TECHBRIEF

Safety Evaluation of Red-Light Indicator Lights (RLILs)

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This document is a technical summary of the Federal Highway Administration report *Safety Evaluation of Red-Light Indicator Lights (RLILs)* (FHWA-HRT-17-077).

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Objective

The Federal Highway Administration (FHWA) established the Development of Crash Modification Factors (DCMF) program in 2012 to address highway safety research needs for evaluating new and innovative safety strategies (improvements) by developing reliable quantitative estimates of their effectiveness in reducing crashes. The goal of the DCMF program is to save lives by identifying new safety strategies that effectively reduce crashes and promote those strategies for nationwide implementation by providing measures of their safety effectiveness and benefit–cost (B/C) ratios through research. State transportation departments and other transportation agencies need to have objective measures for safety effectiveness and B/C ratios before investing in broad applications of new strategies for safety improvements. Forty State transportation departments provide technical feedback on safety improvements to the DCMF program and implement new safety improvements to facilitate evaluations. These States are members of the Evaluation of Low-Cost Safety Improvements Pooled Fund Study, which functions under the DCMF program.

This study investigated the safety effectiveness of red-light indicator lights (RLILs). This effort was intended to reduce the frequency of crashes resulting from drivers disobeying traffic signals by providing a safer and more efficient means for police to enforce the red interval and educate drivers about the existence and purpose of RLILs.

Few studies have explored the safety effectiveness of RLILs; specifically, studies have not shown the crash-based safety effectiveness for four-legged intersections. This study sought to fill this knowledge gap.

Introduction

RLILs—also known as signal indicator lights, enforcement lights, rat lights or boxes, or tattletale lights—are mounted on the signal head or mast arm and activate simultaneously with the red interval. This allows an enforcement officer downstream to identify if a vehicle has violated the red interval.

In its series on innovative intersection safety treatments, the FHWA presented a summary on enforcement lights.(1) The summary states that enforcement lights can provide safety, efficiency, and/or cost benefits compared to other enforcement methods, including the following:

- Allows red-light running monitoring from downstream of any leg of an intersection.
- Eliminates the need for unsafe pursuit from an officer positioned upstream. The officer would normally need to cross the intersection during the red interval.
- Allows one officer to conduct downstream enforcement (instead of requiring two officers), resulting in increased efficiency.
- Has lower installation and maintenance costs than automated enforcement systems (e.g., red-light camera enforcement).
- Does not use controversial automated photography.

A literature review revealed that white enforcement lights allowed police officers in Hillsborough County, Florida, to operate more effectively by reducing the required manpower for red-light enforcement by half.(2) Prior to installation, it took two officers to enforce red lights (one upstream to observe the red light and the other downstream to apprehend the offending driver). The number of red-light running citations increased from 17,561 per year to 24,551 per year after treatment. The researchers documented that police officers found the white lights made the task of red-light enforcement simpler and safer. The red-light violation data collected at the study intersections showed a statistically significant reduction at the 90-percent confidence level in violations, from 759 to 567, after white-light installation.

A review of the crash data indicated an average of 828 crashes per year at the sites before treatment and 860 crashes per year after treatment. Further analysis determined an average of 56 disregarded traffic signal crashes per year in the before period and 52 crashes per year in the after period. Considering only the approaches with white lights, red-light running crashes decreased from 40.17 crashes per year to 28 crashes per year after treatment. The authors noted an increase in all crashes countywide during the study period, while the trend in red-light running crashes stopped increasing in 2002, the year that white-light installation began.

Methodology

This research examined the safety impacts of the application of RLILs at signalized, four-legged intersections in Florida. Installations included blue-light-emitting diode and white incandescent indicators mounted directly on the signal head or mast arm.

The objective of this study was to estimate the safety effectiveness of this strategy as measured by crash frequency. The authors only evaluated intersection-related crashes and the following subtarget crash types:

- Total crashes (all types and severities combined).
- Fatal and injury crashes (K, A, B, and C injuries on KABCO scale) (K is fatal injury, A is incapacitating injury, B is non-incapacitating injury, C is possible injury, and O is property damage only).
- Right-angle crashes (all severities combined).
- Left-turn crashes (all severities combined).
- Rear-end crashes (all severities combined).
- Crashes in which driver(s) disobeyed traffic signal (all severities combined).
- Nighttime crashes (all severities combined).

The researchers used the empirical Bayesian (EB) methodology for observational before–after studies for the evaluation.[3] This methodology is considered rigorous in that it accounts for regression to the mean using a reference group of similar but untreated sites.

