THE RELATIONSHIP BETWEEN INJURY SEVERITY AND INDIVIDUAL CHARACTERISTICS: A SURVEY IN SOUTHERN CHINA

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Abstract. This study aimed to assess the relationships between road traffic injury severity and individual characteristics in Liuzhou, a city in southern China. Data for this study were collected from the Guangxi Public Security Bureau Traffic Police Corps. Multivariate ordinal logistic regression analysis was used. Of all 14,595 individuals involved in accidents, males, motor vehicle drivers, motorcyclists, and those aged 21-45 years accounted for the great proportion of all injuries. Children, the elderly, pedestrians, farmers and migrant workers, unemployed people, and novice drivers were at higher risk of serious injury in crashes. These findings suggest that individual characteristics (age, modes of transport, profession, driving experience) are strongly related to injury severity. To address road traffic related mortality and injuries, there is a need to develop policy strategies, strengthen road supervision, and improve public consciousness of road safety.

Keywords: injury severity, individual characteristics, risk groups, road traffic injuries, China

INTRODUCTION

Road traffic injuries (RTIs) are the ninth leading cause of death worldwide in 2004 and will likely emerge as the fifth leading cause of death in 2030 (WHO, 2008; WHO, 2009a). More than 1.2 million people die in road accidents globally every year. In China, the number of motor vehicles increased 11-fold, and the motor vehicle ownership rate per 1,000 population increased 9-fold between 1990 and 2008 (WHO, 2009b). As a consequence, hundreds of thousands of people lost their lives every year due to RTIs. From 1951 to 2008, RTIs have increased 58-fold, traffic-related fatalities increased 85-fold; moreover, fatalities increased more than 100-fold between 2000 and 2003 (Chi and Wang, 2004; Wang *et al*, 2010). For China, the traffic fatality rate increased in 2007 to 16.5 per 100,000. It was much higher than many developed countries: 13.9 for USA, 7.8 for Australia, 5.4 for UK, 5.0 for

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Japan, and 4.9 for Switzerland (WHO, 2008). The fatality rate was 5.1 per 10,000 vehicles for China, and more than 3-fold higher than those for developed countries (Wang *et al*, 2010).

However, RTIs has not as yet obtained the attention it deserves: there is a lack of understanding of the relationships between traffic injury severity and individual characteristics, and little has been done to effectively reduce RTIs. In this study, Liuzhou, a main automotive industry city in southern China, was selected. In addition, Liuzhou has over 3 million population and nearly 280, 000 registered vehicles; its vehicle volume, the number of road accidents, and RTIs were previously comparable to the country as a whole (Yuan *et al*, 2013). This study aimed to assess the relationships between injury severity and individual characteristics in Liuzhou, which would provide a starting point to make effective intervention measures.

MATERIALS AND METHODS

Study design and data

A retrospective cross sectional study was conducted from 2000 to 2009. All records of Liuzhou RTIs during this decade were registered and gathered by Guangxi Public Security Bureau Traffic Police Corps. The individual characteristics were recorded by five main variables including gender, age, profession, mode of transport, and injury severity. The individuals, including complete records of the above variables were entered into statistical analysis. In addition, drivers were also described by years of driving ('driving experience'). In this study, of all 17,134 individuals involved in accidents, 14,595 (85.2%) individuals were included in the statistic analysis.

Relationship between injury severity and individual characteristics

All eligible individuals (n=14,595) were described by common variables: gender, age, profession, mode of transport, and injury severity. The age of individuals was divided into five groups: ≤15 years (children); 16-30 years, 31-45 years, 46-60 years, and ≥61 years. Professions included nine categories: civil service, enterprises, and institutional staffs; farmers and migrant workers; workers; independent operators; unemployed people; college students; middle-school students; and primary- and pre-school children; others (such as retirees, full-time housewives, foreigners). Modes of transport included six categories: motor vehicles, motorcycles, non-motor vehicles, pedestrians, passengers, and others. The motor vehicle and motorcycle users were considered as 'drivers' (n=10,789), and other people were considered as 'non-drivers' (n=3,806).

