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Effectiveness of red light running camera enforcement program in reducing crashes: Evaluation using “before the installation”, “after the installation”, and “after the termination” data

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ABSTRACT

The focus of this manuscript is to evaluate and assess the effectiveness of red light running camera (RLC) enforcement program in reducing crashes at signalized intersections. Data from January 1997 to December 2010 for thirty-two signalized intersections in the city of Charlotte, North Carolina, where RLCs were installed between August 1998 and August 2000 and terminated in fall 2006, were gathered, analyzed, and compared for “before the installation”, “after the installation”, and “after the termination” periods. Descriptive analysis and paired *t*-tests were performed using rear-end, sideswipe, left-turn, angle, and right-turn crashes as well as the number of total crashes. The expected number of total crashes, had RLC enforcement program not been implemented, was computed using the empirical bayes (EB) method and compared to the actual number of total crashes for “after the installation” and “after the termination” periods. Results obtained indicate that RLC enforcement program leads to an increase in sideswipe and rear-end crashes at ≥50% of the signalized intersections. It is effective in reducing total crashes at 50% and 16% of the thirty-two signalized intersections when analyzed considering “before the installation – after the installation” and “before the installation – after the termination” scenarios, respectively. Benefits due to reduction in the number of total crashes may be higher if RLC enforcement program is implemented at signalized intersections with (1) total entering vehicles per day less than 40,000, (2) fewer than 20 rear-end crashes per year, or (3) fewer than 5 sideswipe crashes per year.

1. Introduction

Red light running is a significant traffic safety problem at many urban and rural signalized intersections. It is defined legally based on whether the law in effect allows “restrictive yellow” or “permissive yellow” (USDOT, 2012). Under a “restrictive yellow” rule, a motorist can neither enter nor be in the intersection on red. A violation occurs if the motorist has not cleared the intersection after the onset of red. Under a “permissive yellow time” rule, as stated in the Manual on Uniform Traffic Control Devices (MUTCD) and Uniform Vehicle Code (UVC), a motorist can legally enter the intersection during the entire yellow interval. In this case, violation occurs if the motorist enters the intersection after the onset of red.

Higher red light running rates are observed in cities with wider intersections and higher traffic volumes, and mostly from 3 PM to 6 PM (Porter and England, 2000). The red light runners are more likely to be younger than age 30, male, have prior moving violations and convictions, and invalid driver’s licenses (Retting et al., 1999). They are also less likely to wear safety belts (Porter and England, 2000). Hispanic subgroups may be more vulnerable to red light running, while driving under the influence of alcohol has an effect on the number of red light running violations (Romano et al., 2005).

In the United States, more than 760 people were killed and an estimated 165,000 people were injured in crashes involving red light running during 2008 (USDOT, 2012). The estimated economic losses due to red light running exceed $14 billion per year, and more than half of the deaths in red light running crashes are other motorists and pedestrians (Blakey, 2012; USDOT, 2005).

Red light running camera’s (RLCs) are automated enforcement systems which detect a vehicle that run a red light and issue a citation. They have been and are being widely used to improve safety at signalized intersections, in many countries, since 1980s (South et al., 1988; Maekinen and Oei, 1992; Hillier et al., 1993; Wissinger et al., 2000). The first sustained RLC enforcement program in the United States was implemented in the New York City in 1992, with about twelve municipal enforcement programs active by 1998. A 2002 nationwide survey sponsored by the National Highway Traffic Safety Administration (NHTSA) and conducted by the Gallup

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Organization found that 75% of motorists favor RLC enforcement program (NHTSA, 2004). Retting et al. (1998), Ruby and Hobeika (2003), Hobeika and Yaungyai (2004), and Retting et al. (2008) observed that RLC enforcement program lowers red light running violations. An increase of the intersection yellow change interval combined with RLC enforcement program produces a reduction of up to 72% in red light violation rate (Hobeika and Yaungyai, 2004). Not moving or rotating the RLCs and keeping enforcement predictable yields a lower average violation rate than moving the RLCs around and making enforcement uncertain (Tay and de Barros, 2009, 2011).

In a recent research, Porter et al. (2013) utilized a opportunity (as the Virginia state legislature allowed the law permitting automated enforcement for red light running violations to expire in 2005) and conducted research to evaluate what would happen to red light running behavior at formerly enforced locations. They found that the low red light running rates at the previously enforced locations had recidivated to red light running rates of the control locations within a year of the law's expiration.

