HHS Public Access
Author manuscript
Inj Prev. Author manuscript; available in PMC 2023 May 09.

Published in final edited form as:
Inj Prev. 2020 April ; 26(2): 116–122. doi:10.1136/injuryprev-2018-043071.

Road safety risk factors for non-motorised vehicle users in a Chinese city: an observational study

Qingfeng Li[1], **Sile Yu**[2], **Ting Chen**[3], **David M Bishai**[3], **Abdulgafoor Bachani**[1], **Adnan A Hyder**[4]

[1]Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA

[2]School of Medicine, Johns Hopkins University, Baltimore, Maryland, USA

[3]Department of Population, Family and Reproductive Health, Johns Hopkins University Bloomberg School of Public Health, Baltimore, Maryland, USA

[4]Global Health, Milken Institute School of Public Health, George Washington University, Washington, District of Columbia, USA

Abstract

Objective—The objective of this study is to describe and analyse the prevalence of speeding, helmet use and red-light running among riders of non-motorised vehicles (NMVs) in Shanghai, China, with a focus on electric bikes (ebikes).

Methods—Observational studies were conducted in eight randomly selected locations in Shanghai. Descriptive statistics and a Cox proportional hazard (PH) model were used in the analyses.

Findings—A total of 14 828 NMVs were observed in November 2017. At the free flow sites, the average speed was 22.5 km/hour for ebikes and 13.4 km/hour for bicycles. 95.5% of ebikes run above 15 km/hour, the legal speed limit for NMVs in China and 83.8% above 20 km/hour, the maximum design speed for ebikes. Helmet wearing rate was 13.5% for ebike drivers and 9.4% for passengers. Riders of commercial ebikes were nearly three times more likely to wear a helmet than personal ebikes. 22.4% of ebikes were observed to run a red light. The Cox PH model showed that ebikes (vs bicycles), males (vs females), clear weather (vs cloudy, rainy and snowy), helmet users (vs nonusers) are associated with a higher hazard for running a red light.

Conclusion—To our knowledge, this study is among the first comprehensive evaluation of road user behaviours for NMVs in China. An effective intervention package including regulating ebike

Correspondence to Dr Qingfeng Li, Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 21205, USA; qli28@jhu.edu.

Contributors QL devised the study and wrote the report. QL led the statistical modelling and analysis. QL, SY, TC, and AB collected, complied and prepared the data. DMB, AB and AAH helped to interpret the results and revise the report. All authors approve this submission.
Author note Professor Hyder was based at Johns Hopkins University at the time that the research was conducted.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

production to national standards, strengthening speed enforcement and passing legislation on mandatory helmet use for ebike users may be able to help.

INTRODUCTION

Road traffic crashes impose a heavy burden in China, causing more than 300 000 deaths every year.[1] One of most vulnerable groups are riders of two-wheelers, including classic bicycles, electric bicycles (ebikes) and motorcycles. According to the Traffic Management Bureau of the Public Safety Ministry of China, ebikes were involved in about 56 200 traffic crashes that resulted in 8431 deaths and 63 500 injuries during 2013–2017.[2] The China Bicycle Association estimates that there are about 250 million ebikes in China in 2018.[2] And the total ebike possession is still increasing rapidly as the Bureau of Statistics of China reported that 32.15 million ebikes were produced in 2016.[3]

Ebikes are bicycles with an integrated electric motor but are categorised as non-motorised vehicles (NMVs) by Chinese Traffic Laws. Compared with classic bicycles and motorcycles, ebikes have several advantages that make them particularly suitable for big cities. They are able to run on narrow streets when traffic congestion is a concern; they produce less carbon emission and noise pollution than gas-fuelled motorcycles[4] and they increase the amount of physical activities for users, which has multiple health benefits.[5] A study based on 3 years of national mobility surveys in Netherlands found that ebike ownership strongly reduced healthcare and public transport use.[6] Based on such evidence, ebikes have been promoted in Western Europe as a healthy and sustainable alternative to motor vehicles for short journeys.[7] During the past decade, ebikes have been increasingly popular in high-income countries, such as Israel,[8] Australia,[9] Sweden[10] and Norway.[5]

However, ebikes are also associated with an increased risk for a traffic crash, mainly due to their ability to reach higher speeds than classic bikes.[11] A study in Netherlands showed that ebike users are more likely to be involved in a crash that requires treatment at an emergency department than classic bikes.[12]

As the most populous city in China, Shanghai has a resident population of 24.4 million. The police reported 868 deaths due to road traffic crashes in 2016; however, that number may be underestimated.[2] According to Shanghai police, ebikes are involved in about 40% of traffic crashes and 50% of traffic deaths in the city. However, only a few small-scale studies have been conducted around safety of ebike users.[13–15]

