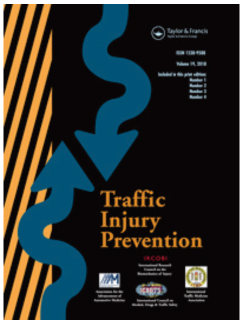

Traffic Injury Prevention

ISSN: 1538-9588 (Print) 1538-957X (Online) Journal homepage: http://www.tandfonline.com/loi/gcpi20

Road traffic injuries among riders of electric bike/ electric moped in southern China

Xujun Zhang, Yaming Yang, Jie Yang, Jie Hu, Yang Li, Ming Wu, Lorann Stallones & Henry Xiang

TRAFFIC INJURY PREVENTION
2018, VOL. 19, NO. 4, 417–422
https://doi.org/10.1080/15389588.2018.1423681

Taylor & Francis
Taylor & Francis Group

Check for updates

Road traffic injuries among riders of electric bike/electric moped in southern China

Xujun Zhang[a,b], Yaming Yang[c], Jie Yang[d], Jie Hu[a], Yang Li[a], Ming Wu[d], Lorann Stallones[e], and Henry Xiang[f]

[a]Injury Prevention Research Institute, Department of Epidemiology and Biostatistics, School of Public Health, Southeast University, Nanjing, Jiangsu Province, China; [b]Key Laboratory of Environmental Medicine Engineering, Ministry of Education, School of Public Health, Southeast University, Nanjing, Jiangsu Province, China; [c]Yixing Center for Disease Control and Prevention, Yixing, Jiangsu Province, China; [d]Jiangsu Provincial Center for Disease Control and Prevention, Nanjing, Jiangsu Province, China; [e]Department of Psychology, Colorado School of Public Health, Colorado State University, Fort Collins, Colorado; [f]Center for Injury Research and Policy and Center for Pediatric Trauma Research, The Research Institute at Nationwide Children's Hospital, The Ohio State University College of Medicine, Columbus, Ohio

ABSTRACT

Objective: Electric bike/moped-related road traffic injuries have become a burgeoning public health problem in China. The objective of this study was to identify the prevalence and potential risk factors of electric bike/moped-related road traffic injuries among electric bike/moped riders in southern China.

Methods: A cross-sectional study was used to interview 3,151 electric bike/moped riders in southern China. Electric bike/moped-related road traffic injuries that occurred from July 2014 to June 2015 were investigated. Data were collected by face-to-face interviews and analyzed between July 2015 and June 2017.

Results: The prevalence of electric bike/moped-related road traffic injuries among the investigated riders was 15.99%. Electric bike/moped-related road traffic injuries were significantly associated with category of electric bike (adjusted odds ratio [AOR] = 1.36, 95% confidence interval [CI], 1.01–1.82), self-reported confusion (AOR = 1.77, 95% CI, 1.13–2.78), history of crashes (AOR = 6.14, 95% CI, 4.68–8.07), running red lights (AOR = 3.57, 95% CI, 2.42–5.25), carrying children while riding (AOR = 1.96, 95% CI, 1.37–2.85), carrying adults while riding (AOR = 1.68, 95% CI, 1.23–2.28), riding in the motor lane (AOR = 2.42, 95% CI, 1.05–3.93), and riding in the wrong traffic direction (AOR = 1.63, 95% CI, 1.13–2.35). In over 77.58% of electric bike/moped-related road traffic crashes, riders were determined by the police to be responsible for the crash. Major crash-causing factors included violating traffic signals or signs, careless riding, speeding, and riding in the wrong lane.

Conclusion: Traffic safety related to electric bikes/moped is becoming more problematic with growing popularity compared with other 2-wheeled vehicles. Programs need to be developed to prevent electric bike/moped-related road traffic injuries in this emerging country.

ARTICLE HISTORY
Received 4 September 2017
Accepted 1 January 2018

KEYWORDS
Road traffic injuries; electric bike; electric moped; bicycle; riders; China