According to the Road Traffic Accident Treatment Ordinances, injury severity was divided into four levels: 'death,' 'serious injury,' 'slight injury,' and 'no injury.' Those who were injured in RTIs in one of the following situations would be identified as 'serious injury': 1) those diagnosed as disabled or may become disabled; 2) those hurt severely and who need major surgery; 3) key parts of the body were severely burned, burns, or scalded, or the other parts of body were burned more than one-third; 4) those with severe fractures or severe concussion; 5) those with severe eye injury; 6) those whose thumb had gadolinium-break, or two fingers that had gadolinium-break, or a severe hand-tendon injury that caused dysfunction or inability to stretch, or who may be disabled; 7) those who have more than three toes with a gadolinium-break, or severe foot-tendon injury that causes dysfunction, or who can not work, or who may be disabled; and 8) those who have visceral injury, internal hemorrhage, or peritoneal injury. Those who were not injured in RTIs according to the above criteria were identified as 'slight injury.'

Relationships between injury severity and drivers

In this study, there were 10,789 drivers (including motor vehicle and motorcycle users). But only 9,810 (90.9%) drivers were recorded by 'driving experience.' Drivers with driving experience information were included in further logistical analysis. Driving experience was divided into five categories: <1 year, 1-5 years, 6-10 years, 10-15 years, and ≥16 years.

Statistical analysis

Descriptive statistics were used to analyze individual characteristics. Comparisons of the injury severity among groups were performed by Kruskal-Wallis H nonparametric test. Univariate logistic regression analysis was used to identify the significant variables for injury severity. The variables with $p<0.2$ were included in multivariate ordinal logistic regression analysis (MOLRA). For non-drivers, the variables included age, profession, and mode of transport; whereas, for drivers, variables included age, profession, mode of transport, and driving experience. MOLRA was use to assess the relationships between injury severity and individual characteristics, and identified the dominant influencing factors. The odds ratio (OR) for reporting injury severity associated with independent variables were calculated. A 2-tailed test at $p<0.05$ was defined as statistically significant. All data analyses were performed by SPSS® (version 19.0; IBM: Armonk, NY).

RESULTS

Relationships between injury severity and individual characteristics

The characteristics of individuals were shown in Table 1. Of all 14,595 individuals, 1,646 people (11.3%) died, and 1,514 (10.4%) suffered from serious injuries. A vast majority of injured people were males (86.7%), and males accounted for more than 70% of all deaths and serious injuries. People aged 16-to-45 years accounted for 81.2% of all injuries and accounted for more than 60% of deaths and serious injuries. Motorcyclists accounted for highest proportion of deaths and serious injuries (31.5% and 33.7%, respectively). Drivers with 1-5 years driving experience had the highest proportion of all injuries (61.7%) and accounted for more than 70% of deaths and serious injuries. There were statistically significant differences among injury severity for all group variables ($p<0.001$).

The results of univariate logistic regression analysis indicated that: 1) non-drivers, age, mode of transport, and profession were strongly associated with injury severity ($p<0.001$); and 2) drivers, variables of age, mode of transport, profession, and driving experience were significantly related to injury severity ($p<0.001$).

Among non-drivers and drivers, the elderly (≥61 years) had the highest risk of death and serious injury ($p<0.001$), but no gender differences were found for injury severity. For drivers, increasing driving experience was a protective factor for injury severity ($p<0.001$); moreover, drivers with <1 year driving experience had a nearly 5-fold risk of serious injury compared with those with ≥15 years experience ($p<0.001$). The population of un-

Table 1
Individual characteristics.