Compared with classic bicycles, ebikes have a higher maximum design speed and consequently a greater potential to reach higher speeds; however, little is known about the actual travel speeds of ebikes.[16] According to Handbook of Road Traffic Safety Law of China, a vehicle's maximum design speed refers to the maximum travel speed guiding the initial design of the vehicle. Article 58 of Road Traffic Safety Law of China stipulates that when an ebike is running on a NMV lane, the maximum speed should not exceed 15 km/hour.[17] The *Electronic Bicycles—General Technical Requirements* enacted on 1 October 1999 regulates the maximum design speed not to exceed 20 km/hour. In May 2018, Chinese government published the revised Safety Technical Specification for Electric Bicycles (set to take effect in April 2019), lifting the maximum design speed 25 km/hour while enhancing requirements on many components, such as pedals and braking systems.[18]

Riders of NMVs are more vulnerable in crashes because these vehicles are not equipped with an outer steel protective shell like four-wheeled vehicles.[19] Since head injuries are the most common cause of death in crashes involving NMVs, helmet use has been promoted globally for the safety of all riders involved in such crashes. There are a few older studies on helmet use among NMV users in China, many of which were conducted a decade ago or earlier. An observational study in two Chinese cities (Shantou and Chaozhou) in 2005 found that 32.3% of the motorcycle drivers and 15.3% of the passengers were properly wearing helmets.[20] Another observational study conducted in Zhongshan in 2009 found that the prevalence of correct helmet use was 43.2% among drivers and 20.9% among passengers.[21] The current prevalence of helmet use among ebike riders is not known.

Running a red light can also cause traffic crashes and studies have been conducted on red-light running among ebike users.[22–24] Some have identified risk factors associated with the red-light running behaviour, including sex, age, prior crash experience and intersection infrastructure.[25–28] However, only one study has addressed the waiting time before a red light.[29] The investigation of red-light waiting time is useful because a better understanding of determinants of waiting time has important implications for intersection design and red-light management.[30] There is a need to understand the current pattern of red light running by ebike rider in China.

The objective of this study therefore was to assess the prevalence of speeding, helmet wearing and red-light running behaviours among riders of NMVs in Shanghai with a focus on ebikes. The study was conducted as part of a global road safety initiative that aims to adopt internationally recognised best practices to improve road safety in selected cities, including Shanghai.[31]

METHODS

An observational study was conducted in eight randomly selected locations, including six free flow sites and two signalised inter-sections in Shanghai (figure 1). Free-flow sites were defined as locations where vehicles travel without influences of congestion, pedestrian crossing, intersections or other adverse conditions (such as bad weather). Site selection was based on a literature review, high frequency crash spots identified from geocoded crash data and expert opinion of Shanghai police. The eight sites covered central urban areas, suburban areas, county centres and locations near a subway station. All eligible sites meet the following three criteria: location must be safe for observers; observers may be located at an elevation that is higher or equal height to passing vehicles and locations where local population rather than tourists are more likely to be observed. Field workers collect information on type of vehicle, age and sex of all drivers and passengers and their road using behaviours. Advanced radar equipment was used to measure the speed of vehicles. Other behaviours including helmet use and red-light violations were observed by trained staffs.

Data collection covered 6 business days and 2 weekends; each day of observation covered most times of the day from 07:00 to 20:00 hours. This allowed a full representation of varying traffic modes during both rush and non-rush hours. Although we collected observations on both light (<40 kg) and heavy (>40 kg) ebikes, we found that driver behaviour was similar for both types. Consequently, this analysis aggregates all size ebikes Although we collected observations on both light (<40 kg) and heavy (>40 kg) ebikes, we found that driver behaviour was similar for both types. Consequently, this analysis aggregates all size ebikes. Radar device was placed on the sidewalks, where it is safe for both our observers and devices (please see the picture below). Although the device is visible to NMV users, we do not believe it interfered with NMV user behaviours because speeding is not enforced and helmet is not required for NMV users.

Although we conducted our studies on NMV lanes that are designed for bikes and ebikes, a small number of motorcycles were included in our sample. While motorcycles are categorised as motor vehicles under the Chinese traffic laws, and therefore should use motorised lanes, some motorcycle drivers violated the rule. But the number of motorcycles is very small because the total possession of motorcycles in Shanghai has declined to a low level since the city stopped issuing new registration plates for motorcycles in 2008. Moreover, motorcycles are prohibited in many areas in the city.

NMV lanes in China are about 2.5–3.5 m wide and placed between sidewalks and motorised vehicle lanes. Most NMV lanes only allow traffic in one direction, as is the case with our observations sites. For run-light running observations, both observation sites have four arms. A total of 4–6 motorised vehicle lanes have been travelled by the riders in order to cross the intersections. Every observational session requires two observers to set up and maintain one set of radar device.