Introduction

Electric bikes/mopeds have emerged as a common transportation mode to and from work and school in China, because they provide an energy-saving, convenient form of personal transportation at a cost that is affordable for many Chinese consumers (US$125 to US$375; Weinert, Ma, and Cherry 2007; Weinert, Ma, Yang, and Cherry 2007; Zhang et al. 2015). The number of electric bikes/mopeds produced in China has increased more rapidly than any other vehicles from nearly 58,000 in 1998 to more than 32 million in 2016 (National Bureau of Statistics 2017). There were 250 million electric bikes/mopeds registered in China by 2016 (National Bureau of Statistics 2017), which might account for 90% of the global market (Research in China 2011). Although electric bikes/mopeds could provide some advantages compared with manual bicycles, the use of electric bikes/mopeds raises safety concerns. During the period 2004–2015, police data reported that in China, electric bike/moped fatalities increased more than 11 times from 589 to 6539, and nonfatal injuries increased 5 times from 5,295 to 30,532, respectively (Bureau of Traffic Management 2004, 2015). Furthermore, fatalities and nonfatal injuries of electric bike/moped riders accounted for 56.7 and 68.0% of nonmotorized traffic (pedestrians excluded) fatalities and nonfatal injuries in China in 2015 (Bureau of Traffic Management 2015). A hospital-based study found that electric bike rider hospitalizations accounted for 57.2% compared to 14.3% bicyclist hospitalizations and 50.0% of direct hospitalization cost for all road traffic casualties in Suzhou (Du et al. 2014). In Israel, the number of nonfatal injuries associated with electric bikes increased 6-fold between 2013 and 2015 (Siman-Tov et al. 2017). Traffic safety related to electric bikes/mopeds is becoming more problematic with growing popularity compared with other 2-wheeled vehicles.

Two main types of electric bikes are produced in China. Most can be categorized as bicycle-style electric bikes (BSEB) or scooter-style electric bikes (SSEB; Jamerson and Benjamin 2004). Currently, China's road traffic safety laws classify electric bikes/mopeds as non-motor vehicles when involved in injury events. They have the same rights as manual bicycles and do not

CONTACT Xujun Zhang xjzhang@seu.edu.cn Injury Prevention Research Institute, School of Public Health, Southeast University Key Laboratory of Environmental Medicine Engineering, Ministry of Education, School of Public Health, Southeast University, 87 Dingjiaqiao, Nanjing, Jiangsu 210009, P.R. China.
Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/gcpi.
Associate Editor Sjaan Koppel oversaw the review of this article.
Supplemental data for this article can be accessed on the publisher's website.

require driver's license, a helmet, or insurance to operate in the bicycle lanes. However, electric bike and motorized scooter riders are more likely than other motor vehicle drivers to be killed or injured in injury events, partly because electric bikes/mopeds use bicycle lanes that mix with slower moving bicycles and pedestrians, hence increasing the risk of traffic crashes (Siman-Tov et al. 2017). The risk behaviors of electric bike riders—for instance, running red lights, speeding, and other violating traffic regulations—are also important risk factors for road traffic injuries (Bai et al. 2015; Yang et al. 2014). A study found that commuting by bicycle 7 days per week, as opposed to riding fewer days a week, and a combination of extreme risk behaviors such as zigzagging through traffic, riding after drinking, and high-speed riding were found to be risk factors for road traffic injuries (Bacchieri et al. 2010). Among these risk behaviors, running red lights is the most important violation of traffic regulations (Johnson et al. 2011, 2013; Wu et al. 2012).

In many Chinese cities, electric bikes/mopeds outnumber manual bicycles on the roadway, and the use of electric bikes/mopeds has reshaped transportation systems (Cherry et al. 2016). Thus, the number of casualties resulting from injury events involving electric bikes/mopeds has risen continuously, although the total mortality rate from traffic crashes and manual bicycle-related fatalities and nonfatal injuries has been declining (Bureau of Traffic Management 2004, 2015; Cherry et al. 2016; Du et al. 2014; Yang et al. 2014; Zhang et al. 2015). Despite this, little data have been published about patterns of and risk factors for road traffic injuries among electric bike/moped riders. The aim of this study was to estimate the prevalence and characteristics of electric bike/moped-related traffic injuries and to study the association between the risk factors and traffic injuries among electric bike/moped riders in a southern region of China.

Figure 1. Electric bike (top) and electric moped (bottom).

Methods

Study design and sampling

In this cross-sectional study, electric bike/moped riders in one county in the southern part of Jiangsu Province were surveyed about electric bike/moped-related road traffic injuries. There are 18 towns and 97 communities in the county. We randomly selected 40 communities in these 97 towns. After the communities were selected, the county's Center for Disease Control and Prevention contacted community leaders and randomly selected 80 participants from each community. A total of 3,200 participants were randomly selected from 40 communities. Eligible participants included any person who lived in this area, owned at least one electric bike or electric moped, and had ridden electric bikes/mopeds for at least 1 year preceding the beginning of the study.

The questionnaire was developed by a research team at the Injury Prevention Research Institute, School of Public Health, Southeast University. These questions in the questionnaire were chosen based on the literatures related to road traffic injuries and the road traffic accident information collection items from the Chinese Police Department. Six graduate students from the Southeast University Injury Prevention Research Institute were trained as interviewers for this study. The research team at the Southeast University Injury Prevention Research Institute pilot-tested the survey questionnaire in a small group of the target population in the study area in May 2015. Minor changes were made before the survey questionnaire was finalized.