Variable	Total N=14,595(%)	Deaths n=1,646(%)	Serious injury n=1,514(%)	Slight injury n=2,718(%)	No injury n=8,717(%)	p-value
Gender						<0.001
Male	12,655 (86.7)	77.2	73.1	74.9	94.5	
Female	1,940 (13.3)	22.8	26.9	25.1	5.5	
Age (years)						<0.001
≤15	456 (3.1)	7.8	7.8	6.5	0.4	
16-30	5,577 (38.2)	30.1	33.3	43.6	38.9	
31-45	6,273 (43.0)	30.0	32.7	35.7	49.5	
46-60	1,810 (12.4)	19.1	16.3	11.1	10.8	
≥61	479 (3.3)	13.0	9.9	3.1	0.4	
Mode of transport						<0.001
Motor vehicle	7,836 (53.7)	6.5	8.1	13.9	82.9	
Non-motor vehicle	674 (4.6)	14.2	12.9	6.0	1.0	
Motorcycling	2,953 (20.2)	31.5	33.7	30.6	12.5	
Walking	954 (6.5)	26.1	21.3	6.3	0.4	
Passengers	2,057 (14.1)	20.2	22.7	42.5	2.6	
Others	121	1.5	1.3	0.8	0.6	
Profession						
Civil service, enterprises, and institutional staffs	1,515 (10.4)	5.9	8.4	8.5	12.2	
Farmers and migrant workers	2,675 (18.3)	31.3	21.3	23.8	13.7	
Workers	3,342 (22.9)	11.7	13.5	19.5	27.7	
Independent operators	4,691 (32.1)	14.4	24.8	27.3	38.3	
Unemployed	376 (2.6)	6.9	6.3	3.8	0.7	
College students	7 (0.0)	0.1	0.1	0.0	0.0	
Middle school students	126 (0.9)	2.1	1.8	1.7	0.2	
Primary school, and pre-school children	349 (2.4)	6.2	6.1	5.1	0.2	
Others	1,514 (10.4)	21.4	17.6	10.3	7.1	
Drivers	N=10,789(%)	Death (n=1,646)%	Serious injury (n=1,514)%	Slight injury (n=2,718)%	No injury (n=8,717)%	p-value
Years of driving						<0.001
<1	52 (0.5)	2.0	0.4	0.6	0.4	
1-5	6,051 (61.7)	70.3	71.5	74.0	59.0	
6-10	2,451 (25.0)	18.8	20.9	18.6	26.4	
11-15	733 (7.5)	6.3	3.8	4.5	8.2	
≥16	523 (5.3)	2.6	3.4	2.3	6.0	

Table 2
Multivariate ordinal logistic regression analysis (MOLRA) for non-drivers and drivers.

Characteristic	Non-drivers		Variable	Drivers	
	OR(95%CI)	*p*-value		OR(95%CI)	*p*-value
Age(years)					
≤15	0.341 (0.208-0.558)	<0.001			
16-30	0.466 (0.370-0.587)	<0.001			
31-45	0.580 (0.459-0.733)	<0.001			
46-60	0.846 (0.666-1.077)	0.174			
≥61[a]	0[a]				
Mode of transport					
Non-motor vehicle	0.582 (0.482-0.703)	<0.001			
Passengers	0.257 (0.219-0.301)	<0.001			
Others	0.101 (0.070-0.147)	<0.001	Motor vehicle	0.053 (0.047-0.060)	<0.001
Walking[a]	0[a]		Motorcycling[a]	0[a]	
Profession					
Farmers and migrant workers	1.112 (0.854-1.446)	0.432		0.822 (0.658-1.026)	0.084
Workers	0.795 (0.591-1.070)	0.131		0.821 (0.672-1.005)	0.055
Independent operators	1.044 (0.786-1.385)	0.769		0.745 (0.614- 0.904)	0.003
Unemployed	1.269 (0.894-1.800)	0.182		1.223 (0.749- 2.002)	0.420
College students	0.653 (0.074-5.737)	0.701		7.434 (0.477- 115.700)	0.152
Middle school students	1.383 (0.846-2.257)	0.196		--	--
Primary school and pre-school children	2.250 (1.297-3.900)	0.004		4.129 (4.129-4.129)	<0.001
Others	1.859 (1.399-2.467)	<0.001		1.110 (0.856-1.411)	0.457
Civil service- enterprises and institutional staffs[a]	0[a]			0[a]	

[a]These were the reference groups.

employed, farmers, and migrant workers had higher injury severity compared with civil service, enterprises, and institutional staffs (OR=4.446 and OR=2.138, $p<0.001$).

The results of the MOLRA are shown in Table 2. Non-drivers, age, mode of transport, and profession were the independent influencing factors for injury severity. Pedestrians had higher risk of death and serious injury than passengers and non-motor vehicle users (OR=0.257 and OR=0.582, $p<0.001$). Primary school and pre-school children more likely suffered from higher injury severity compared to civil service, and enterprise and institutional staffs (OR=2.250, $p=0.004$).

For drivers (Table 2), motorcyclists had higher injury severity than motor vehicle drivers did (OR=0.053, $p<0.001$). Primary school and pre-school children were also more likely to suffer from higher injury severity compared to civil service, enterprise and institutional staffs (OR=4.129, $p<0.001$).

DISCUSSION

In this study, Guangxi Public Security Bureau Traffic Police Corps provided our data. More than 80% of accidents affecting individuals between 2000 and 2009 were included in the analyses.

