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Characteristics of Electric Bike Accidents and Safety Enhancement Strategies

ZHU Jian'an, Dai Shuai, Zhu Xinyu

Road Traffic Safety Research Center of the Ministry of Public Security, Beijing 100062, China

Abstract: The fast increasing popularity of electric bikes in China has generated serious safety concerns. By analyzing the accident data of electric bikes and other travel modes, this paper summarized the characteristics of electric bike accidents in several aspects: traffic safety trends, time and space features, contributing factors, attributes of violator and victim, etc. It is concluded that the number of fatalities caused by electric-bike accidents has increased at a relatively fast speed in recent years, and majority of such accidents were caused by violations of traffic laws and regulations. The analysis also indicated that a relatively high fatality rate correlated with high number of knowingly violators, and intersections as well as morning and evening peak hours. The cyclist characteristics clearly revealed that mid-and old-age group, workers and farmers were major victim groups, and craniocerebral injuries were the primary causes of death. Finally, the paper put forward future safety enhancement strategies for electric-bike in China based on the accident contributing factors and actual management practice. **DOI:** 10.13813/j.cn11-5141/u.2018.0303-en

Keywords: traffic safety; electric bikes; accident characteristics; enhancement strategies

1 Development overview and safety situations of electric bikes

In the past 10 years, electric bikes have become popular in China, and have gradually evolved into one of the most important travel modes of urban transportation. Especially in some cities in the south, they have become the urban residents' first choice for short distance trips. For example, the share of electric bike trips was 34.9% in Haikou, 33.9% in Nanning, and 27.4% in Hefei, which is the most important travel mode for local urban residents in these three cities. The monthly output from the nation's largest electric bike manufacture reached 123 thousand units in 2017, which increased by 25.52% compared with that in the same period of last year. From 2012 to 2016, the number of electric bikes increased from 155 million to about 250 million, a total increment of 61.3%. The annual average growth rate was 9.3%, which is close to the growth rate of motor vehicles (see Figure 1).

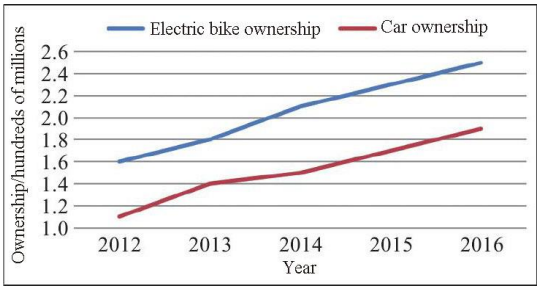

Figure 1 Growth of electric bike and car ownership from 2012 to 2016

Sources: Reference [1].

According to the *Road Traffic Safety Law of the People's Republic of China*, electric bikes that meet the national standard are classified as non-motorized vehicles, and shall be managed by local governments. However, to increase market shares and cater to consumers, some electric bike production and sales companies produced and sold electric bikes that are seriously exceeding the standard in weight, volume and speed, and their travel performance is close to or even exceeds the standard for mopeds. Because most riders of the over-standard electric bikes do not have any driving trainings or riders' licenses, their traffic safety awareness is generally low, and they violate traffic rules and regulations frequently. In addition, over-standard electric bikes are fast and heavy, so they are more likely to cause traffic accidents and seriously jeopardize road traffic safety.

At present, the studies on the safety characteristics of motor vehicles and pedestrians are comprehensive, but less attention has been paid to electric bikes. Most of the previous studies on the safety of electric bikes focused on the safety performance of the physical structure of electric bikes according to two national standards, which are *Electric*

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First author: ZHU Jian'an (1987–), from Wuhan, Hubei Province, Master's degree, assistant researcher, is mainly engaged in the research of urban traffic management policies and road safety management policies. E-mail: zja12gab@gmail.com

Bicycles—General Technical Requirements (GB 17761-1999) and *Technical Specifications for Safety of Power-driven Vehicles Operating on Roads* (GB 7258-2012). The studies on the characteristics of electric bike accidents and management countermeasures began to appear in the past two years. For example, References [2–3] analyzed the characteristics of electric bike accidents in Hangzhou and Hefei. Based on the characteristics of local traffic flow, References [4–5] established a traffic conflict model for electric bikes at intersections with different dimensions. Reference [6] compared and analyzed the safety characteristics of left-turn electric bikes. Reference [7] estimated the probabilities of three levels of electric bike accidents, i.e. property damage, injury, and death, using the ordered logit model, and identified and quantified the significant factors affecting the severity of electric bike accidents based on the elastic analysis method.