Data were collected by face-to-face interviews in July 2015 and September 2015. Each participant was asked about selected characteristics (e.g., gender, age, occupation, education, marital status, category of riding electric bike), selected health status of self-diagnosed (color-blindness, hearing acuity, sleep disorders, depression, anxiety, confusion, and fatigue), electric bike/moped riding-related risk behaviors (e.g., crash history, violating traffic signals or signs, drunk riding history, making or receiving a call, listening to music with headphones, carrying children or adults, and not wearing a helmet), and electric bike/moped-related injury event characteristics (e.g., time of injury event, injury event pattern, and injury event cause). No personal identification information such as name, phone number, or home address was collected in order to protect the confidentiality of the survey and the privacy of the participants.

Informed consent was obtained from participants in accordance with ethical guidelines. The institutional review board of Southeast University reviewed and approved the study protocol.

Definition of study variables

Electric bikes/mopeds are a category of nonmotorized vehicles that includes 2-wheeled bikes moved by auxiliary energy from the battery, including BSEB or SSEB. In order to be more specific, BSEB is called an *electric bike*, and the term *electric moped* is used to denote an SSEB (Figure 1).

Electric bike/moped-related road traffic injury events were defined to include all traffic-related injury events with an electric bike that resulted in nonfatal injury to road users (riders, motorcyclists, cyclists, electric bike/moped passengers, pedestrians, and others) from July 2014 to June 2015.

Statistical analysis

Data were entered into EpiData 3.0 (Odense, Denmark) and analyzed with SPSS 11.0 (SPSS Inc., Chicago, IL). First, we described the sample demographics including gender, age, occupation, education, marital status, and category of riding an electric bike. Second, χ^2 analyses were performed to assess the association of electric bike/moped-related traffic injuries with selected health statuses and riding-related risk behaviors. Third, in order to control for the confounding effects between association factors and traffic injuries in our study variables, multivariate logistic regression analyses were conducted. In our logistic regression analyses, the outcome variable was electric bike/moped-related traffic injury (yes/no), and the independent variables were all potential association factors, including selected characteristics and riding-related risky behaviors. Finally, we described the characteristics of electric bike/moped-related traffic injuries with regard to time of injury event, season of injury event, injury event pattern, and injury event cause. Tests with a $P < .05$ were considered statistically significant in our study.

Results

A total of 3,200 electric bike/moped riders were eligible in the study. Our face-to-face survey obtained 3,151 valid questionnaires, yielding an overall response rate of 98.5%. Reasons for nonresponse included absence from the home when the survey was conducted and incomplete questionnaires.

The mean age of electric bike/moped riders in this study was 36 years, and over 83.75% of riders had full-time work. Most electric bike/moped riders were married (81.34%), had a high school education and above (69.24%), and had an electric moped (73.91%).

The prevalence of electric bike/moped-related road traffic injuries (RTIs) among the riders by selected characteristics is presented in Table A1 (see online supplement). A total of 504 cases of road traffic injuries (15.99%) were reported. The prevalence of RTIs among electric moped riders (17.13%) was significantly higher than that of electric bike riders (12.77%, $P = .02$).

The prevalence of RTIs among the riders by selected health status is presented in Table A2 (see online supplement). The prevalence of RTIs among electric bike/moped among riders who reported color-blindness (35.29%), sleep disorders (26.75%), depression (38.66%), anxiety (36.31%), confusion (39.06%), and fatigue (26.11%) was significantly higher than that among those who did not report these health statuses (all $P < .001$).

The prevalence of RTIs by risk behaviors is shown in Table 1. The prevalence of RTIs among riders who reported a history of crashes (54.60%), running red lights (35.22%), a history of drunk riding (28.99%), making or receiving calls while riding (26.69%), listening to music with headphones (27.73%), carrying children (25.61%), carrying adults (25.72%), not wearing helmets (16.75%), speeding (24.61%), riding in the motor lane (28.10%), and riding in the wrong traffic direction (25.82%) was significantly higher compared to that of those who did not report these behaviors (all $P < .05$).

Table 2 presents the multivariate logistic regression models. The results indicated that RTIs were significantly more likely to occur among riders with the following characteristics: category of electric bike (electric moped vs. electric bike, adjusted odds ratio [AOR] = 1.36, 95% confidence interval [CI], 1.01–1.82), self-reported confusion (always vs. never, AOR = 1.77, 95% CI, 1.13–2.78), history of crashes (yes vs. no, AOR = 6.14, 95% CI, 4.68–8.07), running red lights (always vs. never, AOR = 3.57, 95% CI, 2.42–5.25), carrying children while riding (always vs. never, AOR = 1.96, 95% CI, 1.37–2.85), carrying adults while riding (always vs. never, AOR = 1.68, 95% CI, 1.23–2.28), riding in the motor lane (always vs. never, AOR = 2.42, 95% CI, 1.05–3.93), and riding in the wrong traffic direction (always vs. never, AOR = 1.63, 95% CI, 1.13–2.35).

