An Empirical Bayes Before and After Safety Evaluation of Safety Edge Treatment in Iowa

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Introduction

Problem: Pavement Edge drop-off
- Pavement edge drop-off is the vertical difference in elevation between the paved roadway and the adjacent ground.
- Serious safety concern for vehicles that goes off the track and in order to immediately remount back on the paved roadway encounters tire scrubbing effect.
- lane departure crashes, rollovers, head-on collisions, sideswipes, etc.

Solution: Safety Edge
- A 30 degree fillet constructed along the outside edge of the paved section of roadway which provides a gradual rather than abrupt transition back to the roadway again.

Problem Statement
- Pavement edge drop-off contribute to 18% of rural run-off-road (ROR) crashes. (Hallmark et. al., 2006).
- 11,000 injuries and 160 fatalities are caused each year due to unsafe pavement edges in the United States (FHWA, 2010).
- 150 fatal crashes on rural two-lane roads in Georgia (2004) suggested that 55% of the crashes included edge drop-off issue (Georgia, 2004).

Research Tasks
- Identify road segments provided with Safety Edge in Iowa.
- Identify control segments.
- Conduct a before and after crash analysis to evaluate safety effectiveness of Safety Edge treatment.
- Calculate crash modification factor (CMF).

Data Sources and Description

Locations of Safety Edge segments (Institute of Transportation and Iowa DOT).
Installation Periods (Institute of Transportation and Iowa DOT).
Road and traffic characteristics (Geographic Information Management System (GIMS), Iowa DOT).
11 years of crash data (Iowa DOT).
Crash severity levels (HSIPM, 2010)
- Fatal Injury Crashes (K)
- Disabling Injury Crashes (A)
- Property-Damage-Only (PDO)

Data Quality Assurance

GIMS Characteristics were checked against information from site visits, aerial imagery, and Google forward roadway view.
Contiguous GIMS segments with homogenous roadway characteristics were combined.
Study was concentrated on two-lane rural roadways with asphalt pavement material and with speed limits of 45 mph or more.
Intersection related crashes were manually selected and deleted.
All types of run-off-road crashes chosen as target crashes.

Statistical Method

Development of SPFs
Crisp models were developed using negative binomial regression modeling that is derived from the Poisson model. Predicted number of crashes per segment per year for before and after periods were calculated from the following form:

$$E_i = L_i \cdot \text{EXP} (\theta_0 + \beta X_i)$$

Empirical Bayes Method

Reduces regression to the mean effect

Expected before Crashes

$$N_{ag} = w (N_{pb} + \beta \omega - N_{a})$$
where, $$N_{ag}$$ is predicted before crash frequency from SPFs, and $$\omega$$ is estimated negative binomial model dispersion parameter.

Expected after crashes that would have occurred without the Safety Edge

$$N_{ag} (\text{Expected after}) = N_{bg} (\text{Expected before})$$

Data Quality Assurance

Calculation of Variance of $$\theta$$ and Standard Error (Persaud et al., 2001 and Hauer, 1997)

Target Crashes

Conclusion

- 13.4% reduction for all types of KABCO crashes after the construction of Safety Edge.
- 16.5% reduction for all types of KAB (fatal, major and minor injury) crashes.
- 20% reduction in all types of possible injury (C) and PDO crashes.
- Above results are statistically significant at 95% confidence level.
- Crash reduction for target crashes ranged from 10% to 11% for the three different crash severity levels but were not statistically significant at 95% confidence level.

Limitations and Future Studies

- One third of the total crashes were not coded with any sequence of events.
- Problems in selection of target crashes.
- Improvement in accuracies of GIMS data may improve results.
- Future studies: effectiveness of Safety Edge on 4-lane roads, CMFs for Safety Edge on PCC pavement.

References

- Georgia 2010: Pavement edge drop-off crash problem in Georgia.
- Personal, R. S. Safety Effect of roundabout Conversions in the United States.