Transportation Research Part F 37 (2016) 144–153

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

A field investigation of red-light-running in Shanghai, China

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ARTICLE INFO

Article history:
Received 1 May 2014
Received in revised form 3 April 2015
Accepted 13 December 2015
Available online 13 January 2016

Keywords:
Signalized intersection
Red-light-running
Field investigation
Comparison group
Driver characteristics
Random effects logistic regression model

ABSTRACT

Red-Light-Running (RLR) is the major cause of severe injury crashes at signalized intersections for both China and the US. As several studies have been conducted to identify the influencing factors of RLR behavior in the US, no similar studies exist in China. To fill this gap, this study was conducted to identify the key factors that affect RLR and compare the contributing factors between US and China. Data were collected through field observations and video recordings; four intersections in Shanghai were selected as the study sites. Both RLR drivers and comparison drivers, who had the opportunity to run the light but did not, were identified. Based on the collected data, preliminary analyses were firstly conducted to identify the features of the RLR and comparison groups. It was determined that: around 57% of RLR crossed the stop line during the 0–0.4 second time interval after red-light onset, and the numbers of red light violators decreased as the time increased; among the RLR vehicles, 38% turned left and 62% went straight; and at the onset of red, about 88% of RLR vehicles were in the middle of a vehicle platoon. Furthermore, in order to compare the RLR group and non-RLR group, two types of logistic regression models were developed. The ordinary logistic regression model was developed to identify the significant variables from the aspects of driver characteristics, driving conditions, and vehicle types. It was concluded that RLR drivers are more likely to be male, have local license plates, and are driving passenger vehicles but without passengers. Large traffic volume also increased the likelihood of RLR. However, the ordinary logistic regression model only considers influencing factors at the vehicle level: different intersection design and signal settings may also have impact on RLR behaviors. Therefore, in order to account for unobserved heterogeneity among different types of intersections, a random effects logistic regression model was adopted. Through the model comparisons, it has been identified that the model goodness-of-fit was substantially improved through considering the heterogeneity effects at intersections. Finally, benefits of this study and the analysis results were discussed.

1. Introduction

Red-Light-Running (RLR) is a common traffic violation and the major cause of crashes at signalized intersections (Wang, Zhang, & Wang, 2011). In the United States, RLR is associated with about 260,000 crashes and 750 fatalities each year

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http://dx.doi.org/10.1016/j.trf.2015.12.010
1369-8478/

(Retting & Williams, 1996). In China, according to the statistics revealed by The Ministry of Public Security (2012), 4227 severe injury crashes and 789 fatalities between January and October 2012 were attributable to RLR.

Given the similar traffic safety problems caused by RLR in China and the US, there are major gaps between the two countries in the aspects of traffic regulations, enforcement procedures, and signal settings. For example, traffic regulations in China do not allow vehicles to enter the intersection during the yellow phase, whereas it is legal in the US. Another difference is that red light cameras are more frequently used in China compared to the US. Regarding the signal settings, green signal countdown displays are commonly utilized in China to make it easier for drivers to anticipate the end of the green phase, to avoid entering the intersection during the yellow phase.

Previous studies focused on RLR in the US have provided important findings regarding the characteristics of RLR behavior, which include the characteristics of drivers and corresponding driving conditions. However, RLR studies in China have only focused on the characteristics of RLR vehicles; no comparison studies that investigate factors that would separate RLR and non-RLR vehicles have been conducted. This study fills the gap through acquiring data for both RLR and non-RLR vehicles, and the development of models to identify the influencing factors for RLR events. Results from this study will be compared to studies in the US, which will further help us to understand the RLR events across different countries.