In fact, the safety situation of electric bikes is very serious in China. In terms of the travel mode of traffic accident fatalities, the proportion of deaths from riding electric bikes accounted for 11.41% of the total traffic accident fatalities in China in 2016, which is close to autos. Therefore, it is more necessary and urgent to study the safety characteristics of electric bikes.

2 Characteristics of electric bike accidents

The summary of accident characteristics is inseparable from the mining and analysis of statistical data. The statistical data used in this paper were obtained from two sources. One is the Annual Report on Traffic Accident Statistics issued by Traffic Management Bureau of Ministry of Public Security. Another source is the traffic accident statistics system, in which only the accidents handled following the standard procedures were retrieved, and those handled following the simplified procedures were not included. In the analysis of accident statistics, in general, the comparison between absolute numbers was of little significance. For example, accidents occurred on straight road segments on sunny days took the largest portion of accidents, but this is because the total traffic volume under such driving conditions is tremendous and it is not reasonable to conclude that accidents are more likely on straight road segments or on sunny days. Therefore, this paper focuses on the mining and analysis of proportional relationships with the goal to reach reliable conclusions.

2.1 The number of deaths involving electric bikes rises rapidly

From 2012 to 2016, there were 193 000 traffic accidents involving electric bikes, resulting in a total of 37 700 deaths, among which electric bikes were at fault in 56 200 accidents with 8 431 deaths. The proportion of accidents in which electric bikes were at fault was as high as 29.1% and they accounted for 22.3% of deaths. In terms of growth, in the past four years, the number of electric bike accidents and the number of deaths have been increasing year by year. The annual average increase in deaths was 18.21%, which is much higher than that in other travel modes (see Figure 2).

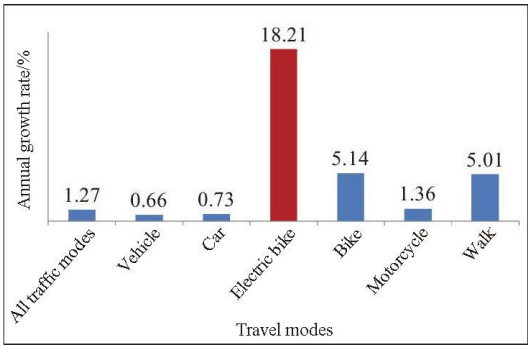

Figure 2 Annual growth rate of accident fatality by different travel modes from 2012 to 2016

Note: With reference *Types of motor vehicle—Terms and definitions* (GA 802—2014), vehicle includes cars, motorcycles, tractors and other vehicles.

2.2 The at-fault rate and mortality rate are high

In 2016, the number of deaths in accidents involving electric bikes was 7 201 nationwide, and 1 896 electric bike riders were killed due to their own faults, which accounted for 26.3% of deaths. This rate was significantly higher than those of other travel modes except motorcycles (see Figure 3). At present, motorcycles are in the stage of large-scale elimination in China. The number of motorcycles and its share among motorized vehicles are rapidly declining year by year. On the other hand, the number of electric bikes is maintaining a rapid upward trend, and electric bikes are inheriting the high at-fault rate and high mortality rate of motorcycles.