Table 1. Association of risk behaviors and road traffic injuries among electric bike/moped riders.

	Participants (*N*)	No. of road traffic injuries, *n* (%)	χ^2	*P* value
Crash history			204.25	<.001
No	2,977	409 (13.74)		
Yes	174	95 (54.60)		
Red light running			97.22	<.001
Never	2,350	293 (12.47)		
Sometimes	642	155 (24.14)		
Always	159	56 (35.22)		
History of drunk riding			76.22	<.001
Never	2,776	386 (13.90)		
Sometimes	306	98 (32.03)		
Always	69	20 (28.99)		
Making or receiving a call while riding			74.58	<.001
Never	2,292	291 (12.70)		
Sometimes	603	137 (22.72)		
Always	256	76 (26.69)		
Listening to music with headphones while riding			44.27	<.001
Never	2,744	393 (14.32)		
Sometimes	288	78 (27.08)		
Always	119	33 (27.73)		
Carrying children while riding			70.12	<.001
Never	1,692	193 (11.41)		
Sometimes	889	165 (18.56)		
Always	570	146 (25.61)		
Carrying adults while riding			85.75	<.001
Never	1,348	137 (10.16)		
Sometimes	1,076	180 (16.73)		
Always	727	187 (25.72)		
Helmet use			5.33	.070
Never	912	126 (13.82)		
Sometimes	339	63 (18.58)		
Always	1,901	315 (16.75)		
Speeding (≥40 km/h)			69.97	<.001
Never	1,893	222 (11.73)		
Sometimes	555	109 (19.64)		
Always	703	173 (24.61)		
Riding in the motor lane			137.56	<.001
Never	2,679	154 (9.17)		
Sometimes	899	189 (21.02)		
Always	573	161 (28.10)		
Riding in the wrong traffic direction			52.72	<.001
Never	2,113	271 (12.83)		
Sometimes	674	139 (20.62)		
Always	364	94 (25.82)		

RTIs by time of injury event, month of injury event, injury event patterns, and injury event causes are presented in Table 3. More than half of injury events occurred during the daytime (52.58%). By month, electric bike injury events occurred as follows: January–March (21.83%), April–June (30.36%), July–September (19.25%), and October–December (28.57%). The most common injury event pattern was a single electric bike/moped crash (45.44%) followed by an electric bike/moped crash with motorized vehicles (26.39%), an electric bike/moped crash with an electric bike (12.69%), an electric bike/moped crash with a person (7.74%), and an electric bike/moped crash with a bicycle (7.74%). In 77.58% of RTIs, electric bike/moped riders were determined by the police to be

Table 2. Multivariate logistic regression model of road traffic injuries among electric bike/moped riders.

	β	S	OR (95% CI)	*P* value
Category of electric bike				
Bicycle style			1.00	
Scooter style	0.307	0.149	1.36 (1.01–1.82)	.040
Self-reported confusion				
Never			1.00	
Sometimes	0.779	0.226	2.18 (1.40–3.40)	.001
Always	0.572	0.230	1.77 (1.13–2.78)	.013
Crash history				
No			1.00	
Yes	1.815	0.139	6.14 (4.68–8.07)	.000
Red light running				
Never			1.00	
Sometimes	0.797	0.228	2.16 (1.43–3.23)	.000
Always	1.271	0.198	3.57 (2.42–5.25)	.000
Carrying children while riding				
Never			1.00	
Sometimes	0.346	0.166	1.41 (1.02–1.96)	.037
Always	0.687	0.193	1.96 (1.37–2.85)	.000
Carrying adults while riding				
Never			1.00	
Sometimes	0.338	0.162	1.40 (1.02–1.93)	.035
Always	0.516	0.158	1.68 (1.23–2.28)	.001
Riding in the motor lane				
Never			1.00	
Sometimes	0.834	0.160	2.30 (1.69–3.15)	.000
Always	0.856	0.165	2.42 (1.05–3.93)	.022
Riding in the wrong traffic direction				
Never			1.00	
Sometimes	0.224	0.169	1.25 (0.90–1.74)	1.185
Always	0.489	0.186	1.63 (1.13–2.35)	.009

responsible for the injury event, with the underlying causative factors of violating traffic signals or signs (15.48%), careless riding (9.33%), speeding (8.33%), being in the wrong lane (6.75%), fatigue while riding (4.12%), carrying children or adults while riding (4.12%), alcohol use while riding (3.37%), and other behaviors affecting safety (25.99%). The road, electric bike/moped, and weather factors accounted for 4.76, 6.15, and 11.51% of these crashes, respectively.