The radar device recorded the videos while simultaneously measuring the speed of passing vehicles. Demographic characteristics, vehicle variables and arrival/departure times at intersections are coded in the office by manually analysing the recorded videos.

Similar observational method has been used in road safety studies.[26 32 33] This method provides access to road safety behaviours of interest in real life situations, has stronger validity than interviews that are vulnerable to misreporting and is able to reach a wide range of people at a reasonable cost.[34] We provided comprehensive trainings to all field workers before the data collection. Through the trainings, the field workers practiced the observational methods on the roads.

Descriptive statistics were used to analyse the speed and helmet use data. We developed a Cox proportional hazard (PH) model for red-light running behaviour. The aim was to identify factors that influence road users' patience before a red light, measured by the waiting time after arriving at the intersection. This survival analytic technique has been applied to study red-light waiting time for pedestrians and cyclists.[29 35 36] For each vehicle that arrived at the intersection during a red light, we recorded its arrival and departure time. We model the failure to wait for the light to turn green as a survival problem where the clock starts on arrival and a failure to wait is coded as a failure and timed. Motorists who wait and depart after the light turns green are regarded as survivors of the event. We first conducted a bivariate analysis by plotting the Kaplan-Meier (KM) survival curve by sex, type of vehicle, weather and helmet use. The KM survival function (or endurance probability) is defined as the cumulative proportion of ebikes who are still surviving at time t: $S(t) = \Pr(T)$.[37] Then, we fit a Cox PH model that can be expressed as below[38]:

$$\lambda(t \mid X_i) = \lambda_0 \exp(X_i \beta)$$

where $\lambda(t \mid X_i)$ denotes the hazard function for ebikes i; λ_0 denotes the underlying baseline hazard function; X_i denotes covariate vector and β denotes the coefficient vector. The advantage of using a HR over an OR is that the former is less affected by selection bias with respect to the choice of endpoints and is able to indicate risks before the endpoint. The advantage of hazard analysis over logistic regression is superior power because the former is using more information about the timing of the event. Logistic regression just throws out the information about the timing of the failure and simply records any failure.

All analyses were conducted in Stata 15 SE. Ethical approval was obtained from Johns Hopkins Bloomberg School of Public Health, USA.

FINDINGs

Data collection was conducted during 12–19 November 2017. A total of 14 828 NMVs were observed, including 10 990 in the six free flow sites and 3838 in the two signalised intersection sites.

The 10 990 NMVs in the free flow sites include 8206 ebikes, 2515 classic bicycles, 50 motorcycles and 219 others (including three-wheeled motor vehicle and electric vehicles for the disabled). The number of motorcycles is relatively small for three reasons.

The average speed of ebikes was 25.3 km/hour (SD: 5.7) and the maximum speed was 57.6 km/hour. About 95.5% of ebikes ran above 15 km/hour, implying a speed limit compliance rate of below 5% (figure 1). The speed of 83.8% of ebikes were above 20 km/hour, meaning that less than 20% of the ebikes met the national standard on design speed. 52.6% were above 25 km/hour, meaning more than half of the ebikes on the road will not meet the 2018 proposed standard on design speed. In comparison, the average speed for bicycles is 13.4 km/hour, which is statistically significantly lower than ebikes (p<0.01).

Among ebike riders, males are more likely to exceed the legal speed limit than females (95.8% vs 93.7%; p<0.001; table 1), while average speed and proportion exceeding the three speed limits are very close for all age groups. χ^2 tests are used in all bivariate analyses. Ebike speed is slightly higher during late morning (ie, non rush hours) than other times. The difference in speed by usage of vehicle is small and not statistically significant, though the result for commercial ebikes should be interpreted with caution due to the small sample size. Commercial ebikes refer to those used for commercial purposes (eg, delivery) as opposed to personal purposes (eg, go to work). The average speeds are lower during rainy and snowy days than clear and cloudy days while proportion exceeding the speed limit is higher on cloudy days. Helmet users have a lower speed than nonusers.

The observed speed is higher than reports from previous studies conducted in other Chinese cities and high-income countries, though we arrived at the same conclusion that ebikes were running considerably faster than bicycles.[39 40]

In the two intersection sites, we observed 3838 vehicles. Among them, 2719 arrived at the intersections during a green light and therefore are excluded from the calculation of red-light running rate and waiting time. Among the 1119 vehicles that arrived at the intersections during a red light, 964 were ebikes, 148 bicycles and 7 others (table 2). The overall red-light running rate was 23.1%; and the rate was highest (28.4%) for classic bicycles, followed by 22.4% for ebikes. Disaggregated by sex, the rate for males is 1.7 times higher than for females (26.6% vs 15.8%). Commercial vehicles have a higher red-light running rate than personal vehicles. That may be due to the pressure on commercial riders to deliver or arrive on time. The rate is about five times higher in the morning than the afternoon, perhaps because in the morning most people are required to arrive at workplace on time while in the afternoon they usually do not have to rush to home. Weather is another important determinant: 34.7% in clear weather vs 6.0% otherwise. As was the case with speeding, helmet users are more cautious and more likely to obey the red light. The per cent of running a red light among helmet nonusers is more than twice higher than users.

