Exploring factors affecting pedestrians' red-light running behaviors at intersections in China

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ABSTRACT

Pedestrians' Red-light running behavior is one of the most critical factors for pedestrian involved traffic crashes at intersections in China. The primary objective of this study is to explore how various factors affect pedestrians' red-light running behaviors at intersection areas, using the data collected from Hefei, China. A questionnaire was well designed aiming at collecting pedestrians' socio-economic characteristics, trip related features, and attribute variables in different crossing facilities. Based on 631 valid samples, a binomial logistic model was established to evaluate the impacts of contributing factors on pedestrians' red-light running behavior. The modeling results show that four variables significantly affect the probability of pedestrians' red-light running behavior, which are the trip purpose, time period in one day, pedestrian's attitude towards whether to run a red light when in hurry, and pedestrian's attitude towards whether quality of road facility affects crossing behavior. With those variables, the probability of pedestrians' red-light running behavior at intersections could be predicted. Findings of this study can help understand why pedestrians in China run red-lights and identify which pedestrian groups and intersections are more likely to have such behaviors. This study can also help propose countermeasures more efficiently to reduce pedestrian-related crashes at intersections in China.

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1. Introduction

Pedestrian involved traffic crashes has been considered as a serious problem in both traffic safety and public health areas around the world. Over 270,000 pedestrians were killed in traffic crashes each year which accounts for about 22% of total fatalities (World Health Organization, 2014). The safety situation for pedestrians is even worse in developing countries such as China. According to the China Road Accidents Statistics Report, pedestrian involved traffic crashes account for a quarter of all traffic deaths (CRTASR, 2011). A report also shows that there are 127,000 pedestrians running red-lights in city of Shenzhen, China, during the first half year of 2015 (Yi, 2015).

Previously, studies have reported that pedestrians' red-light running behavior is one of the main causes for pedestrian involved traffic crashes at the intersection areas (Liu et al., 2007; Schneider et al., 2010). The red-light running decision of pedestrian is affected by many factors such as personal characteristics, trip attributes, and even pedestrians' attitudes towards red-light running and crossing facilities. It would be interesting to see how those factors affect pedestrians' red-light running behaviors. In addition, though several previous studies have studied pedestrians' red-light running in multiple countries (Florian et al., 2011; Duduta et al., 2014; Medina et al., 2014; Onelcin and Alver, 2015), a study focusing on the topic in China is still necessary in comparing the results between China and other countries.

The primary objective of this study is to explore the factors affecting pedestrians' red-light running behaviors using data collected from a city in China. The study can help better understand why pedestrians run red-lights to propose more effective countermeasures to reduce pedestrian involved traffic crashes at intersections in China. In the following section, a review of relevant studies is provided. In Section 3, the data collection is introduced. In Section 4, the method for analysis is introduced. Section 5 discusses the modeling results. The paper ends with brief concluding remarks in future work in Section 6.

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2. Literature review

In the initial stage, previous studies generally focused on evaluating pedestrians' crossing characteristics. For example, Fruin (1971) examined the spatial characteristics, behavioral characteristics, pedestrian movement patterns to study pedestrian flow. In particular, researchers have analyzed the influential factors of pedestrians' street crossing behaviors from the perspective of individual socioeconomic and psychological characteristics, road environment, etc.

In the recent years, studies have been conducted to evaluate pedestrians' crossing behaviors in some risky situations. Holland and Hill (2007) used the theory of planned behavior (TPB) to explore the effect of gender on the intentions of pedestrians' crossing in a risk situation. They concluded that women were more sensitive to risk perception and less likely to cross street in a high risk situation. Men got a higher safety perception of direct crossings than women (Cantillo et al., 2015). Bernhoft and Carstensen (2008) found that older crossing pedestrians had a higher safety consciousness than younger pedestrians. The older pedestrians always paid more attention to making a safer street-crossing decisions by using safer facilities (zebras, signalized intersection); whereas the younger pedestrians more often focused on how to arrive at the destination more quickly. On the other hand, older pedestrian involved accident occupied a higher proportion of injuries and fatalities because of their fragility, deteriorations of motion perception and judgement ability, and increased reaction time (Li et al., 2003; Snowden and Kavanagh, 2006; Zivotofsky et al., 2012).

Some other studies have examined the pedestrian's crossing speed and the herd mentality effect in the crossing behaviors. The pedestrian crossing speed is an extremely important parameter in operation and safety analysis, and provides important information for intersection geometric and signal design. Previous studies found that in general male pedestrians' walking speed was faster than female (Tanaboriboon and Guyano, 1991; Chandra and Bharti, 2013; Tarawneh, 2001). Also, as the growth of the age, pedestrians' crossing speed would slow down. Griffiths et al. (1984) found that the averaged crossing speed of young pedestrians was 1.72 m/s, 1.47 m/s for the middle-aged, and 1.16 m/s for the elderly. Feng and Wu (2004) observed and analyzed the situation of pedestrian crossing in Harbin. They found that the average pedestrian crossing speed was 1.47 m/s and the crossing speed was 1.74 m/s for 85% of pedestrians. Carey (2005) found that when the pedestrians are crossing in groups, their walking speed tended to be slower.

