Estimating Crash Modification Factors for Lane Departure Countermeasures in Kansas

tech transfer summary

The safety effectiveness results from this study can be used as a decision-making tool when implementing lane departure countermeasures on similar roadways in Kansas and other states.

Problem Statement

Lane departure crashes make up a significant percentage of Kansas motor vehicle fatalities, so the Kansas Department of Transportation (KDOT) is looking at various countermeasures to reduce the number of these crashes in the state. However, it is important to know which countermeasures will be most effective, because implementing and evaluating the effectiveness of these countermeasures can be costly and time consuming.

Project Objectives

- Identify suitable methods to develop crash modification factors (CMFs) for lane departure countermeasures given the data available
- Estimate CMFs for lane departure countermeasures in Kansas
- Provide recommendations for implementing lane departure countermeasures in the future based on roadway characteristics

Background

Nearly 80% of transportation agencies in the US use CMFs for safety evaluations of design alternatives, expectations, and consistency evaluations. The use of CMFs to estimate the safety effectiveness of countermeasures such as composite shoulders, unpaved shoulders, wide shoulders, and bypass lanes in work zones has not been fully developed specifically for lane departure crashes.

The safety effectiveness of countermeasures can vary due to traffic, environmental, and demographic characteristics; human behavior; road culture; and geometric characteristics of the roadway. It may not be accurate to assume that a countermeasure successful in reducing crashes in a specific location in one region may prevent a similar type of crash in a different region.

Existing methods of developing CMFs can be divided into two main categories: before-and-after studies and cross-sectional studies. Neither method can be used in every situation due to limitations on the required data and expected accuracy. Before-and-after studies require crash data to be gathered from treatment and non-treatment sites and dated before and after the crash time period. Cross-sectional studies require only after-crash data for treatment and non-treatment sites; however, results can vary depending on the methods used to evaluate safety effectiveness.

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Kansas Department of Transportation
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PRINCIPAL INVESTIGATOR
Sunanda Dissanayake, Professor
Department of Civil Engineering
Kansas State University
sunanda@k-state.edu / 785-532-1540

MORE INFORMATION
www.intrans.iastate.edu/

MTC
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103

The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

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Research Methodology

Following discussions with KDOT, six lane-departure countermeasures were selected for further analysis:

- Centerline and shoulder rumble strips
- Paved shoulders
- Median cable barriers
- Chevrons
- Post-mounted delineators
- Safety edges

Only two-lane undivided road segments and four-lane divided road segments were considered for the analysis. These make up a large percentage of the total road network in Kansas, and a majority of lane departure crashes occur on these roadways. Also, consideration was given to data availability for the road segments where the countermeasures had been implemented.

After reviewing the available methods for developing CMFs, the CMFs were estimated for each of the six lane-departure countermeasures using a different, appropriately selected method.

Three methods of developing CMFs were used. Cross-sectional and case-control methods based on cross-sectional data were used to develop CMFs when the date of implementation of the countermeasure was not known. The empirical Bayes (EB) method was selected to develop CMFs where the date of implementation was known, which was the case for safety edge treatments. To check the predictive power of the model validation methods, cross-sectional and case-control methods were employed.

Key Findings

Estimated CMFs from both the cross-sectional and case-control methods showed that the combination of centerline and shoulder rumble strips was the most effective countermeasure to reduce all lane departure crashes on rural two-lane tangent (14% to 33% reduction) and curved road (11% to 24% reduction) segments.

Shoulder rumble strips were shown to have a statistically positive relationship with all lane departure crashes on rural two-lane road segments, which implies that this countermeasure might have a crash increasing effect of 2% to 26%.

Of the two countermeasures considered for the models developed for four-lane divided road segments, shoulder rumble strips with paved shoulders greater than or equal to 2 ft were found to be the most effective countermeasure for reducing all lane departure crashes on tangent road segments, with a 9% to 20% crash-reduction effect.

For the curved road segments, paved shoulders greater than or equal to 2 ft were shown to be the most effective countermeasure, reducing crashes by 16% to 26%. For fatal and injury crashes on four-lane, divided tangent and curved segments, shoulder rumble strips with paved shoulders greater than or equal to 2 ft showed significant crash-reduction effects of 50% to 68% and 69% to 70%, respectively.

Models developed to estimate the safety effectiveness of cable median barriers on four-lane divided road segments showed that cable median barriers reduced all lane departure crashes by 50% to 65% and reduced fatal and injury lane departure crashes by 18% to 61%.

Models developed for chevrons and post-mounted delineators on rural two-lane curved-road segments showed that the presence of chevrons led to a safety effectiveness of 10% to 27% for all lane departure crashes and 12% to 47% for fatal and injury lane departure crashes. Post-mounted delineators showed a safety effectiveness of 15% to 31% for all lane departure crashes and 10% to 32% for fatal and injury crashes. Even though the models were developed to estimate CMFs, they accurately predicted crashes on their respective road segments.

Implementation Readiness and Benefits

Those who rely on modeling methods to test for highway safety effectiveness can use the results of this analysis when considering the choice of their next model methodology.

This study suggests that the case-control method is better suited to develop models for road segments where there are fewer crashes or fewer variations in crashes that do occur. The cross-sectional method is more appropriate for developing models for road segments where there is a larger range in the number of crashes. Furthermore, these two approaches (including the before-and-after EB method) are useful to estimate CMFs for the countermeasures where the implementation date is known.

These findings on the safety effectiveness of the countermeasures considered are based on data from the Kansas road network. The results can be used as a decision-making tool when implementing lane departure countermeasures on similar roadways in Kansas and other states.