

Diagnostic analysis of the logistic model for pedestrian injury severity in traffic crashes

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Abstract

This study attempts to evaluate the injury risk of pedestrian casualties in traffic crashes and to explore the factors that contribute to mortality and severe injury, using the comprehensive historical crash record that is maintained by the Hong Kong Transport Department. The injury, demographic, crash, environmental, geometric, and traffic characteristics of 73,746 pedestrian casualties that were involved in traffic crashes from 1991 to 2004 are considered. Binary logistic regression is used to determine the associations between the probability of fatality and severe injury and all contributory factors. A consideration of the influence of implicit attributes on the trend of pedestrian injury risk, temporal confounding, and interaction effects is progressively incorporated into the predictive model. To verify the goodness-of-fit of the proposed model, the Hosmer–Lemeshow test and logistic regression diagnostics are conducted. It is revealed that there is a decreasing trend in pedestrian injury risk, controlling for the influences of demographic, road environment, and other risk factors. In addition, the influences of pedestrian behavior, traffic congestion, and junction type on pedestrian injury risk are subject to temporal variation.

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Keywords: Binary logistic regression; Pedestrian casualty; Injury severity; Interaction effect; Hosmer–Lemeshow statistic; Logistic regression diagnostics

1. Introduction

In Hong Kong, pedestrian fatalities account for one half of total fatalities in traffic crashes, a number that is much higher than that in the United States, Japan, and most Western countries (Hayakawa et al., 2000; NHTSA, 2006). The high pedestrian injury risk in Hong Kong could be attributed to pedestrian–vehicle conflicts in a densely populated urban area with numerous roadside activities (Loo et al., 2007). Effective remedial measures and road safety strategies that reduce pedestrian fatalities and casualties are essential. Recently, in land use and transportation planning, a greater emphasis has been placed on the needs of pedestrians, and pedestrian zones are now widely established. This encourages more walking trips, which are non-polluting, and offers a safer pedestrian environment. More importantly, pedestrian–vehicle conflicts on crowded urban road networks can be eliminated and, consequently, the crash and injury risk of pedestrians can be reduced (Transport Bureau, 1999).

Many researchers have attempted to establish a predictive model that identifies possible explanatory factors, such as traffic characteristics, road environment, and human error, for the probability of pedestrian–vehicle crashes through spatial analysis with comprehensive geographical information systems (LaScala et al., 2000; Garder, 2004; Loo and Tsui, 2004; Schneider et al., 2004). In addition, crash consequence models have been established to determine the injury severity of pedestrian casualties by logistic or ordered probit regression (Davis, 2001; Demetriades et al., 2004; Zajac and Ivan, 2003; Lee and Abdel-Aty, 2005). The likelihood of mortality and severe injury has been found to be highly correlated to vehicular speed and the crash environment.

Specifically, Al-Ghamdi (2002) suggested that crash attributes, together with the injury and demographic characteristics of the victims, determined the likelihood of mortality in pedestrian–vehicle crashes. Wazana et al. (2000) and Graham et al. (2005) attempted to estimate the risk of severe injury and mortality for pedestrians of different socioeconomic status. They found that children were at a greater risk of mortality and injury in traffic crashes, and these crashes were strongly influenced by environment and driver characteristics. Ballesteros et al. (2004), Martinez and Porter (2004), and

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Roudsari et al. (2004) established a logistic regression model to estimate the associations between pedestrian mortality risk and various human, vehicular, and environmental contributory factors. Pedestrian–vehicle crashes that involved light truck vehicles, vans, or sport utility cars led to a higher risk of mortality and serious injury, which is attributed to the vehicle masses, speeds, and front-end design. In addition, driver and pedestrian errors that were related to alcohol and drug impairment also significantly contributed to severe injury.

In Hong Kong, taking advantage of the well-compiled historical crash record in the Traffic Accident Database System (TRADS), Yau (2004) and Yau et al. (2006) attempted to identify the factors that contribute to severe single- and multiple-vehicle crashes, respectively, by binary logistic regression. Using information that was obtained from the same system, the current study emphasized instead the injury risk of pedestrian casualties. Logistic regression was again applied to estimate the likelihood of mortality and severe injury in pedestrian casualties by considering the associations of such factors as demographic characteristics, injury characteristics, crash time, location, road environment, traffic control, and traffic conditions.