We found that injury severity is significantly associated with individual characteristics. The main influencing factors included age, mode of transport, profession, and driving experience. Males and people aged 16-to-45 years accounted for more than 80% of all injuries. This finding is similar to several previous studies (Peden *et al*, 2004; WHO, 2009c; Ma *et al*, 2012; Zhang *et al*, 2013). Zhang *et al* (2013) found that people aged 21-50 years accounted for more than 60%, and males accounted for 76.2% of all RTIs from 2004-2008. Ma *et al* (2012) found that the people aged 20-45 accounted for the highest rates of road traffic-related deaths, particularly among males. Peden *et al* (2004) found that people aged 15-44 years accounted for more than half of all road traffic deaths worldwide, and the RTI fatality rate for males was more than three times higher than for female in the world, as well as in China (WHO, 2009c).

We found that motorcyclists accounted for a larger proportion of deaths and serious injuries than other groups. This phenomenon may be related to the following factors: the considerable number of motorcycles (Blackman and Haworth, 2013), speeding violations, drivers' risky behaviors, and inappropriate use of safety equipments (Ouellet and Kasantikul, 2006; Elliott *et al*, 2007; Haque *et al*, 2009; Ozkan *et al*, 2012). To deal with these problems, the government has implemented some targeted policies, including the limitation of the amount of the motorcycles that could be registered each year and the regulation for the issuance of driving license. However, there is a need to evaluate the effectiveness of these programs. In this study, motorcyclists, pedestrians, passengers and non-motor vehicle drivers accounted for 92.0% of road traffic-related fatalities and 90.6% of all RTIs.

One prior study in China found that pedestrians and cyclists constituted up to 60% of road traffic deaths, and motorcyclists accounted for 20% (Wang *et al*, 2008). Another study in China (Zhang *et al*, 2011) suggested that more than 86% of all traffic-related deaths involved pedestrians (24.6%), passengers (24.1%), motorcyclists (22.0%) and bicyclists (15.6%). These findings suggest that many of vulnerable traffic users lack both traffic safety consciousness and necessary protective measures on the one hand, and there is also a lack of safe road infrastructure. We also found that disadvantaged professions (such as, farmers, migrant workers, workers, and unemployed) accounted for more than half of road traffic deaths. This finding suggested that RTIs might be related to income and education background. But the facticity of this relationship should be confirmed by further study.

In our study, the findings suggested that individual characteristics were strongly associated with injury severity. Age, profession, and mode of transport were common influencing factors for non-drivers and drivers. Driving experience was a protective factor for drivers. With increasing driving experience, the RTIs rates were significantly reduced. A study conducted in another setting, also reported similar results (Peden *et al*, 2004). These findings indicated that drivers' proficiency, responsiveness, and familiarity with the traffic environment might be related to accidents.

There are several limitations in the present study. First, a retrospective cross sectional study was performed in this study, so we cannot examine any causal associations between the RTIs and crash environments and individual characteristics. In addition, several issues led to missing data including: the large amount of information, long time span, data-collection system update during this period, and the potential for underreporting. These factors could lead to information and selection bias, but these problems were controlled by a strict study design and statistic analysis. Second, only individual characteristics were included in the logistic regression analysis, whereas other factors, such as traffic circumstance factors were not included. Further study should simultaneously consider the circumstance factors and individual characteristic factors on logistic analysis.

Our recommendations would include: strengthening traffic supervision, improvement of safe traffic environment, adopting strict regulatory measures (written examination and road test), to issue drivers license and monitoring of licensing authorities to identify any inappropriate conduct in the issuance of drivers license, and assurance that those who are physically or psychologically unfit to drive are off the road. According to WHO reports (WHO, 2009c; WHO, 2011), several suggested effective strategies include: strengthening road safety legislation (speeding limitation, setting blood alcohol concentration limits, seat belts, helmets, child restraints, strict driving license issuance system), improving road designs that provide a safer traffic environment and routes for road users (for example, increasing the separation of motorized and non-motorized road users, and appropriate pedestrian crosswalks and bridges), promoting the safety levels of vehicles, developing public transport and road safety audits, enhancing post crash response, and increasing public consciousness of road safety.

Adoption of these strategies should be examined in Chinese cities to improve RTIs related morbidity and mortality. Our findings have relevance, besides other medium size Chinese cities, to other low and middle-income countries, which are economically and environmental closer to this Chinese city.

In conclusion, the findings of the current study suggested relationships between individual characteristics (age, modes of transport, profession, and driving experience) and injury severity. These findings recommend rigorous measures that would address the individual factors. Given the fact that the provincial government is developing policy strategies to address growing RTIs in Guangxi Province, incorporating the findings of this study would strengthen any newly developed intervention programs.

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