In the process, the use of safety performance functions (SPFs) addressed the following:

- Overcame the difficulties of using crash rates in normalizing for volume differences between the before and after periods.
- Accounted for time trends.
- Reduced the level of uncertainty in the estimates of safety effect.
- Properly accounted for differences in crash experience and reporting practice in amalgamating data and results from diverse jurisdictions.
- Provided a foundation for developing guidelines for estimating the likely safety consequences of a contemplated strategy.

The researchers estimated the SPFs used in the EB methodology through generalized linear modeling assuming a negative binomial error distribution, which is consistent with the state of research in developing these models. In specifying a negative binomial error structure, the research team iteratively estimated an overdispersion parameter from the model and the data and used this parameter in the EB calculations. For a given dataset, smaller values of this parameter indicate relatively better models.

The full report includes a detailed explanation of the methodology, including a description of how the estimate of safety effects for target crashes was calculated.

Results

Based on the data for all three districts combined, this brief presents results in two parts. The first part contains aggregate results, and the second part is based on a disaggregate analysis that attempted to discern factors that may be most favorable to the installation of enforcement lights.

Aggregate Analysis

Table 1 shows the aggregate results for all three districts and provides the estimates of expected crashes in the after period without treatment, the observed crashes in the after period, and the estimated CMF and its standard error (SE) for all crash types considered.

The results in table 1 indicate statistically significant reductions at the 95-percent confidence level for all crash types analyzed except rear-end crashes, for which the negligible increase (CMF = 1.02) was not statistically significant at the 95-percent confidence level. The crash type with the smallest CMF (which translates to the greatest reduction) was left-turn crashes with a CMF of 0.600. For all crash types combined, the researchers estimated a CMF of 0.94. The CMFs for fatal and injury, right-angle, disobeyed-signal, and nighttime crashes were 0.86, 0.91, 0.71, and 0.89, respectively.

Disaggregate Analysis

The disaggregate analysis sought to identify those conditions under which the treatment is most effective. Since total, fatal and injury, right-angle, and disobeyed-signal crashes were the focus of this treatment, these crash types are the focus of the disaggregate analysis. The results in table 2 suggest the RLILs become more effective with time. This was evident, as the CMFs for total, fatal and injury, and right-angle crashes become smaller as additional time accumulates for the treatment.

Table 1. Aggregate results.

Statistic	Total	Fatal and Injury	Right-Angle	Left-Turn	Rear-End	Disobeyed-Signal	Nighttime
EB estimate of crashes expected in the after period without strategy	5,337.4	2,816.0	1,023.3	507.3	2,291.6	470.8	1,673.8
Count of crashes observed in the after period	5,012	2,411	927	305	2,329	336	1,495
Estimate of CMF	0.939*	0.856*	0.905*	0.600*	1.016	0.713*	0.892*
SE of estimate of CMF	0.022	0.027	0.042	0.041	0.033	0.048	0.034

*Indicates CMF estimates that are statistically significant at the 95-percent confidence level.

Table 2. Results disaggregated by treatment duration and district.

Crash Type	Treatment Duration	CMF (SE)	District	CMF (SE)
Total crashes	1	1.024 (0.037)	1	0.736 (0.077)*
Total crashes	2	0.963 (0.027)	2	0.995 (0.033)
Total crashes	2+	0.939 (0.022)*	5	0.934 (0.031)*
Fatal and injury crashes	1	0.917 (0.047)	1	0.676 (0.082)*
Fatal and injury crashes	2	0.888 (0.035)*	2	0.895 (0.044)*
Fatal and injury crashes	2+	0.856 (0.027)*	5	0.868 (0.037)*
Right-angle crashes	1	0.989 (0.079)	1	0.756 (0.112)*
Right-angle crashes	2	0.944 (0.057)	2	1.036 (0.075)
Right-angle crashes	2+	0.905 (0.042)*	5	0.856 (0.054)*
Disobeyed-signal crashes	1	0.748 (0.099)*	1	0.368 (0.086)*
Disobeyed-signal crashes	2	0.784 (0.074)*	2	0.797 (0.088)*
Disobeyed-signal crashes	2+	0.713 (0.048)*	5	0.750 (0.066)*

*Indicates CMF estimates that are statistically significant at the 95-percent confidence level.

For enforcement and education practices, the research team disaggregated the results by district, as shown in the last two columns of table 2. Across all crash types, the CMFs were smallest for district 1. Local agencies in district 1 responded to the research team regarding the enforcement of the indicator lights. Several counties and cities reported initial advertisements in local newspapers and participation in awareness campaigns. Additionally, a few agencies in this district noted that they utilized the lights and increased enforcement after their application. No agencies in districts 2 or 5 reported awareness campaigns or increased enforcement. The CMF estimates for districts appear to support these implementation practices.