Controlling for the temporal variation in pedestrian injury risk, a design variable was introduced to deduce the trend of mortality and injury risk that was associated with the change in implicit attributes over a number of years. This change is most probably related to improvements in road infrastructure, advances in vehicular performance, and the enhancement of safety through the various remedial measures and road safety strategies that have been undertaken. More importantly, to address concerns over the suitability and efficiency of the proposed model, the Hosmer–Lemeshow test and logistic regression diagnostics were applied to measure the overall goodness-of-fit and to identify any outlier or poorly fit observations, respectively.

2. Data

The information that is used in this study was obtained from the TRADS that is maintained by the Hong Kong Police Force and Transport Department. TRADS consists of three components: crash environment profile, casualty injury profile, and vehicle involvement profile. The crash environment profile illustrates precisely the crash date, time, location, number of vehicles and casualties that were involved, weather conditions, road type, traffic conditions, and status of traffic control. The casualty injury profile indicates the role (whether the casualty is the driver, a passenger, or a pedestrian) and demographic characteristics of every victim, the use of a seat belt or helmet, the injury characteristics, the location of the passenger and/or pedestrian that was involved, the actions of the pedestrian, and any other special circumstances. The vehicle involvement profile provides driver information, vehicle class, license status, and age, and crash information for each of the vehicles that were involved. These profiles were not compiled into a database system with consistent, comprehensive, and compatible information until 1991, when the new system was established through a strategic recoding and aggregation process.

Table 1

Summary of the parameters in the pedestrian injury model

Factor	Attribute	Count (proportion)
Year	1991	6,326 (8.6%)
	1992	6,009 (8.1%)
	1993	6,005 (8.1%)
	1994	5,961 (8.1%)
	1995	5,435 (7.4%)
	1996	5,266 (7.1%)
	1997	5,320 (7.2%)
	1998	4,932 (6.7%)
	1999	4,830 (6.5%)
	2000	4,785 (6.5%)
	2001	4,978 (6.8%)
	2002	4,805 (6.5%)
Injury severity	2003	4,517 (6.1%)
	2004	4,577 (6.2%)
Injury severity	Killed or severe injury	21,611 (29.3%)
	Slight injury	52,135 (70.7%)
Sex	Male	41,864 (56.8%)
	Female	31,882 (43.2%)
Age (years)	Under 15	15,304 (20.8%)
	15–65	45,214 (61.3%)
	Above 65	13,228 (17.9%)
Injury location	Head injury	24,898 (33.8%)
	Others	48,848 (66.2%)
Pedestrian location	On the crossing	10,422 (14.1%)
	Within 15 m of crossing	3,154 (85.9%)
	Others	60,170 (4.3%)
Pedestrian action	Crossing road or junction	35,831 (48.6%)
	Walking along footpath	21,503 (29.2%)
	Others	16,412 (22.2%)
Special circumstance	Overcrowded footpath	2,032 (2.8%)
	Obstructed footpath	927 (1.3%)
	Others	21,430 (29.1%)
	None	49,357 (66.8%)
Pedestrian contributory	Heedless crossing	23,747 (32.2%)
	Inattentive	2,208 (3.0%)
	Others	9,582 (13.0%)
	None	38,209 (51.8%)
Day of week	Monday–Friday	54,159 (73.4%)
	Weekend	19,587 (26.6%)
Time of day	7:00–9:59 a.m.	12,277 (16.6%)
	10:00 a.m.–3:59 p.m.	29,127 (39.5%)
	4:00–6:59 p.m.	16,810 (22.8%)
	7:00 p.m.–6:59 a.m.	15,532 (21.1%)
Speed limit	Above 50 km/h	1,245 (1.7%)
	50 km/h	70,934 (96.2%)
	Below 50 km/h	1,567 (2.1%)
Traffic aids	Poor aids	670 (0.9%)
	Normal	73,076 (99.1%)
Traffic congestion	Severe congestion	2,317 (3.1%)
	Moderate congestion	6,015 (8.2%)
	No congestion	65,414 (88.7%)
Obstruction	At or near obstruction	3,790 (5.1%)
	No obstruction nearby	69,956 (94.9%)
Junction control	Not at junction	38,379 (52.0%)
	Signalized intersection	14,997 (20.3%)
	Other control types	20,370 (27.6%)

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