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Hit-and-run crashes in urban river-crossing road tunnels

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ABSTRACT

Hit-and-run crashes are a relatively infrequent but severe offense worldwide because the identification and emergency rescue of victims is delayed, which increases the injury severities and the mortality rate. However, no studies have been conducted on hit-and-run crashes in urban river-crossing road tunnels (URCRTs), which can greatly threaten the safety of motorists driving in the tunnels. This study, which employs a dataset of vehicle crashes that happened in thirteen urban road tunnels traversing the Huangpu River, established a binary logistic regression model to identify thirteen factors that contribute to escaping after crashes in Shanghai related to the offending drivers, the vehicular and environmental conditions, the tunnel characteristics and crash information. Among the thirty-five variables considered, this study found that a perpetrator's tendency to leave the crash scene without reporting an accident was higher at night, in the tunnel exit, near to or in short tunnels, when a two-wheeled vehicle or heavy goods vehicle (HGV) was involved and when alcohol was involved. While a perpetrator was more likely to remain on the scene in the tunnel entrance, on a rainy day, in a rear end collision, when a bus was involved, in a single vehicle or a multi-vehicle accident. Based on these findings, several countermeasures for better supervision and hit-and-run prevention are proposed.

1. Introduction

Mortality and injuries resulting from road traffic accidents have long been a major social issue all over the world. Every year, almost 1.24 million people die as a result of road accidents and between 20 and 50 million more people suffer non-fatal injuries, with many incurring disabilities as a result (WHO, 2013). The frequency and injury severities in a road traffic collision is an integrated outcome with numerous contributing factors, but a significant determinant of mortality is hit-and-run (Kim et al., 2008; Tay et al., 2008). Hit-and-run crashes are defined as collisions in which the driver of the striking vehicle flees the scene before offering information or aid to the victims (MacLeod et al., 2012). Hit-and-run perpetrators are generally major offenders and should therefore incur most of the responsibility for an accident and any subsequent losses. In the United States, hit-and-run crashes accounted for 18.1% of the approximately 48,000 pedestrian fatalities between 1998 and 2007, with high variation on a state-by-state basis, ranging from 6.6% in Mississippi to 29.8% in the District of Columbia (MacLeod et al., 2012). According to Roess et al. (2004), approximately 35% of fatalities occur within 1–2 h of the time that the crash occurred, therefore leaving the victim at the crash scene without reporting it impedes crash notification and medical assistance, which in turn increases the mortality risk (Tay et al., 2009). In view of the above-mentioned issues, hit-and-run behavior is prohibited and generally acknowledged as a criminal offense worldwide, despite that sentences vary in different countries. For example, according to the Criminal Law of the People's Republic of China, perpetrators who leave a crash scene without reporting the event, or with other extremely criminal behavior, will be sentenced to imprisonment for a fixed term of over 3 years and less than 7 years, and those perpetrators who cause death will be sentenced to imprisonment for a fixed term of over 7 years.

Although severe criminal penalties have been explicitly legislated in most countries for those who leave the scene of an accident, fail to report it or who do not provide timely medical assistance to victims, no evidence shows that the rate of hit-and-run crashes or mortality has significantly declined. Researchers have attempted to discover the reasons for the incidence of hit-and-run crashes. Table 1 shows the six most cited studies on hit-and-run crashes during the past 10 years.

To our knowledge and based on these existing studies, most research concerning hit-and-run incidents are focused on crashes that occurred on conventional urban roadways, highways or other

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Table 1
The six most cited studies on hit-and-run crashes during the past 10 years.

Researches	Crashes data used in studies							Technique
	Region	Sources	Time span	Pedestrian	Sample size	No. of hit-and-run	Hit-and-run (%)	
Tay et al. (2008)	Singapore	NRAD[a]	1992–2002	Yes	67,228	N/M[b]	1.83%	Logistic regression
Tay et al. (2009)	California	FARS[c]	1994–2005	Yes	42,420	3420	8.1%	
Tay et al. (2010)	Calgary	AT[d]	2005	No	36,936	6625	17.9%	
MacLeod et al. (2012)	U.S.	FARS	1998–2007	SV-P[e]		–[f]	18.1%	
Aidoo et al. (2013)	Ghana	NRTAD[g]	2004–2010	V-P[e]	21,578	1668	7.7%	
Zhang et al. (2014)	Guangdong	GPSD[h]	2006–2010	Yes	40,373	3609	8.94%	
This study	*Shanghai*	*OP110ARC*[i]	*2011–2012*	No	*10,523*	*468*	*4.45%*	*Logistic regression*