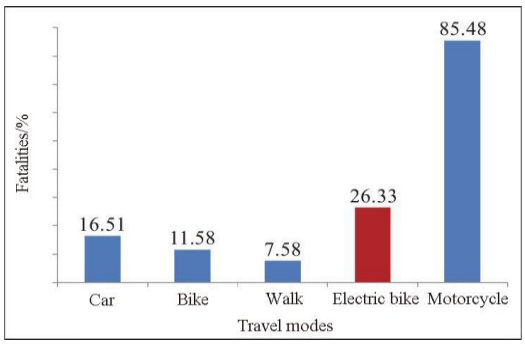

Figure 3 Fatalities caused by knowingly violators by different travel modes in 2016

Sources: Reference [8].

2.3 Intersections are accident-prone areas

In 2016, 77.2% of deaths in accidents involving electric bikes were on urban roads, among which 38.7% occurred at T-intersections or cross intersections. Considering that only 17.1% of deaths in urban traffic accidents occurred at

intersections, electric bikes had a much higher probability of death at intersections than other travel modes (see Figure 4).

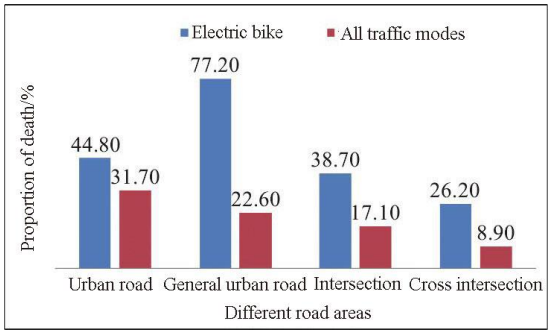

Figure 4 Fatal road traffic accidents in different areas in 2016

Note: Proportion of urban road deaths = Fatalities on urban road/Fatalities on all road (including highway); Proportion of death in other regions = Fatalities in specific region/Fatalities on all urban road. Source: Reference [8] and traffic accident statistics system of the Ministry of public security of China.

2.4 Violation of traffic rules is the main cause of fatal accidents

In 2016, among the fatal traffic accidents in which the at-fault electric bike riders were killed, 19.1% failed to yield the right-of-way; 18.6% violated traffic signals; 15.6% occupied roadways for motorized vehicles; and 11.1% traveled in the wrong direction. In total, about 2/3 were caused by not following traffic rules. In contrast, other travel modes had a much lower rate of death due to the violations mentioned above. Especially the difference of mortality rate in the violation of traffic signals was obvious (see Figure 5). This had a certain causal relationship with the high probability of fatal accidents at intersections mentioned previously.

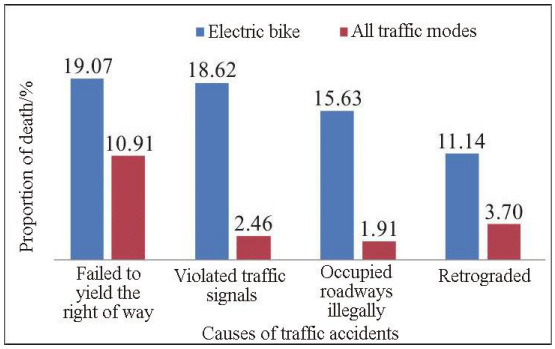

Figure 5 Main causes of fatal road traffic accidents in 2016

Sources: Reference [8] and traffic accident statistics system of the Ministry of public security of China.

2.5 Fatal accidents are more likely to occur in the morning and evening peaks

The proportions of deaths from electric bike accidents in the daytime were higher than those from total traffic accidents, as shown in Figure 6 between 6:00 and 19:00. Especially during the morning and evening peaks, more than 7% of deaths from electric bike accidents occurred between 7:00 and 8:00 and between 17:00 and 18:00, which became the two most noticeable hours of the day. This showed that fatal electric bike accidents were more likely to occur during the time periods in which the major trip purposes were commuting and picking up or dropping off children from/to schools. In comparison, 19:00 to 20:00 is the hour with the most deaths from total traffic accidents, showing a time lag of two hours from the peak death hour of electric bikes.