Table 3. Characteristics of road traffic injuries involving electric bikes/mopeds.

	n	%
Time of crash		
Daytime (6:00 a.m.–6:00 p.m.)	265	52.58
Nighttime (12:00 a.m.–6:00 a.m.)	239	47.42
Month of crash		
January–March	110	21.83
April–June	153	30.36
July–September	97	19.25
October–December	144	28.57
Crash pattern		
Single crash (with object or fall)	229	45.44
Crash with person	39	7.74
Crash with motorized vehicles	133	26.39
Crash with electric bike/moped	64	12.69
Crash with bicycle	39	7.74
Crash cause		
Violating traffic signals or signs	78	15.48
Careless riding	47	9.33
Speeding	42	8.33
Wrong lane	34	6.75
Fatigue of riding	21	4.12
Carrying children or adults while riding	21	4.12
Alcohol	17	3.37
Other behaviors affecting safety	131	25.99
Road factors	24	4.76
Vehicle factors	31	6.15
Weather factors (rain, snow, and wind)	58	11.51

Discussion

This article is a descriptive study of RTIs among electric bike/moped riders in southern China. Our study indicated that 15.99% of riders in the study area who had ridden an electric bike/moped in the past year suffered RTIs. We also found that the risk of electric bike/moped-related RTIs was significantly associated with factors such as category of electric bike, self-reported confusion, history of injury events, running red lights, carrying children while riding, carrying adults while riding, riding in the motor lane, and riding on the wrong side of the road. With the increasing use of electric bikes/mopeds in China, electric bike/moped-related RTIs may soon become a bigger societal and public safety problem than before in the absence of appropriate road traffic injuries prevention measures.

In our study, electric bike/moped-related RTIs among electric moped riders were about 1.4 times that of electric bike riders. Our result was consistent with a number of studies that estimated SSEBs as a risk factor for serious injury among electric bike/moped riders (Bai et al. 2015; Hu et al. 2014). Compared to BSEBs, SSEBs are heavier and faster, and injuries caused by crashes are more serious. The weight of a bicycle may affect safety because additional weight has to be handled while riding and not riding at low speed and active steering are required to stabilize the bicycle (Schepers et al. 2014). Higher vehicle speeds may also increase crash risk, because motor vehicle drivers or electric bike/moped riders have to estimate speed more precisely, as well as time to collision or time to arrival (TTA), "the time remaining before something reaches a person or particular place," (Tresilian 1995, p. 231) on a regular basis (Schleinitz et al. 2016). However, the observer's perception of the rider and the rider's speed might have an impact on TTA judgments of approaching bicyclists (Schleinitz et al. 2016). In addition, higher electric bike speeds could result in other road users misjudging the speed of an approaching electric bike (Schleinitz et al. 2016). In China, most electric bikes, especially electric mopeds, can travel at speeds in excess of the limit due to higher powered motors that allow the bike to go as fast as 40–50 km/h (General Administration of Quality Supervision, Inspection and Quarantine of PRC 1999; Siman-Tov et al. 2017; Weinert, Ma, and Cherry 2007). Regarding electric bike speeds, most cyclists and nearly 50% of electric bike riders think that electric bikes are too fast for the bicycle lane (Weinert, Ma, Yang, and Cherry 2007). Studies on of motor vehicle speeds in various countries have shown that an increase of 1 km/h in mean traffic speed typically results in a 3% increase in the incidence of nonfatal injuries or an increase of 4 to 5% for fatalities (Finch et al. 1994). Therefore, it could be inferred that nonfatal injuries and fatalities among electric bike/moped riders increases with an increase in speed.

The behaviors of electric bike/moped riders may also play an important role in traffic injury risk. Motor vehicle crash history has been well described as a risk factor for traffic crashes (Fort et al. 2013; Meuser et al. 2009). In our study, the prevalence of RTIs among electric bike/moped riders who reported a history of injury events was more than 6 times that of riders who did not report a history of injury events. Other researchers also found that motor vehicle crash involvement was associated with a short time interval before the next crash (Hamed et al. 1998).