Several authors have researched on the effectiveness of RLC enforcement program in reducing crashes. Retting et al. (1998) found that crashes reduced by the 7%, injury crashes reduced by 29%, right-angle crashes reduced by 32%, and right-angle crashes involving injuries reduced by 68% after the installation of RLCs in Oxnard, CA. Fitzsimmons et al. (2007) found that the expected average number of total crashes per quarter decreased by 20% from the before to after periods for intersections with RLC enforcement, while total number of crashes increased by almost 7% for control intersections. Hu et al. (2011) through research found that RLC enforcement programs were associated with a statistically significant citywide reductions of 24% in the rate of fatal red light running crashes and 17% in the rate of all fatal crashes at signalized intersections, when compared with rates that would have been expected without RLCs. In general, RLCs lower right-angle crashes (Hillier et al., 1993; Retting et al., 2003; FHWA, 2005; Shin and Washington, 2007) but leads to an increase in rear-end crashes (Hillier et al., 1993; FHWA, 2005; Garber et al., 2007; Shin and Washington, 2007). They are, hence, beneficial at intersections with relatively few rear-end crashes and many right-angle crashes (FHWA, 2005; Council et al., 2005). The greatest economic benefits are associated with higher total entering vehicles per day, with a high ratio of right-angle to rear-end crashes, with shorter cycle lengths and inter-green periods, and with one or more protected left-turn phases (FHWA, 2005; Council et al., 2005).

Garber et al. (2007) found that the total number of crashes increased after the implementation of the RLC enforcement program. They hypothesized that a large increase in rear-end crashes after RLC installation might be followed by a decrease in rear-end crashes as motorist become habituated to the RLC enforcement program, but found no such change.

Overall, most researchers compared data "before the installation" and "after the installation", for treatment intersections and control intersections or at an aggregate level to evaluate the effectiveness of RLC enforcement program in the past. Several intricate details pertaining to crash types and aspects related to where RLCs might work are generally ignored when analyzing at an aggregate level.

The authors of this manuscript concur with Tay and de Barros (2011) that agencies should not be using RLC enforcement program for revenue generation, but instead implement it at signalized intersections that are most prone to crashes. Several aforementioned research efforts assist in identifying signalized intersections that would benefit from such a program. Negative consequences have to be accounted for in such a decision-making process.

As observed by Walden et al. (2011) and Porter et al. (2013), terminating the RLC enforcement program could revert and increase red light running violation rates over time. If this is the case, the number of total crashes should increase over time at the previously enforced signalized intersections. However, no work comparing crash data "before the installation", "after the installation", and "after the termination" of RLC enforcement program could be found in the existing body of knowledge to support this notion.

This research utilizes data from "after the installation" and "after the termination" time periods and compares it with "before the installation" time period to assess and affirmatively state whether RLCs help reduce crashes, and, where they could be more effective.

2. Methodology

Two different scenarios were considered to evaluate the effectiveness of RLC enforcement program in reducing crashes at signalized intersections. They are: "before the installation – after the installation" scenario and "before the installation – after the termination" scenario. The study design is similar to the removed-treatment quasi-experiment design comparing with pretest and posttest (Cook and Campbell, 1979).

2.1. Selection of signalized intersections and study periods

Thirty-two signalized intersections in the city of Charlotte, North Carolina were selected for evaluation and assessment. RLCs were installed at these thirty-two signalized intersections between August 1998 and August 2000. The RLC enforcement program was suspended in March of 2006 and citations were no longer issued. It was eventually terminated and the equipment was removed in July 2006. The majority of the warning signs at the selected signalized intersections were removed between July and September of 2006. The reasons for suspension and termination of the RLC enforcement program are outside of the scope of this research and manuscript.

The period from January 1997 to a month "before the installation" of RLC and its activation at a signalized intersection was considered as "before the installation" period. This varied from 1.5 years to 3.5 years based on the installation month. The period from 6 months "after the installation" of RLC and its activation at the signalized intersection to December 2005 was considered as "after the installation" period. The period from January 2007 to December 2010 was considered as "after the termination" period.

Wilson et al. (2009) through research and review of case studies found that time halo effect may vary from one hour to eight weeks after the enforcement activity is ceased. As exact dates pertaining to the installation/removal of signs and equipment as well as the duration and type of outreach/awareness program was not available, periods longer than eight weeks were considered to account for novelty and adjustment effects in this research. Overall, one month "before the installation", 6 months "after the installation", and year 2006 were not considered for analysis to minimize novelty and adjustment effects.

2.2. Data collection

Available crash data and total entering vehicles (traffic volume) data from 1997 to 2010 was obtained for eighty signalized intersections (includes thirty-two signalized intersections with RLC, while the remaining are similar/control signalized intersections) from the city of Charlotte Department of Transportation (CDoT). Crash data prior to 1997 was not available for this research as CDoT changed from an older data system to a newer data system to enter, store, and archive crash database from 1997.

As roadway/network characteristics influence crashes, data pertaining to whether the intersection is skewed (angle between approaches is less than 80 degrees or greater than 100 degrees), the number of approaches with a median, speed limit on the major