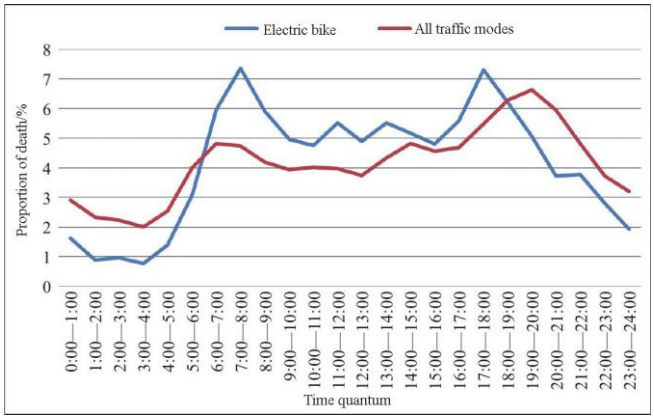

Figure 6 Time distribution of fatal road traffic accidents in 2016

Sources: Traffic accident statistics system of the Ministry of public security of China.

In summary, electric bikes in China showed characteristics such as continuous deterioration in safety and high mortality rate of at-fault riders. Compared with other travel modes, electric bikes had a high proportion of deaths on urban roads, mainly due to non-compliance with traffic rules, especially violating traffic signals at intersections and occupying roadways for motorized vehicles. The consequences were more serious than other travel modes, also. In addition, compared with the overall fatal traffic accidents, fatal electric bike accidents were mainly concentrated in the daytime, especially in the morning and evening peak hours.

3 Characteristics of electric bike riders killed in traffic accidents

3.1 In terms of age, most victims are middle-aged and elderly people

In terms of the age distribution of electric bike riders killed in traffic accidents, the over 60 years old group took the largest proportion, followed by the 50–60 and the 40–50 years old groups (see Figure 7). Overall, these three age groups (40 years old and above) accounted for almost 80% of total deaths. Electric bikes were indeed so-called “killer of middle-aged and elderly people”. Other travel modes had lower shares than electric bikes for all age groups over 40 years old. According to Reference [9], most electric bike users were students, middle-aged and elderly people,

low-income people and courier. Since the middle-aged and elderly people had lower safety awareness, reaction ability and physical condition compared with younger people, they are prone to accidents and are more likely to be killed in traffic accidents.

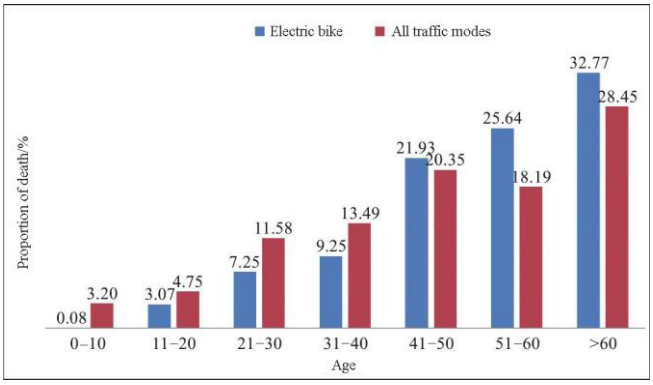

Figure 7 Age distribution of road traffic accident death toll in 2016

Sources: Reference [8] and traffic accident statistics system of the Ministry of public security of China.

3.2 In terms of occupation, most victims are workers and farmers

More than 50% of people killed in electric bike accidents and in all traffic accidents were farmers (see Figure 8), indicating that farmers were the largest victim population of road traffic safety issues. Compared with all traffic accidents, a bigger proportion of people killed in electric bike accidents were office employees, workers and migrant workers. Therefore, office employees, workers, farmers and migrant workers who used electric bikes were more vulnerable to traffic safety threats. Especially for workers and migrant workers, their proportions of deaths from electric bike accidents were 3% higher than those in all traffic accidents.