Road traffic statistics reported that more than 60% of the fatal crashes involving 2-wheelers result from violations of traffic regulations (Bureau of Traffic Management 2015). One of the main traffic violations is running red lights. A study in Brazil found that more than 95% of cyclists thought that they should obey traffic regulations but that most violate traffic safety laws, such as running red lights (Bacchieri et al. 2010). In Australia, some cyclists violated traffic regulations because they thought that their behavior was safe and that infrastructure factors were associated with running red lights (Johnson et al. 2013). In terms of traffic direction, some cyclists turn left (traffic travels on the left side in Australia) through the red light. This most common risk behavior and the opportunity to ride through the red light during low cross-traffic times influence the likelihood of violating traffic regulations (Johnson et al. 2011). Our study suggested that running red lights was associated with electric bike/moped-related traffic injuries. The logistic regression model suggested that a rider was most likely to go through a red light when she or he was alone, when there was no one waiting, and when there were other riders going through a red light (Wu et al. 2012). This may reflect the poor law enforcement and peoples' low safety awareness and the frequency of running red lights, representing a substantial traffic hazard in China city intersections (Wu et al. 2012). There are consistent reports of running red lights as a major contributor to road crash injury or fatalities in virtually all studies, regardless of variations in regulations legislation and methods of enforcement (Bai et al. 2015; Rosenbloom 2009; Wu et al. 2012).

Alcohol use remains a major risk factor for vehicle crashes compared to those with a zero blood alcohol concentration, and this risk increases with increased blood alcohol concentration (Peden et al. 2004). A study found that alcohol use is significantly associated with fault assignment (Wang et al. 2017). Drunk drivers are 76.5% more likely to be found solely at fault and electric bike riders are more likely to be solely at fault (by 126.8%) when driving under the influence of alcohol (Wang et al. 2017). In our study, however, there was no association between riders reporting a history of drinking alcohol while riding and electric bike/moped traffic injuries in multivariate analysis. This is in contrast to several international studies of drinking alcohol while driving as a traffic crash risk factor (Peden et al. 2004; Wang et al. 2017).

The use of cellular phones can adversely affect driver behavior with regard to physical as well as perceptual and decision-making tasks (Peden et al. 2004). In fact, some recent studies found that a greater reported frequency of cell phone use while driving or riding was associated with a broader pattern of behaviors that may increase the overall risk of crashes (Truong et al. 2016; Zhao et al. 2013). However, there was no association between riders reporting a history of cell phone use while riding and electric bike/moped traffic injuries in multivariate analysis. This is inconsistent with a number of recent studies of cell phone use while driving as a traffic crash risk factor (Truong et al. 2016; Zhao et al. 2013).

In China, many consumers prefer electric mopeds to electric bikes because they can carry more cargo and passengers, are more comfortable, and create more opportunities for unique, fashionable styling (Weinert, Ma, and Cherry 2007). Electric moped riders are commonly seen carrying as many as 2 passengers (children often stand on the foot platform while another passenger sits behind the rider; Weinert, Ma, and Cherry 2007). Clearly, SSEBs' larger batteries and higher powered motors make these behaviors much easier. Carrying a passenger on an electric bike or electric moped is another serious problem that deserves attention (Wang et al. 2017). Results in our study suggest that riders carrying children or adults were more than 1.9 times and 1.6 times likely to report crashes than those not reporting carrying passengers while riding. A mixed logit model suggested that electric bike riders are 87.5% more likely to be found solely at fault when carrying passengers at the time of traffic crash (Wang et al. 2017). The behavior of electric bike riders carrying passengers may be a result of the weight, which would increase the difficulty in operation (Schepers et al. 2014). This may also be due to motor vehicle driver distraction, with talking or yelling reported as the most common type of distraction (Heck and Carlos 2008). In addition, motor vehicle driver distraction is the likely reason for the association between young passengers and crash risk and has been identified as a key cause of accidents among adults (Stutts et al. 2003).

The proportion of electric bike riders, especially electric moped riders, riding in the motor lane or in the wrong traffic direction was significantly higher than that of bicycle riders (Bai et al. 2015). Results in our study suggest that the prevalence of electric bike/moped traffic injuries among riders who report riding in the motor lane or the wrong direction was significantly higher compared to those who did not report these behaviors. A comparative analysis at signalized intersections found that electric moped riders rode more speedily to bypass busy intersections than BSEB and bicycle riders, whereas electric bike and bicycle riders were quite similar with respect to overall risk behaviors as they were crossing intersections (Bai et al. 2015). The fact that electric mopeds are the fastest electric bikes may be part of the reason for the speedy behavior of electric moped riders (Bai et al. 2015). In addition, the purpose of travel is significantly associated with the behaviors of electric bike riders. This finding suggests that with a clear objective and penalty during the morning peak period, such as arriving to work on time and avoiding being late for work, electric bike riders tend to ride faster (e.g., riding in the wrong traffic direction) to reach their workplace than they do riding home after work during the evening peak period (Bai et al. 2015).

