is currently working on developing a process to track projects not successfully mitigating the safety issue they were intended to address.

Key Accomplishments

- Established a group focused on safety project evaluation.
- Promoted the use of effective countermeasures.
- Provided feedback to engineers on the effectiveness of their individual safety projects and various countermeasures.

The evaluation group compiles a spreadsheet of all the completed project evaluation studies. The spreadsheet provides the category of improvement, before and after traffic volumes, location, traffic control, geometry, etc., and provides a link to the detailed evaluation report. The spreadsheet is updated regularly and posted on the NCDOT web site (http://www.ncdot.org/doh/preconstruct/traffic/safety/Reports/completed.html). It can be used by engineers to determine which treatments have worked in the past.

The group also develops crash modification factors (CMF) using the Empirical Bayes (EB) method when enough sample sites and data are available. North Carolina specifically focuses on developing CMFs for countermeasures not already extensively researched.



In efforts to promote a particular countermeasure to the field engineers, NCDOT's evaluation group has also conducted studies on well documented countermeasures to provide evidence of crash reduction effectiveness. One example is the use of four-way stop control. Although several studies document the effectiveness of this countermeasure, many field engineers in North Carolina did not consider it a viable countermeasure. The group evaluated over 50 intersections throughout the State and demonstrated four-way stop controls were effective. Study results were presented to field engineers in an effort to change their perspective. While field engineers were very receptive to the study results, it is too early to determine if it has increased the use of four-way stop control in the State.

Results

Since the establishment of the safety evaluation group, North Carolina has evaluated and documented the results of more than 600 projects. The evaluation reports provide field engineers with valuable feedback on the effectiveness of their safety projects, as well as various countermeasures, and promote the use of effective countermeasures.

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University Conducting HSIP Project Evaluations Using Empirical Bayes

Wisconsin

Wisconsin DOT contracted with the University of Wisconsin Traffic Operations and Safety (TOPS) Laboratory to investigate multiple project evaluation methods through a research grant for HSIP evaluation support. Initial research efforts included project evaluations based on before and after collision maps using the software Intersection Magic and before-after evaluations using benefit-cost analysis. From the beginning of the research, the intent was to use Empirical Bayes (EB) analysis in the project evaluations, but Wisconsin did not have safety performance functions (SPFs), which are required for the EB method. However, once the State acquired the SafetyAnalyst software, the TOPS Laboratory was able to incorporate the EB method into the project evaluations by using the SPFs contained in SafetyAnalyst. The SPFs in SafetyAnalyst were developed using national data and are intended to be calibrated to local conditions. While it was not possible to calibrate the SPFs to Wisconsin conditions due to lack of data, the TOPS Laboratory uses the SPFs to provide a comparison of performance in Wisconsin to that of the nation.

The TOPS Laboratory developed a process to extract the appropriate crashes (by location, type, and year) from the Wisconsin crash database based on the project location and scheduled start and completion dates for evaluation purposes. HSIP projects are evaluated based on five years of before data and three years of after data. Fatal and injury crashes are the focus of the evaluation, but the analysis also considers target crash types based on the nature of the improvement.

The TOPS Laboratory conducts a benefit-cost analysis based on results of both a simple before-after evaluation and an EB analysis to evaluate the projects from an economic perspective. This provides a simple comparison of the results of the two evaluation methods (as shown[1]) and demonstrates how a simple before-after evaluation can overestimate the safety benefits.

Key Accomplishments

- Developed a project evaluation process incorporating Empirical Bayes analysis into all HSIP project evaluations.
- Demonstrated the importance of using statistical evaluations to reduce the overestimation of safety benefits due to regression-to-the-mean bias.

S. No.	FOS ID	Benefit-Cost Analysis Using Empirical Bayes Estimates	Benefit Cost Analysis Using Before-After Data
1	10220674	1.38	2.86
2	11504371	31.64	44.66
3	12060680	N/A	N/A
4	15300191	5.34	5.94
5	22001570	1.39	2.01
6	22401570	7.72	7.91
7	40500971	1.01	1.21
8	44790371	5.14	5.34
9	45401572	1.66	1.79
10	46851471	1.22	1.24
11	50600072	0.76	1.28
12	52520071	1.04	2.21
13	69960674	1.58	1.52
14	69991072	-1.19	-0.86
15	70300370	0.33	0.36
16	72200191	13.09	14.66
17	86100270	1.71	1.62
18	86810571	1.44	1.47
19	92000371	2.00	2.94

[1] In the table shown, "S. No." refers to the site number for the project evaluated, and the "FOS (financial operating system) ID" is used by Wisconsin DOT as the specific project identifier.

Results

Originally, engineers in Wisconsin were reluctant to use EB. However, with the assistance of the TOPS Laboratory, the Wisconsin DOT was able to successfully implement a project evaluation process incorporating EB analysis and to receive buy-in at the regional level. The TOPS Laboratory demonstrated the importance of statistical EB techniques in project evaluations through a comparison benefit-cost analysis using simple before and after results to before and after using EB. The results demonstrate the EB analysis reduces the overestimation of safety benefits due to regression-to-the-mean bias.

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