Accident Analysis and Prevention 120 (2018) 101–113

Contents lists available at ScienceDirect

Accident Analysis and Prevention

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

Influence of on-network, traffic, signal, demographic, and land use characteristics by area type on red light violation crashes

Ajinkya S. Mane[a], Srinivas S. Pulugurtha[b,*]

[a] Student of Infrastructure & Environmental Systems (INES) Ph.D. Program, The University of North Carolina at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223-0001, USA

[b] Professor of Civil & Environmental Engineering Department, Director of IDEAS Center, The University of North Carolina at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223-0001, USA

ARTICLE INFO

Keywords:
Red light violation
Crash
Area type
Demographic
Land use
Traffic

ABSTRACT

The focus of this research paper is on extraction of predictor variables pertaining to on-network, traffic, signal, demographic, and land use characteristics, by area type, and examining their influence on the number of red light violation crashes. Data for the city of Charlotte, North Carolina was extracted and used for analysis. Three different sets of signalized intersections were selected in the three different area types - Central Business District (CBD), urban, and suburban areas. Each set is comprised of sixty signalized intersections (total 180 signalized intersections). The number of red light violation crashes from January 2010 to December 2014, within the vicinity of each selected signalized intersection, was considered as the dependent variable to develop crash estimation models for each area type. The crash estimation models by area type were compared with the crash estimation model developed considering all the 180 signalized intersections together. Different predictor variables were found to be significant at a 95% confidence level in three different areas. Log-link model with Negative Binomial distribution was observed to best fit the data used in this research. Findings indicate that enforcement, either manually or using red light running cameras (RLCs), at signalized intersections with high traffic volume in the CBD area; at signalized intersections with high traffic volume, high all-red clearance time, near high density of horizontal mixed non-residential and open space/recreational type land uses in urban area; at signalized intersections with high traffic volume, speed limit on the major approach, the number of lanes on the minor approach, and all-red clearance time and areas surrounded with horizontal mixed non-residential and retail type land use in suburban areas, would lead to a reduction in the number of red light violation crashes.

1. Introduction

An estimated 165,000 people were injured and 800 people were killed, annually, in crashes due to red light running in the United States (Insurance Institute for Highway Safety (IIHS, 2007). Retting and Williams (1996) reported two red light runners per hour in, total, 234 h of data collection. Their study concluded that the red light runners are drivers under the age of thirty years, with poor driving history, less likely to use seat belts, and drove small and older cars. Retting et al. (1998) reported red light violations at the rate of 5.2 runners/hour and 1.3 runners/hour for two different sites. Porter and England (2000) stated that unbuckled and non-Caucasian drivers are more likely to run and violate red light.

Most of the past studies on red light violation have analyzed the safety effect of red light running cameras (RLCs). Maisey (1981), South et al. (1998), Kamyab et al. (2002), Garber et al. (2007), Tay and de Barros (2009), (2011), Pulugurtha and Otturu (2014) investigated red light running violations and/or the effectiveness of RLCs in reducing red light running violations or crashes. Retting and Kyrychenko (2002) found that injury crashes reduced by 29%, while right-angle crashes reduced by 32% after the implementation of RLCs. On the contrary, Maisey (1981), South et al. (1998) reported an increase in rear-end collisions after the implementation of RLCs. Weldegiorgis and Jha (2009) stated that factors such as driver behavior, approach speed, and intersection geometry contribute to red light violations.

Studies in the past concluded that younger drivers are prone to traffic violations while older drivers are prone to crashes at intersections (McGwin and Brown, 1999; Chapman et al., 2014). Similarly, Shell et al. (2015) found that teens taking driver education are less likely to be involved in crashes or traffic violations in the first two years of driving. Alver et al. (2014) studied the relationship between demographic characteristics, socio-economic characteristics, traffic rule

* Corresponding author.
E-mail addresses: amane@uncc.edu (A.S. Mane), sspulugurtha@uncc.edu (S.S. Pulugurtha).

https://doi.org/10.1016/j.aap.2018.08.006
Received 13 February 2018; Received in revised form 23 July 2018; Accepted 6 August 2018
0001-4575/

Table 1
Summary of Past Research on Factors Attributed to Red Light Violation Behavior and Crashes.