Electric bike/moped crashes with an object or fall are the most common crash type. This may be related to the fact that Chinese riders use electric mopeds more than electric bikes and electric mopeds are faster. Results from all of these studies indicate that higher speed was associated with longer TTA estimates (which in turn should result in riskier motor vehicle driver or electric bike rider behaviors; Schleinitz et al. 2016; Tresilian 1995). Many developing countries have mixed lane use for road traffic, such as pedestrians, handcarts, bicycles, motorcycles, vans, cars, trucks, and buses (Peden et al. 2004). Therefore, riders may be more likely to have single electric bike crashes with motorized vehicles because traffic flows are not divided in many regions in China. Our study suggested that more than 45% of electric bike traffic injuries resulted from single-vehicle crashes, more than 26% resulted from electric bike crashes with motorized vehicles, more than 12% resulted from electric bike crashes with electric bikes, and more than 10% resulted from electric bike crashes with a person or a bicycle.

Comparing causes of traffic crashes suggested human behavioral factors as the main cause, with a smaller contribution of vehicle and road factors (Lyznicki et al. 1998; Zhang et al.

2013). Our study suggests that electric bike/moped riders were determined by the police to be responsible for 77.58% of traffic injuries. Common risk factors contributing to traffic injuries included violating traffic signals or signs, followed by careless riding, speeding, and riding in the wrong lane. Identifying major risk factors for electric bike/moped-related traffic injuries could guide future preventive measures and enforcement of traffic laws in China.

There are some limitations to be considered when interpreting the results of our study. First, information on electric bike/moped-related road traffic injuries in the past 12 months was collected through a cross-sectional survey. Recall bias might lead to an inaccurate estimation of traffic injury prevalence and reporting errors regarding injury characteristics. In addition, electric bike/moped-related road traffic injuries might be underestimated due to social desirability bias with regard to reporting on running red lights, riding while intoxicated, etc. Second, the sample in our study was solicited from only one county in southern China. The results of this study may not be extrapolated to all electric bikes/mopeds in China. Third, because this study was cross-sectional, it was not possible to determine causal relationships between risk factors and electric bike/moped-related road traffic injuries.

In summary, electric bike/moped-related road traffic injuries are a serious issue in China. Traffic safety issues related to electric bikes/mopeds are expected to increase in the future with the rapid growth and increasing popularity. Our study indicates that types of electric bikes, risk behaviors while riding, and injury characteristics were associated with electric bike/moped rider and passenger injuries in China. Risk behavior factors were the principal self-reported cause of injury events. Further studies are needed to develop interventions for the prevention of electric bike/moped-related road traffic injuries among electric bike/moped riders in China.

Acknowledgments

We gratefully acknowledge the Yixing Center for Disease Control and Prevention for assistance with data collection for this study.

Funding

This study was supported by funding from the Research Innovation Program of College Graduates of Jiangsu Province (SJZZ15_0021).

References

Bacchieri G, Barros AJ, Dos Santos JV, Gigante DP. Cycling to work in Brazil: users profile, risk behaviors, and traffic accident occurrence. *Accid Anal Prev*. 2010;42:1025–1030.

Bai L, Liu P, Guo Y, Yu H. Comparative analysis of risky behaviors of electric bicycles at signalized intersections. *Traffic Inj Prev*. 2015;16:424–428.

Bureau of Traffic Management. *China Road Traffic Accidents Statistics*. Beijing, China: Ministry of Public Security of PRC; 2004.

Bureau of Traffic Management. *China Road Traffic Accidents Statistics*. Beijing, China: Ministry of Public Security of PRC; 2015.

Cherry CR, Yang HT, Jones LR, He M. Dynamics of electric bike ownership and use in Kunming, China. *Transp Policy*. 2016;45:127–135.

Du W, Yang J, Powis B, et al. Epidemiological profile of hospitalised injuries among electric bicycle riders admitted to a rural hospital in Suzhou: a cross-sectional study. *Inj Prev*. 2014;20:128–133.

Finch DJ, Kompfner P, Lockwood CR, Maycock G. *Speed, Speed Limits and Accidents*. Crowthorne, England: Transport Research Laboratory; 1994. Project Report 58.

Fort E, Chiron M, Davezies P, Bergeret A, Charbotel B. Driving behaviors and on-duty road accidents: a French case–control study. *Traffic Inj Prev*. 2013;14:353–359.

General Administration of Quality Supervision, Inspection and Quarantine of PRC. *Electric Bicycles General Technical Requirements*. Beijing, China: Chinese Standards Press; 1999. GB17761-1999.