Data of RLR drivers and comparison drivers (who did not run the red lights) were collected at four intersections in the urban area of Shanghai. Drivers' genders, safety belt use, hand-held cell phone use, and presence of passengers were manually recorded by observers at each intersection and double checked through video recordings; drivers' vehicle operations as they approached and traveled through the intersections were recorded by video cameras. The characteristics of RLR drivers and comparison drivers were then compared through preliminary analysis with a Chi-square test and systematic modeling analysis with an ordinary logistic regression model. However, the ordinary logistic regression models only have the capability of analyzing variables at the vehicle level; factors at the intersection level (such as position of traffic signals and lane markings) may also have substantial influence on red-light running behavior. Because these variables were not included in the ordinary logistic regression model analysis due to the small sample size, a random effects logistic regression model was utilized to capture the influence of unobserved heterogeneity across the intersections.

2. Background

Previous RLR studies in the US have examined various aspects of RLR, which include RLR prevalence, frequency, antecedents (e.g., signal control, cycle length), and correlates (e.g., age, gender). For example, Retting and Williams (1996) conducted an on-site survey in Arlington County, Virginia, and observed 462 RLR drivers and 911 non-RLR drivers during 234 h of data collection. They found that 48% of RLR drivers entered the intersection 0.5–0.9 s after red onset; 34% at 1.0–1.4 s; 11% at 1.5–1.9 s; and 7% at least 2.0 s. It was also identified that longer red intervals were associated with higher RLR frequencies. Additionally, Yang and Najm (2007) analyzed 47,000 red light violations captured by enforcement cameras from 11 signalized intersections in the city of Sacramento, California. They found that the 8:00 PM to 5:00 AM off-peak period had fewer RLR drivers, but that the RLR drivers showed a higher probability of entering intersections two or more seconds after red onset.

Regarding driver characteristics, RLR drivers have been found to be younger, less likely to be belted, have worse driving records, and drive smaller and older vehicles than the non-RLR drivers (Retting & Williams, 1996). Other researchers have also found RLR drivers to be unbelted (Porter & England, 2000); they are more likely to be male (Retting, Ulmer, & Williams, 1999) and without passengers (Porter & Berry, 2001).

Signaling, traffic, and geometric variables have also been identified to be associated with RLR. When the yellow signal duration is under 3.5 s, drivers are more likely to run red lights compared to longer yellow signal timing (Brewer, Bonneson, & Zimmerman, 2002). However, longer yellow timing alone does not always eliminate the need for better enforcement (Retting, Ferguson, & Farmer, 2008), since it also has been observed that shorter duration light cycles are associated with higher rates of RLR (FHWA, 2009). Traffic environment variables have also been determined to have significant impact on red-light-running, including higher volumes, closer vehicle proximity to the intersection, and higher approaching speeds (Chang, Messer, & Santiago, 1985). Geometric variables associated with increased RLR rates include level and uphill approaches (FHWA, 2009), and wider approaches (Bonneson, Brewer, & Zimmerman, 2001). In addition, Elmitiny, Yan, and Radwan (2010) took advantage of three camera videos and observers to record driver behavior at an intersection in Orlando, and identified positive relationships between red-light-running and vehicle speed.

The enforcement strategy of using red light cameras has been shown to reduce the frequency of RLR. An interrupted time series design study with a comparison group was conducted, and concluded that drivers are about 3.4 times more likely to run red lights when there is no camera present, as compared to intersections with cameras (Martinez & Porter, 2006). However, although the cameras reduce RLR behaviors, occurrence of rear-end crashes can increase (Shin & Washington, 2007).

In China, studies related to RLR are limited. The primary method for investigating RLR has been through questionnaire analysis (Zhang, He, & Sun, 2009; Xian & Han, 2010; Bai, Qi, Zhao, 2007), sometimes combined with video recording (Bai et al., 2007). Wang (2006) examined the nature of the dilemma zone by looking at signal control and RLR. It was found that the wide use of red light running enforcement cameras has substantially reduced red light running behavior. Xian and Han (2010) studied responses of drivers during signal countdown using video observation, and found that about 40% of drivers crossed the intersection within the last seconds of the green interval. Based on a before–after survey, they concluded that the