Category	Study	Contributing Factors
Behavior	Van der Horst et al. (1986)	Yellow change time
	Baguley (1988)	High traffic volume
	Retting and Williams (1996)	Profiling of violators: young drivers, drivers of small and older cars, drivers with poorer driving record, and drivers who are less likely to use seat belts
	Kamyab et al. (2000)	High traffic volume
	Porter and England (2000)	Large intersections, and high traffic volume, time period (3 pm to 6 pm), safety belt use, and ethnicity
	Schattler et al. (2003)	All-red clearance and yellow change time
	Kulanthayan et al. (2007)	Day (weekday / weekend), camera enforcement, type of vehicle (four-wheel / two-wheel vehicles), cycle length, and type of traffic signal
	Zimmerman (2007)	Dilemma zone, additional time for trucks at a signalized intersection
	Gates and Noyce (2010)	Dilemma zone, vehicle type, time of the day and platooning
Crashes	Mohamedshah et al. (2000)	Number of lanes on both streets, left- and right-turn lanes, entering/crossing traffic flow, traffic control type (fully actuated, semi actuated, and pre-timed), speed limit (a potential variable but was not present in the dataset)
	Bonneson et al. (2002)	Traffic volume of the subject approach, traffic volume of the cross-street, and red light running rate
Behavior and crashes	Datta et al. (2000), Schattler and Datta (2004)	All-red clearance and yellow change time

violations, and crashes among young drivers. Four different traffic violations, red light violation, seat-belt violation, speed limit violation, and driving under the influence of alcohol or drugs, were considered in their study. Their results indicate that crash rate increased to 38.3% for drivers who received at least one traffic citation.

Studies in the past have also reported factors contributing to red light violation behavior and red light violation crashes. Table 1 summarizes factors contributing to red light running behavior and red light violation crashes from selected past research studies.

Van der Horst et al. (1986) found that extending yellow change time from three to four seconds would decrease red light runners (car drivers) by 50%. Datta et al. (2000) found that introducing a well-designed all-red clearance time following the yellow change time would significantly reduce red light violations and right-angle crashes at urban signalized intersections. Schattler and Datta (2004) concluded that at urban intersections, all-red clearance time would decrease the probability of right-angled crashes even after red light violation. A similar result was observed in the Schattler et al. (2003) study. Zimmerman (2007) observed that if yellow change time was extended by 1.5 s, it would improve intersection safety by reducing the number of trucks by 47% in the dilemma zone. Gates and Noyce (2010) observed that tractor-trailer and single-unit trucks are more likely to be involved in red light running compared to passenger car. Also, the number of red light violations are observed to be higher during peak hours compared to off-peak hours.

1.1. Limitations of past research and need for this research

Most of the past studies have investigated the effectiveness of RLCs, while a few researchers focused on identifying on-network (the number of lanes, width of intersection, speed limit, etc.), traffic, and signal (phasing and timing plan) characteristics that influence red light violations and associated crashes. The spacing between intersections and width of intersections in Central Business District (CBD) area is comparatively lower than the spacing between intersections and width of intersections in urban and suburban area. Likewise, the speed limit, network density, traffic volume, and signal timings also differ by area type. While on-network, traffic, and signal characteristics were observed to have an influence on the number of red light violation crashes, the influence of these characteristics, by area type, on the number of red light violation crashes were not explored much in the past.

Different land use types such as office buildings, commercial centers, industrial areas, and recreational areas attract people from different parts of the city. High-rise office buildings are typically located in the CBD area but not in the suburban area. On the other hand, single-family residential areas prevail more in the suburban area. High-rise commercial centers and mixed land uses are typically located in the CBD area, while horizontal mixed use or commercial centers are typically located in urban and suburban areas. The demographic characteristics as well as the number of trips generated and attracted by each land use type vary by area type. Therefore, traffic volume and congestion within the vicinity of each land use differ by area type. As stated in Kamyab et al. (2000), an increase in traffic volume and congestion influence drivers' aggressive behavior and hence, the number of traffic violations. In other words, the demographic and land use characteristics vary by area type and could also influence the number of red light violation crashes.

Literature review indicates that majority of past studies on red light violation were conducted considering urban signalized intersections. As on-network, traffic, signal, demographic, and land use characteristics not only vary by area type but influence the number of red light violation crashes, examining the relationship between the number of red light violation crashes and predictor variables such as on-network, traffic, signal, demographic, and land use characteristics, by area type, helps proactively identify where they could potentially happen for enforcement or implementation of remedial measures (implementation of manual or automated enforcement; signal timing changes; etc.). The findings from such a research are vital to identify, prioritize, and allocate limited available transportation funds, either manually or using RLCs.

2. Methodology

The city of Charlotte, North Carolina was considered as the study area to gather data and conduct analysis. The methodology includes the following steps.

1 Identify study signalized intersections by area type
2 Identify predictor variables contributing to red light violation crashes
3 Generate buffers and conduct geospatial analysis
  a Extract the number of red light violation crashes
  b Extract on-network, traffic, and signal characteristics
  c Extract demographic characteristics
  d Extract land use characteristics
4 Check for multicollinearity between predictor variables
5 Develop crash estimation models by area type
6 Validate the models

Each step is explained next in detail.