Further analyses indicated RLILs appear to be more effective for total, fatal and injury, and right-angle crashes in rural areas; at signalized intersections with lower total entering volume; and a lower proportion of entering traffic from the minor road. The researchers found the opposite to be true for disobeyed-signal crashes where RLILs appear to be more effective in urban areas, at signalized intersections with higher total entering volume, and a higher proportion of entering traffic from the minor road. Results showed positive correlation between total entering volume, number of RLILs, proportion entering from the minor road, and area type. These factors should not be combined for quantitative analysis, but they could be considered when prioritizing intersections for treatment.

Economic Analysis

For the purposes of the economic analysis, the research team conservatively assumed the treatment as the installation of RLILs for which the recommended combined CMF was 0.94 for total crashes (table 1). The analysis assumed that the installation of RLILs cost $3,000 per intersection. In total, 108 intersections received the RLIL treatment at an estimated cost of $324,000. The analysis assumed the useful service life for safety benefits was 5 years. This is likely conservative, since it is the minimum service life reported from several vendors, who indicated potential service lives of up to 10 years.

The FHWA Office of Safety Research and Development suggests that, based on the Office of Management and Budget *Circular A-4,* a real discount rate of 7 percent be applied to calculate the annual cost of the treatment for the 5-year service life.[4] With this information, the capital recovery factor is 4.1 for all intersections.

For the benefit calculations, the researchers applied the most recent FHWA mean comprehensive crash costs, at the time the research was performed, disaggregated by crash severity and crash geometry type as a base.[5]

The researchers calculated the total crash reduction by subtracting the actual crashes in the after period from the expected crashes in the after period had the treatment not been implemented. They then divided the total crash reduction by the average number of after-period years per site to compute the total crashes saved per year. The number of total crashes saved per year was 58.7 for all intersections. Considering the number of treated intersections, this resulted in an average savings of 0.54 crashes per intersection per year.

The researchers obtained the annual benefits (i.e., crash savings) by multiplying the crash reduction per site year by the cost of a crash, all severities combined. The research team calculated the B/C ratio as the ratio of the annual benefit to the annual cost. The B/C ratio is 92:1 for all signalized intersections. The U.S. Department of Transportation (USDOT) recommends that sensitivity analysis be conducted by assuming values of a statistical life of 0.57 and 1.41 times the recommended 2014 (when the research was performed) value.[6] These factors can be applied directly to the estimated B/C ratios to get a range of 53:1 to 130:1 for all signalized intersections.

These results suggest that the strategy, even with conservative assumptions on cost, service life, and the value of a statistical life, can be cost effective for reducing total crashes at signalized intersections. While the resulting B/C ratio is very high, users should keep in mind the low-cost nature of this strategy and that implementing other strategies with lower B/C ratios may result in larger reductions in crashes.

Summary and Conclusions

The objective of this study was to undertake a rigorous before–after evaluation of the safety effectiveness, as measured by crash frequency, of RLILs. The research team recommended the CMFs shown in table 3 for various crash types.

A disaggregate analysis of the results indicated that RLILs are almost immediately effective, and the effect is sustained for disobeyed-signal crashes. For other crash types, CMFs decrease over the first few years of treatment, suggesting that they are more effective for reducing crashes as drivers become accustomed to them. The only district with agencies that noted increased enforcement and public awareness campaigns found the smallest CMFs. The researchers found no significant difference between indicator types used.

Additionally, RLILs appear to be more effective for total, fatal and injury, and right-angle crashes in rural areas; at signalized intersections with lower total entering volume; and a lower proportion of entering traffic from the minor road. The researchers found the opposite to be true for disobeyed-signal crashes where RLILs appear to be more effective in urban areas, at signalized intersections with higher total entering volume, and a higher proportion of entering traffic from the minor road. The analysis showed that quantitative analyses should not combine these factors but can consider them when prioritizing intersections for treatment.

The B/C ratio, estimated with conservative cost and service life assumptions and considering the benefits for total crashes, was 92:1 for all signalized intersections. With the USDOT recommended sensitivity analysis, this value could range from 53:1 to 130:1. These results suggested that the strategy—even with conservative assumptions on cost, service life, and the value of a statistical life—can be cost effective.

Table 3. Results for Florida.

Variable	Total	Fatal and Injury	Right-Angle	Left-Turn	Rear-End	Disobeyed-Signal	Nighttime
Estimate of CMF	0.939*	0.856*	0.905*	0.600*	1.016	0.713*	0.892*
SE of estimate of CMF	0.022	0.027	0.042	0.041	0.033	0.048	0.034

*Indicates CMF estimates that are statistically significant at the 95-percent confidence level.

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