Different road crossing environment could also lead to different characteristics of pedestrian crossing. Sisiopiku and Akin (2003) studied pedestrians' perceptions in different pedestrian crossing situations such as signalized and unsignalized intersection, marked and non-striped midblock, with and without physical barriers, shelters and colored paving at medians, and pedestrian warning signs. Li (2013) characterized pedestrians' intended waiting time by proposing a U-shaped distributional model which was helpful to understand the mechanism of pedestrians' street-crossing behavior at signalized intersections. The waiting time of pedestrians crossing in Montreal was also found in other studies, which had provided the basis for properly timing pedestrian signals (Brosseau et al., 2013; Yang et al., 2015). In addition, Hamed (2001) found that pedestrians tended not to accept higher risk if they involved in a traffic accident in the past, or they were accompanied by children, or they have heavy luggage, or their mobility is impaired.

Previous studies have considered many methods to study the characteristics of pedestrians' red-light running behaviors. Yagil (2000) proposed a hierarchically multivariate regression models to examine pedestrians self-reported road-crossing behavior in relation to beliefs regarding the consequences of the behavior incorporated in the health belief model, instrumental and normative motives for compliance with safety rules, and situational factors. Diaz (2002) developed a model of structural equation which consisted of attitude, subjective norm, perceived control, behavioral intention and reported violations, errors and lapses. Li (2014) established a bi-level multivariate model to analyze the risk of pedestrians' unsafe street crossing behavior at signalized intersections. Cantillo et al. (2015) proposed a hybrid framework to analyze the pedestrians' crossing choice on the urban road. Through investigating and analyzing, we found that crossing the street with a minor could reduce risk.

Some literatures on the topic of characteristics of pedestrian crossing were also found. Along with the widely use of mobile telephone, the man who used mobile while road crossing was more likely to cause traffic accidents. Most conclusions suggested that talking on a mobile phone is associated with cognitive distraction that may undermine pedestrian safety (Bungum et al., 2005). A research showed that females appeared to pay less attention to traffic both before and during crossing and a similar pattern of results for males at unsignalized crossings may have reached significance in a larger sample. Further, talking on a mobile was associated with slower crossing speeds for females at signalized crossings, and for males at unsignalized crossings. These effects suggested that talking on a mobile phone is associated with cognitive distraction that may undermine pedestrian safety (Hatfield and Murphy, 2007).

In summary, previous studies have evaluated why pedestrians run a red-light considering individual socioeconomic features, psychological characteristics, and road environment factors. However, previous studies seldom considered the impacts of pedestrians' attitude related factors on the red-light running behaviors. As human behaviors are affected by attitudes, it would be necessary to consider such factors in the analysis. Furthermore, traffic environment, cultural background, and travelers' decisions making process in China are quite different from those in other countries. Thus, it is very necessary to conduct a research on exploring what factors affect pedestrians' red-light running behaviors at intersections in China.

3. Data

3.1. Survey design

In order to capture the potential influencing factors on pedestrian's red-light running decision, a SP survey which includes fifteen intelligible items is designed to obtain the individual characteristics, trip characteristics and pedestrian's attitude. The survey collects three parts of information. The first part addresses questions on pedestrian individual socioeconomic characteristics such as gender (coded 0 = female, 1 = male), age (coded 0 = less than 12, 1 = 12-18, 2 = 19-25, 3 = 26-35, 4 = 36-55, 5 = more than 55), education level (coded 0 = primary school, 1 = junior middle school, 2 = senior middle school, 3 = junior college, 4 = undergraduate, 5 = postgraduate), profession (coded 0 = student, 1 = worker, 2 = attending staff, 3 = civil servant, 4 = individual worker, 5 = retiree, 6 = others) and income (coded 0 = nearly no, 1 = less than 10000, 2 = 10000-30000, 3 = 30000-50000, 4 = 50000-70000, 5 = 70000-100000, 6 = more than 100000).

The second part addresses questions on trip characteristics such as trip purpose, time requirement, intersection familiarity, the tolerable waiting time and the time segment that running a red-light more easily. Trip purpose was divided into 5 groups (coded 0 = go work or go to school, 1 = living include entertainment, shopping, see a doctor etc., 2 = stroll, 3 = go home and 4 = others). Time requirement was divided into 2 groups (coded 0 = harsh and 1 = not harsh). Intersection familiarity was divided into 3 groups (coded 0 = familiar, 1 = general and 2 = unfamiliar). Tolerable waiting time