Hamed MM, Jaradat AS, Easa SM. Analysis of commercial mini-bus accidents. *Accid Anal Prev*. 1998;30:555–567.

Heck KE, Carlos RM. Passenger distractions among adolescent drivers. *J Safety Res*. 2008;39:437–443.

Hu F, Lv D, Zhu J, Fang J. Related risk factors for injury severity of e-bike and bicycle crashes in Hefei. *Traffic Inj Prev*. 2014;15:319–323.

Jamerson F, Benjamin E. *Electric Bicycle Worldwide Report*. 7th ed. Florida, Michigan, USA; 2004.

Johnson M, Charlton J, Oxley J, Newstead S. Why do cyclists infringe at red lights? An investigation of Australian cyclists' reasons for red light infringement. *Accid Anal Prev*. 2013;50:840–847.

Johnson M, Newstead S, Charlton J, Oxley J. Riding through red lights: the rate, characteristics and risk factors of non-compliant urban commuter cyclists. *Accid Anal Prev*. 2011;43:323–328.

Lyznicki JM, Doege TC, Davis RM, Williams MA. Sleepiness, driving, and motor vehicle crashes. *JAMA*. 1998;279:1908–1913.

Meuser TM, Carr DB, Ulfarsson GF. Motor-vehicle crash history and licensing outcomes for older drivers reported as medically impaired in Missouri. *Accid Anal Prev*. 2009;41:246–252.

National Bureau of Statistics. *Chinese Statistical Yearbook*. Beijing, China: Chinese Statistical Press; 2017.

Peden M, Scurfield R, Sleet D, et al. *World Report on Road Traffic Injury Prevention*. Geneva, Switzerland: World Health Organization; 2004.

Research in China. *Industry Report of Electric Bicycles in China, 2010–2011*. Beijing, China: Author; 2011.

Rosenbloom T. Crossing at a red light: behaviour of individuals and groups. *Transp Res Part F Traffic Psychol Behav*. 2009;12:389–394.

Schepers JP, Fishman E, den Hertog P, Wolt KK, Schwab AL. The safety of electrically assisted bicycles compared to classic bicycles. *Accid Anal Prev*. 2014;73:174–180.

Schleinitz K, Petzoldt T, Krems JF, Gehlert T. The influence of speed, cyclists' age, pedaling frequency, and observer age on observers' time to arrival judgments of approaching bicycles and e-bikes. *Accid Anal Prev*. 2016;92:113–121.

Siman-Tov M, Radomislensky I, Israel Trauma Group, Peleg K. The casualties from electric bike and motorized scooter road accidents. *Traffic Inj Prev*. 2017;18:318–323.

Stutts J, Feaganes J, Rodgman E, et al. *Distractions in Everyday Driving*. Washington, DC: AAA Foundation for Traffic Safety; 2003.

Tresilian JR. Theory and evaluative reviews perceptual and cognitive processes in time-to-contact estimation: analysis of prediction-motion and relative judgment tasks. *Percept Psychophys*. 1995;57:231–245.

Truong LT, Nguyen HT, De Gruyter C. Mobile phone use among motorcyclists and electric bike riders: a case study of Hanoi, Vietnam. *Accid Anal Prev*. 2016;91:208–215.

Wang C, Xu C, Xia J, Qian Z. Modeling faults among e-bike-related fatal crashes in China. *Traffic Inj Prev*. 2017;18:175–181.

Weinert J, Ma C, Cherry C. The transition to electric bikes in China: history and key reasons for rapid growth. *Transportation*. 2007;34:301–318.

Weinert J, Ma C, Yang X, Cherry CR. Electric two-wheelers in China: effect on travel behavior, mode shift, and user safety perceptions in a medium-sized city. *Transp Res Rec*. 2007;2038:62–68.

Wu C, Yao L, Zhang K. The red-light running behavior of electric bike riders and cyclists at urban intersections in China: an observational study. *Accid Anal Prev*. 2012;49:186–192.

Yang J, Hu Y, Du W, et al. Unsafe riding practice among electric bikers in Suzhou, China: an observational study. *BMJ Open*. 2014;4:e003902.

Zhang X, Cui M, Gu Y, Stallones L, Xiang H. Trend in electric bike-related injury in China, 2004–2010. *Asia Pac J Public Health*. 2015;27:NP1819–NP1826.

Zhang X, Yao H, Hu G, Cui M, Gu Y, Xiang H. Basic characteristics of road traffic deaths in China. *Iran J Public Health*. 2013;42:7–15.

Zhao N, Reimer B, Mehler B, D'Ambrosio LA, Coughlin JF. Self-reported and observed risky driving behaviors among frequent and infrequent cell phone users. *Accid Anal Prev*. 2013;61:71–77.