Project Summary Report:

FHWA/MT-21-004/9679-699

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Developing a Methodology for Implementing Safety Improvements on Low-Volume Roads in Montana

https://www.mdt.mt.gov/research/projects/planning/lvr-safety.shtml

Introduction

Low-volume roads are an integral part of the highway system serving local traffic in rural areas. These roads usually have two lanes, one in each direction of travel, and many of them are unpaved roads in less populated rural areas. Further, some of the low-volume roads are outside the jurisdiction of state highway departments as they are owned and operated by local agencies such as counties, townships, and tribal governments.

Recent statistics show that about 50 percent of fatal crashes occur on rural roads, even though only 19 percent of the US population reside in rural areas (NHTSA, 2018). This statistic highlights the importance of traffic safety on rural roads, including low-volume roads. While low-volume roads are unique in the type and amount of traffic they serve, they also pose unique challenges for highway agencies particularly those related to safety management programs. Specifically, on roadways with higher traffic volumes, the more frequent occurrence of crashes allows for the direct identification of high crash locations using historical crash data. However, on low-volume roads, crash occurrence, particularly fatal and serious injury crashes, is less frequent. This makes it difficult to identify candidate sites on the network for possible safety improvements using historical crash data. Even so, roadway, roadside and traffic characteristics may lend themselves toward crashes potentially happening at spot locations for increased level of risk. Therefore, an approach for identifying candidate sites for safety improvements on low-volume roads without solely relying on crash history is necessary. Such an approach would help improve safety on low-volume roads, both those operated by the Montana Department of Transportation as well as those operated by local agencies, by reducing the number and severity of highway crashes.

The objective of the current project was to develop a method for identifying candidate sites for safety improvements that would help reduce crashes and severities occurring on the low-volume roads networks. The prospective method would facilitate the implementation of safety improvement programs on low-volume roads despite the challenges discussed earlier.

What We Did

Six major tasks were carried out to achieve the project objective. They are listed as follows.

1. A state-of-the-art review was carried out to review and summarize information about risk factors associated with low-volume roads and the existing network

screening methods. Many research articles, research reports, agency websites, and government publications were used in the literature review task.

2. The second task in the project aimed at developing criteria for assessing the different network screening methods identified in the previous task. Several criteria were developed to examine the merits (or demerits) of any network screening method, to be used later in the assessment of the different network screening methodologies.
3. A review of the state-of-practice was conducted to collect information about safety management practices for low-volume roads across the nation. An online survey was developed and distributed to all the 50 state departments of transportation. The survey inquired about safety management practices on both state-owned and non-state-owned low-volume roads.
4. An assessment of the different network screening methods identified in the first and the third tasks of the project was performed using the criteria developed in the second task. Weights were assigned for different assessment criteria using pairwise comparisons. Further, a scoring scheme was developed for each of the assessment criteria. Using the scoring scheme and criteria weights, the network screening methods were evaluated.
5. A network screening method for low-volume roads in Montana was developed to satisfy three major requirements: 1) Method does not rely on crash history alone in network screening, and 2) Method requires minimal information that can easily be acquired, and 3) Method can be implemented by staff with a limited technical background.
6. The last major analytical project task involved an extensive benefit-cost analysis to investigate the economic feasibility of using the proposed network screening methodology.

What We Found

The state-of-the-art review identified various risk factors associated with safety performance on low-volume roads and different network screening methods. The identified risk factors were all associated with roadway and roadside characteristics. Risk factors related to roadside features, cross-sectional elements, and roadway alignment were found to affect the safety performance on low-volume roads. The identified network screening methods from this task were classified into three classes: methods using historical crash data, predictive models, and methods using crash data and crash prediction models in combination.

In the second task, eight important criteria for assessing the suitability of different network screening methods for low-volume roads were developed and discussed. The eight criteria involved sensitivity to level of risk, sensitivity to economic effectiveness, precision, previous performance record, ease of understanding, ease of implementation, data requirements, and resource requirements.

The state of practice survey was sent to all 50 states, out of which 32 states responded. The major findings regarding the safety management practices for low-volume roads are listed below.

