Joint Transportation Research Program

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Safety Performance of Non-Signalized Traffic Control Strategies

Research Problem

One of the objectives of Indiana's Safety Management Program is improving safety at rural high-speed, two-way stop-controlled (TWSC) intersections. These intersections account for a considerable number of serious crashes statewide that have a high risk for serious injuries and fatalities. Human errors, aggressive behavior, and violation of the right of way, coupled with high traffic volumes and speeds, create risky conditions that result in frequent collisions and severe outcomes.

Serious crashes at TWSC intersections occur even at sites that do not exhibit obvious deficiencies in geometry and traffic control. This confirms that human error is a primary causal factor for crashes, which is compounded by high speeds reducing driver reaction time. Intersection Conflict Warning System (ICWS) is designed to alert drivers on the crossing road about vehicles approaching or entering the TWSC intersection from a high-speed major road. This system is viewed as a promising countermeasure for the aforementioned conditions. Recently, the Indiana Department of Transportation (INDOT) installed these systems at 17 intersections statewide.

The primary objective of this research was to evaluate the effectiveness of the installed conflict warning system and to identify local conditions that make the system more effective. There were three research elements in the reported study.

1. The frequency and severity of crashes was compared before and after installation of the system, and safety changes that were observed at similar intersections without ICWS were implemented.
2. Conditions were identified that justified installation of the system to increase the effectiveness of this countermeasure. The conditions considered included speed, volume, road geometry, and sight distance.
3. Crash modification factors (CMF) were estimated for ICWS at various levels of severity to see if the countermeasure affected severity differently at different levels. If not, a single CMF was proposed instead.

Findings

This study investigated the effectiveness of ICWS installed at unsignalized TWSC intersections in Indiana. Since the ICWS system was only installed at high-crash locations, several intersections with no ICWS were used as control intersections to adjust for the expected selection bias.

A negative binomial analysis was used to identify key safety factors at the TWSC intersections studied. The results confirmed that ICWS reduced the number of crashes. Although traffic volume was associated with the increased crash risk, three-legged intersections experienced lower risk, and the presence of medians with speed limits under 45 mph decreased the crash risk.

While previous studies have reported mixed results on the effectiveness of ICWS across different states, they did not explore the relationship between system performance and traffic volume. By including AADT as a safety factor, this research could demonstrate that the system's effectiveness was reduced at intersections with a high traffic volume on major roads. This insight calls for a more customized criteria for installing the system. For more robust decision-making, it is recommended that the decision to install the system be supported with a benefit-cost (B-C) analysis. Statistical models of crash frequency and severity were developed in this study to facilitate the B-C analysis.

The field observations conducted with the help of the CRS traffic scanning system (TScan) provided no statistical evidence of speed reduction on the main road after the system was installed and activated. This finding eliminated the primary method by which the system was expected to reduce crash severity. Indeed, the statistical analysis confirmed that the crash reduction might be assumed equal at all the studied levels of crash severity. This safety improvement was particularly effective at intersections with low volumes on major roads, but it was less effective at intersections with higher volumes on major roads. The safety benefits at locations with a major road AADT higher than 9,000 veh/day could not be confirmed. Consequently, the estimated crash modification factors (CMF) increase with the increase of the major traffic volume, and CMF reaches 1.00 at an AADT close to 9,000 veh/day. This result applied to crashes at all the severity levels.

An attempt to confirm the safety improvement mechanism with an expected increase in the post-encroachment time (PET) at intersections with the installed ICWS was inconclusive due to the insufficient number of safety-relevant low-value PETs. Although the cumulative distributions showed an increased proportion of high PET values, they were within the range of long and safe values of PET.

Implementation

The statistical analysis confirmed that ICWS installations at rural TWSC intersections have a considerable and statistically significant reduction in the number of crashes. However, the effectiveness diminished at intersections with high AADT on a major road. It is presumed that this trend was caused by the growing frequency of warnings that make drivers wait a long time for a gap. This situation caused impatience, and it made drivers prone to ignore the warnings. The research identified the volume upper range of 9,000 veh/day on a major road to as a potential location for safety improvement after the ICWS installation. The recommended CMF factor is calculated with the developed equation in this project, which involves AADT on the major road. The equation is applicable to major road AADT between 2,000 and 9,000 veh/day. The lower range is the value observed in the field. The actual lower range should be decided based on the B-C analysis.

The analysis of crash severity before and after installation of the ICWS did not confirm that the crash reduction was different at different crash severity levels. It implied that a common CMF may be used for all the crash severity levels.

Although the AADT upper range on major roads is a convenient criterion for installing the ICWS; to make the countermeasures more cost-effective at the system level, the benefit-cost (B-C) analysis is recommended for individual installation. The analysis should involve consideration of the installation and maintenance costs, and an assessment of the expected safety benefits should be calculated with the help of the CMF equation provided.

The B-C analysis for Indiana safety projects is facilitated with a tool called RoadHAT. Although the presented study provides some of the needed inputs, the current version of RoadHAT needs to be modified. The current RoadHAT version assumes that considered safety improvements have fixed CMFs, and that they are applied repeatedly at a frequency determined by the countermeasure's fixed lifetime. In the case of the ICWS, the safety effect of the countermeasure varies with the traffic volume and may need to be removed when the AADT reaches a critical value.

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