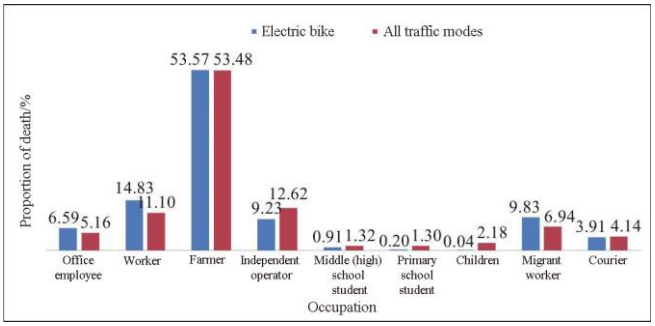

Figure 8 Occupation distribution of road traffic accident death toll in 2016

Sources: Reference [8] and traffic accident statistics system of the Ministry of public security of China.

3.3 In terms of causes of death, craniocerebral injury is the leading cause

Craniocerebral injury is the leading cause of death in road traffic accidents, whether considering only the electric bike accidents or all traffic accidents. However, the proportion of deaths caused by craniocerebral injury was higher in electric bike accidents, which is more than 80%. The main reason is that in the event of a collision accident, electric bike riders are often hit in their heads first or hit their heads on the ground. The effective protection of heads is the last chance to save the lives of electric bike riders, but the use of helmets is not ideal in reality. Except for parts of Hainan Province, electric bike riders in most areas of China do not wear helmets. In contrast, the proportions of electronic bike riders' deaths caused by chest and abdomen injuries, suffocation, burns, etc. were relatively low (see Figure 9).

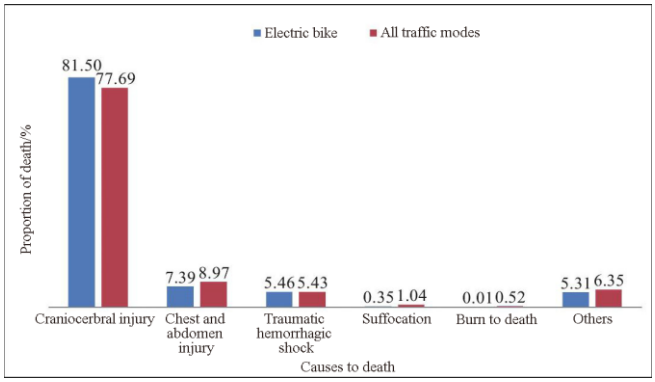

Figure 9 Cause of death of traffic accidents in 2016

Sources: Reference [8] and traffic accident statistics system of the Ministry of public security of China.

In summary, among the electric bicycle riders, workers, farmers, migrant workers and office employees who were over 40 years old are the main victim groups. They are also the populations who need the most attention in safety management. Meanwhile, advocating the protection of heads is an important measure to reduce the mortality rate of electric bike accidents.

4 Countermeasures to improve the safety of electric bikes

Based on the characteristics of electric bike accidents and riders, this paper proposed some measures to reverse the deterioration trend of electric bike safety situations, and to improve the overall traffic safety environment.

4.1 Regulate the production and sales of electric bikes comprehensively

The current chaotic situation of electric bikes was caused by the defects of *Electric Bicycles–General Technical Requirements* (GB 17761-1999) and *Electric Motorcycles and Electric Mopeds–General Technical Requirements* (GB/T 24158-2009) in the past ten years. As a result, many over-standard electric bikes have been illegally produced and sold in the market, which is the fundamental reason for the deterioration of the safety situation of electric bikes.

Along with the gradual completion of the revision work in these two national standards, relevant defects would be fixed. The mandatory provisions and tamper-proof regulations in the newly revised *Technical Specifications for Safety of Electric Bikes* (GB/T 17761-2018) ensure that electric bikes that exceed the standards would be classified as electric mopeds in the future. They provide the legal basis for the traffic control authorities to enforce laws and to determine who is liable. They also provide the technical basis to promote the full implementation of the license management of electric bikes in all jurisdictions. After the official implementation of the newly revised standards, the industry and commerce administration authorities, the quality inspection authorities and other authorities must conduct supervisions in full accordance with these new standards, with the goal to completely change the current status in which the electric bike source is out of control.