[a] NRAD: National Road Accident database.
[b] N/M: Not directly Mentioned in the manuscript.
[c] FARS: Fatality Accident Reporting System, a surveillance system operated by the U.S. Department of Transportation (DOT)'s National Highway Traffic Safety Administration (NHTSA).
[d] AT: Alberta Transportation.
[e] SV-P: Single Vehicle–Pedestrian crashes; V-P: Vehicle–Pedestrian crashes.
[f] Three models whose sample sizes varied across models were established based on different objects.
[g] NRTAD: National Road Traffic Accident Database at the Building and Road Research Institute (BRRI) of the Council for Scientific and Industrial Research (CSIR), Ghana.
[h] GPSD: Guangdong Provincial Security Department.
[i] OP110ARC: the Official Platform of "*110*" Alarming Receiving Center (OP110ARC) of the Shanghai Public Security Bureau (SPSB).

open roads. However, the results of a study by Zhang et al. (2014) show that hit-and-run behavior is more likely to occur with crashes that happen in tunnels rather than those that occur at intersections, ordinary roads and on bridges: it is the only existing literature that explicitly shows the impact of tunnels on hit-and-run crashes. As a solution to increasing urban development and the growing demand for land in urban areas, the construction of urban road tunnels is, however, becoming more frequent in order to enhance the capacity and accessibility of road transport systems (Meng and Qu, 2012). Drivers can be nervous and suffer from visual impairments when driving in tunnels because of the relatively confined driving environment and also because of the lighting employed in them. Normally, driving in a tunnel may cause anxiety because it is dark, as well as narrow and monotonous (PIARC, 2008). A typical driver's anxiety response when in a tunnel includes the urge to exit, which then causes them to be more prone to missing information along the tunnel (Evans et al., 1984; Yeung et al., 2013) as well as in their peripheral vision. For instance at a tunnel entrance, reflected sunlight from the tunnel portal or direct sunlight might blind a driver before the tunnel is entered, while the darkness in the tunnel entrance might reduce visibility because a driver's eyes adapt slowly to the dark (Caliendo et al., 2013). Many crashes occur inside the urban road tunnels because of a failure to keep a safe following distance, which leads mostly to rear-end accidents, and even to fires. Fires are one of the most serious outcomes of crashes that occur in urban tunnels and can have catastrophic consequences because of the confined nature of tunnels (Meng and Qu, 2012). Moreover, hit-and-run behavior in urban road tunnels can cause traffic congestion, delay medical assistance and might result in secondary damage, which exacerbates the severity of the victims' injuries. Previous studies on urban river-crossing road tunnels (URCRTs) – a peculiar type of the underwater tunnels[1] – have concentrated merely upon the analysis of the temporal and spatial distribution characteristics of traffic accidents (Lu et al., 2014), safety assessment models (Xing et al., 2014) and an injury severity analysis (Jiang et al., 2015) in Shanghai. Therefore, the main objective of this study was to investigate the effects of traffic, roadway and environmental factors on a driver's decision to leave the scene without reporting an accident in the URCRTs in Shanghai, China.

[1] Tunnels can be classified into three categories by location: mountain tunnels, underwater tunnels and urban tunnels. Strictly speaking, the urban river-crossing road tunnels in Shanghai studied in this research belong to the underwater tunnel classification.

The remainder of this paper is organized as follows. Section 2 describes a theoretical construct used to analyze a perpetrator's decision to run and Section 3 discusses the methodology, the data and the variables used to develop the models. Section 4 presents the empirical results and discussion. Section 5 concludes the study, as well as recommendations for policy implications to decrease the rate of hit-and-run crashes in URCRTs.

2. Theoretical construct

A conceptual framework to model a perpetrator's decision to leave the crash scene was put forward by Tay et al. (2008) by using an economic cost–benefit approach, which was utilized by most subsequent researchers who studied hit-and-run crashes. According to this framework, the main determinant of remaining at the crash scene is the expected cost associated with reporting the crash, while the main determinant of running is the likelihood of apprehension, the expected benefit of getting away (not being caught) and the expected cost of being apprehended (Tay et al., 2009).

The factors leading to a crash can be placed into two categories: subjective (i.e. anthropic) and objective factors (vehicle, roadway and environmental factors). The subjective, anthropic factors involve a driver's violation (e.g. drunk driving, poor vehicle operation, speeding, fatigued driving, etc.), while the objective factors are inducements related to vehicular (mechanical failure), roadway (design defects, e.g., blocked sight or confusing traffic signs) and environmental factors (e.g., adverse weather conditions or poor lighting). For example, a driver's ability to adapt to a change in the lighting conditions (i.e., a change between natural and artificial lighting) when driving into or out of a tunnel is largely related to the driver's prompt perception of hazards and the execution of appropriate evasive action. If not, a crash occurs because of the driver's subjective operating failure – a long perception–reaction time. A driver's subjective deficiencies such as drunk driving, speeding and failure to promptly perceive a hazard and to take appropriate evasive action can increase his subjective-responsibility-ratio (SRR) for the crash, which then exacerbates the perpetrator's likelihood of running away because of his aversion to responsibility. Note that the subjective factors are merely related to the driver himself, which means that a subjective factor for driver A can be an objective factor to driver B, if A and B are two parties involved in a single crash.

As a theoretical supplement to Tay's cost–benefit approach, the present study proposes the concept of a subjective-responsibility-ratio (SRR) to model a driver's decision about staying and reporting