- Cost-effectiveness was the most frequently reported criterion in justifying safety improvement projects on state-owned and non-state-owned low-volume roads. Further, crash severity was the most frequently used criterion for identification of potential safety improvement sites on low-volume roads.
- Around half of the responding agencies reported using the Federal Highway Administration (FHWA) systemic approach in combination with the conventional network screening process. Further, around 70 percent reported allocating less than 20 percent of total safety funds to systemic improvements on non-state-owned local roads.
- About 80 percent of the responding agencies had a separate method for selecting safety improvement sites on state-owned low-volume roads from that used for the rest of the roadway network under their jurisdiction. Crash experience at sporadic sites was the most frequently reported method for identifying safety improvement sites on non-state-owned low-volume roads.
- More than half of the respondents (55 percent) reported using one process for identifying safety improvement sites on both state-owned and non-state-owned low-volume roads.
- Most of the responding agencies (70 percent) reported not allocating a set amount of funds for safety projects on non-state-owned local roads.

Assessment of the different network screening methods using a scoring scheme and weights developed for various assessment criteria was performed in task 4. The assessment found that the conventional crash frequency, rate, and severity method as well as the Highway Safety Manual (HSM) Empirical Bayes (EB) method to have the highest scores, while methods using surrogate safety measures to have the lowest score. While the FHWA systemic approach scored somewhere in the middle, it could have scored much higher if the cost-effectiveness criterion (used in the assessment) had accounted for the high benefit-cost ratio usually associated with low-cost systemic improvements.

The development of the network screening method was accomplished over the next task guided by the following requirements: 1) Method is based on theoretical principles in safety science and/or empirical evidence that are well accepted in practice by the traffic safety community, 2) Method incorporates roadway and roadside characteristics (risk factors) that are associated with crash occurrence, 3) Method does not require extensive and exact roadway and traffic data inputs, and 4) Method is easy to use and requires staff with limited skills and qualifications. The proposed method assigns scores to a site using roadway and roadside characteristics, traffic characteristics, and crash history. Separate scoring schemes were developed for roadway segments and intersections as shown in Figures 1 and 2 respectively. The roadway segment scoring scheme uses lane width, horizontal curvature, grade, driveway density, side slope, roadside fixed objects, pavement presence and condition, speed, volume, and crash history. The intersection scoring scheme uses intersection skew angle, traffic control, presence of turn lanes, presence of lighting, speed, traffic level, and crash history. Scores for roadway and roadside characteristics as well as traffic volumes were derived using published crash modification factors and the HSM safety performance functions, respectively. Scores for crash history were selected such that a single fatal or serious injury crash will cause the site to be identified for consideration of safety improvement regardless of existing roadway and traffic characteristics.

LVR Segments Ranking Scheme	
Safety-Related Questions	**If yes, add:**
Risk Factors	
Total width (TD)	
TD ≤ 20 ft.?	7
20 ft. < TD ≤ 24 ft.?	4
Horizontal curve?	
Flatter curve (R ≥300 ft.)	30
Sharper curve (R<300 ft.)	60
Grade steeper than ± 4%?	3
Six or more driveways per mile?	5
Side slope steeper than 1V:3H?	4
Fixed objects within 15 ft of travel lane?	4
Unpaved Road?	14
Poor pavement condition? (ruting, potholes, etc.)	7
Crash History?	
Fatal or serious injury crashes (N_1)	N_1 X 80
Other crashes (N_2)	N_2 X 5
Relative Risk Compound Score (RRCS)	
Speed ≥ 50 mph?	RRCS X 1.25
Got ADT?	
ADT *≤ 300*	RRCS X 1.0
300 < ADT ≤ 600	RRCS X 3.0
600 < ADT ≤ 1000	RRCS X 5.0
ADT > 1000	RRCS X 7.0
Global Risk Score (GRS)	

Figure 1: Relative Risk Ranking Scheme for Roadway Segments

LVR Intersections Ranking Scheme	
Safety-Related Questions	**If yes, add:**
Baseline Score	50
Roadway Factors	
Skew angle > 20 deg ?	10
Non-controlled intersection?	60
Lighting?	-7
Left-turn lanes on non-controlled approach?	-30
Crash History?	
Fatal or serious injury crashes (N_1)	N_1 X 80
Other crashes (N_2)	N_2 X 5
Relative Risk Compound Score (RRCS)	
Got ADT?	
$ADT_{int} \leq 600$	RRCS X 1.0
$600 \leq ADT_{int} \leq 1200$	RRCS X 2.0
$1200 < ADT_{int} \leq 2000$	RRCS X 4.0
$ADT_{int} > 2000$	RRCS X 6.0
Global Risk Score (GRS)	