4.2 Manage existing over-standard electric bikes rationally

Although a breakthrough has been made in the source management of electric bikes, the existing over-standard electric bikes are over 100 million, which remains an issue to face. Therefore, in light of the actual management status and with reference to the experience of Nanning, it is proposed to promote all measures to reduce the inventory of over-standard electric bikes rapidly, including disposal at the end of lifecycle, trade-in, buyback at a discounted price, and disposal subsidization. In this process, the production and sales enterprises should take the major responsibilities. At the same time, along with the implementation of the vehicle registration system, it is proposed to determine and clarify the transition period for over-standard electric bikes, with the goal to eliminate them in two to three years. After the transition period, it is proposed to clarify the law enforcement standards for electric bikes according to the technical regulations of References [10–11]. The electric bikes that meet the standards are managed as non-motorized vehicles, and those that exceed the standards are classified in the category of mopeds, and should be managed as motorized vehicles. For motorized vehicles, drivers must obtain appropriate drivers' licenses, register vehicles, display vehicle license plates, and purchase corresponding insurances. Otherwise, it is a law violation since the driver would be driving a motorized vehicle with no driver-license, no vehicle license plate, or no insurance. In addition to fines, the public security and traffic control authorities can also take compulsory measures such as holding vehicles and administrative detention. These measures will greatly squeeze the market for over-standard electric bikes, thus leaving clearly two markets to manage: electric bikes and mopeds.

4.3 Strengthen the management and control of electric bikes in accident-prone areas

Data showed that urban street sections with mixed motorized and non-motorized flow and intersections are fatal accident-prone areas for electric bikes. This is an important basis for traffic control authorities and urban construction authorities to improve the understanding of the right of way management for electric bikes and to clarify key control areas. On the one hand, electric bikes should be provided with space on roadways. They should be guided into the non-motorized vehicle lane through signs and pavement markings. Traffic barriers should be used to separate non-motorized flow from motorized flow to reduce the proportions of roadway sections with mixed flows. On the other hand, more slow down signs should be provided in areas with concentrated conflicts between motorized vehicles and the electric bikes. In addition, at intersections where two-stage crossing with a center refuge island is difficult to implement, waiting lines should be marked for left-turn non-motorized vehicles. Waiting areas for electric vehicles should be clear, and direction indication arrows should be added on the pavement. The *Specification for Road Traffic Signal Setting and Installation* (GB 14886-2006) should be followed to install signals for non-motorized vehicles or add left-turn signals. Right-turn signals for motorized vehicles can be added at some intersections, and they should serve as the bases for law enforcement. With the help of road management facilities, stricter law enforcement should be maintained on the violations by electric bikes, such as non-compliance of traffic signals, traveling in the wrong direction, and using the motorized lanes, to prevent the conflicts between motorized and non-motorized vehicles, and to eliminate the threat of electric bikes to bicycles and pedestrians.

4.4 Strengthen the management and control of electric bikes during accident-prone time periods

Fatal accidents involving electric bikes are more likely to occur during the morning and evening peak periods, especially 7:00–8:00 and 17:00–18:00. Traffic control authorities should improve the accident prevention mechanism for electric bikes, strengthen the management of electric bikes during these two periods, develop control measures according to local conditions, and scientifically coordinate the relationship between the congestion of motor vehicles and the safety of electric bikes. The fatal accidents involving electric bikes at intersections during peak periods should be reduced gradually by optimizing the service and law enforcement, and by dispatching more assistant traffic officers and guides.

4.5 Improve the safety education of middle-aged and elderly people, workers and farmers

Education on electric bike traffic rules and road traffic safety should be improved for the middle-aged and elderly people, workers and farmers. Through the centralized carriers such as factories, enterprises and agricultural cooperatives, electric bike safety awareness should be promoted

among the key accident-prone populations. In the process to eliminate over-standard electric bikes, the emphasis is to speed up the replacement of electric bikes for people who are over 40 years old as well as workers and farmers. Laws and regulations should be developed to reduce the proportion of electric bike riders who are over 60 years old.

4.6 Take mandatory measures of head protection

Studies in Reference [12] have shown that wearing a high-quality helmet can reduce the risk of death from traffic accidents by 40% and the risk of serious injuries by 70%. Since more than 80% of deaths in electric bike accidents are caused by craniocerebral injuries, it is necessary to enhance the rider's head protection measures. Therefore, in combination with the revision of the Road Traffic Safety Law, increasing the proportion of head protection for electric bike riders will significantly reduce the mortality rate in electric bike accidents.

5 Conclusions

From the perspective of vehicles, the road traffic safety management in China focuses on motor vehicles, especially buses and vehicles used to transport hazardous material. From the perspective of roads, it focuses on national highways and rural roads. Not enough attention has been paid to the safety of urban traffic and electric bikes. In fact, electric bikes are important potential threats and difficulties in urban road traffic. This paper summarizes the characteristics of electric bike traffic accidents through data analysis, reveals the main contributing factors, and proposes some targeted countermeasures based on the newly released national standards for electric bikes. This paper can be used as a reference to strengthen the management of electric bikes scientifically and systematically.

References

[1] Traffic Management Bureau of the Ministry of Public Security. Statistical Communiqué of the People's Republic of China on the Motor Vehicle and Driver [R]. Beijing, Traffic Management Bureau of the Ministry of Public Security, 2012–2016 (in Chinese).

[2] Xu Linhuan, Tang Benyang, Xu Cheng. Characteristics Analysis and Management Countermeasures of Electric Bicycle Traffic Accidents [C]. The 12th Annual Conference on China Intelligent Transportation. Changshu, 2017, Innovation Makes Intelligent Travel Better(in Chinese)

[3] Wu Jianxiong, Tang Benxiang. Study on Road Traffic Safety Management of Hefei Electric Bicycles [J]. Journal of Transportation Engineering, 2017, 17 (6) : 49–53 (in Chinese).

[4] Cheng Bo. Study on Traffic Safety of Electric Bicycles Based on Traffic Conflict Technique [D]. Chengdu: Southwest Jiaotong University, 2014 (in Chinese).

[5] Zhang Kairan, Qiu Qianqian. Innovative Traffic Jam-Dissolving Model for the Motor-Bicycles in the Cross-Road Sections [J]. Journal of Safety and Environment, 2017, 17 (2) : 422–425 (in Chinese).

[6] Wei Lingxiang, Wang Yonggang, Li Wenwen, et al. Analysis on the Safety Characteristics of Left Turn for Electric Bicycle at Urban Road Intersection [J]. Journal of Yancheng Institute of Technology (Natural Science Edition) , 2017, 30 (2) : 11–15 (in Chinese).

[7] Wang Tao, Li Wenhao, Li Wenyong. Influence Factors and Injury Severity in Electric Bicycles Traffic Crashes [J]. Journal of Guangxi University (Natural Science Edition), 2017, 42 (6) : 2080–2088 (in Chinese).

[8] Traffic Management Research Institute of Ministry of Public Security. Statistical Communiqué of the People's Republic of China on the Road Traffic Accident [R]. Beijing, Traffic Management Bureau of the Ministry of Public Security, 2017 (in Chinese).

[9] The Moxin Website. The Illness of Urban Traffic Stress Need an Efficient Medicine Called Electric Bicycles [EB/OL]. 2016[2018–02–25]. http: //www. chmotor. cn/dynamic_detail. php?id=23030 (in Chinese).

[10] GB/T 17761–2018. Electric Bicycles-General Technical Requirements [S]. (in Chinese).

[11] Shanghai Motor Vehicle Inspection Certification and Tech Innovation Center Co. Ltd, China Automotive Technology and Research Center Co Ltd. Motorcycles and Electric Mopeds General Specifications (draft standard for approval) [R] Beijing, State Administration for Market Regulation, 2018 (in Chinese).

[12] World Health Organization. Global Status Report on Road Safety [R]. Geneva: World Health Organization, 2010 (in Chinese).