Figure 2: Relative Risk Ranking Scheme for Intersections

The final analytical task of the project assessed the benefits of the proposed network screening method. This assessment was done using the conventional benefit-cost analysis. The costs associated with the application of the proposed method are methodology development, training resources development, training sessions, and additional agency staff. The main benefit of using the proposed method is the increase in crash reduction for the selected safety improvement sites. It was assumed that the crash reduction would increase by 5 percent due to the use of a more robust site selection process. The existing crash reduction was found using the crash modification factors for the most common safety countermeasures used on Montana low-volume roads. The benefit-cost ratios for a 10-year analysis period were calculated for three different crash reduction scenarios: reduction in all crashes, reduction in fatal and serious injury crashes only, and reduction in all crashes except property-damage-only crashes. The benefit-cost ratios for the three scenarios varied between 16 and 23 as shown in Table 1.

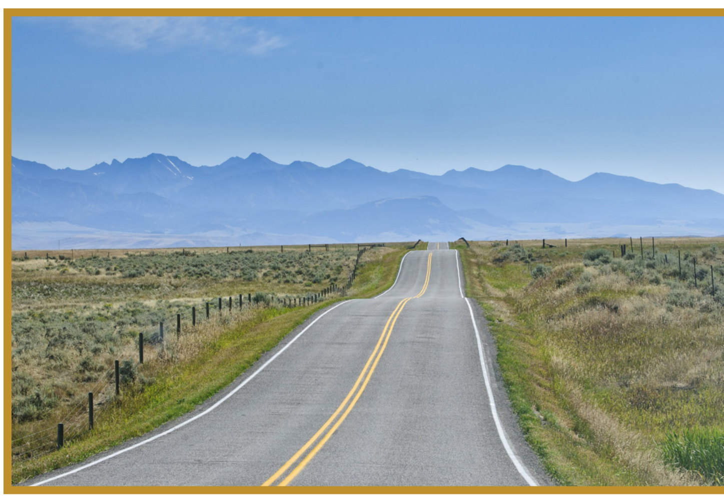
Table 1: Benefit-Cost Ratios for Different Crash Reduction Scenarios

Scenarios	Benefit-Cost Ratios
All crashes (KABCO)	23.29:1
Fatal and serious injury crashes only (K & A Only)	16.09:1
All crashes except no apparent injury crashes (KABC)	20.91:1

What the Researchers Recommend

Given the overall project findings, the researchers' recommendations include:

- Consider reviewing on a periodic basis that the percentage of HSIP Funding being spent on low-volume roads balances with the higher severity crash percentages experienced on these roads.
- Appoint exclusive personnel for safety management on low-volume roads due to the unique safety challenges encountered on these roads and the multi-agency ownership of the low-volume road network.
- Implement the network screening methodology developed in this project for identifying and ranking candidate sites for safety improvement projects. This research project confirmed the lack of any robust and science-based methodology for network screening on low-volume roads at the national level. Therefore, applying the proposed methodology has a lot of potential in improving the safety management process on these roads.
- As a large proportion of low-volume roads is owned and operated by local agencies, appropriate training on the use of the proposed methodology should be provided to local agency staff for those agencies to successfully adopt the new network screening process.
- The full implementation of the proposed methodology by state and local agencies is expected to take some time. Therefore, it is recommended that the proposed method be used in the interim for ranking sites as part of identifying systemic safety improvement project sites, or as part of selecting safety improvement project sites on local roads, i.e., using the methodology score as one of the considerations in selecting safety improvement project sites on Montana low-volume roads.



References

National Highway Traffic Safety Administration (NHTSA). Rural Urban Comparison of Traffic Fatalities. Washington D.C. (2018).

For More Details . . .

The research is documented in Report FHWA/MT-21-004/9679-699, https://www.mdt.mt.gov/research/projects/planning/lvr-safety.shtml.

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MDT Implementation Status: September 2021

Implementation will be documented in the Implementation Planning and documentation form for this project as per the implementation report, which can be found at the above URL.