Table 3 and figure 2 show KM survival function. A substantial proportion of riders immediately run the red light on arriving at the intersection. After the initial several seconds, the survival function becomes quite flat, implying that few riders started crossing before the light turned green. Overall, 15% of riders waited less than 1 s; 20% less than 5 s (table 3) and 23% less than 30 s. Disaggregated by type of vehicle, classic bicycle riders are slightly more likely to run a red light than ebike riders. Additionally, 90% of female riders waited for at least 1 s and 85% for at least 30 s; the proportion is 82% and 74% for male riders. The red-light running rate is lower than the 21% reported in a previous study.[29]

Clear weather is strongly associated with an elevated risk of running a red light. During clear weather, about 23% of riders immediately start crossing; and by the end of 30 s, only 66% are still waiting. During other weather (cloudy, rainy and snowy), about 6% of riders immediately start crossing on arrival; after that nearly no riders start crossing until 30 s. Helmet users waited more than non-users. Total 88% of users wait for at least 1 s, and that only reduces to 77% by the end of 30 s. For non-users, a smaller proportion wait for at least one second, and the proportion declines to 72% after 30 s.

The results from the Cox PH model show the relationship between the hazard of running a red light and risk factors after adjusting for the influence of other factors (table 4). A HR larger than 1 implies a higher hazard than the reference group. For example, the bivariate relationship in the KM survival curves shows that ebike riders have a lower survival curve; however, that relationship may be confounded by other factors. The Cox PH model implies that after adjusting for sex, weather and helmet use, the hazard for ebike is still 11% lower than classic bicycles, but the difference in hazard between classic bikes and ebikes is not statistically significant (p>0.1; table 4).

The hazard for females is 40% lower than for males, and the difference between sexes is statistically significant. It is consistent with previous studies that females are more patient and less likely to infringe on traffic laws than males.[22] The hazard during clear weather is six times higher than during other weather. Helmet users have a hazard 44% lower than non-users.

We pooled the data from free flow and intersection sites together to estimate the helmet wearing rate. Among the 14 828 NMVs, the helmet wearing rate was 13.5% for ebike drivers and 9.4% for ebike passengers (table 5 and figure 3). The helmet wearing rate is lower at 5.2% and 3.6% for classic bicycle drivers and passengers, respectively.

The helmet use rate is higher for riders aged 17–60 years than young and old riders that fall outside this age range (table 5). It was also higher in the afternoon than the morning. Riders of commercial ebikes are about three times more likely to wear a helmet than personal ebike users. Similar to speed, weather is also an important determinant for helmet use. The use rate is highest during rainy days. Surprisingly, the rate is very low during snowy days.

DISCUSSION

To our knowledge this study is among the first comprehensive investigation of road using behaviours for NMVs in a Chinese city. Most previous studies were based on a small sample and focused on just one risk factor. Our sample of nearly 15 000 vehicles provides a comprehensive overview of the problems with NMV users, particularly for ebikes.

Nearly all (95.5%) ebikes run over 15 km/hour, the legal speed limit for NMVs per Chinese traffic laws; this finding may reflect weak enforcement of these laws. 83.8% of ebikes were above 20 km/hour, which is the maximum design speed for ebikes; this may indicate that the manufacturers of those ebikes failed to comply with national regulations.

The Shanghai Non-motorized Vehicle Management Measures enacted in March 2013 introduced a product catalogue management system. The government maintains a catalogue of ebikes that are allowed to be sold and used in the city. Manufacturers of ebike need to submit technical specifications about their ebikes to the government. Lacking human resources and technical capacity to check all ebikes, the government usually relies on submitted materials to decide on whether to include the ebike brand/model in the catalogue. Our observations call for a better assessment procedure as the high speeding rate shows that submitted materials may not be accurate. Another possibility for these high speeds is that users might have modified the ebikes and increased their speed capacity. That modification is forbidden by the Management Measures, but again enforcement has been weak. Given the well-established relationship between speed and crash risk, urgent action is required to regulate ebike speed. That regulation should cover the whole life course of ebikes, from production, to sale and registration, to use.

Only 13.5% of ebike drivers and 9.4% of passengers wear a helmet; this is substantially lower than high-income countries and many low-income and middle-income countries.[41 42] Wearing a helmet correctly can result in a 40% reduction in the risk of death from a crash and a 70% reduction in the risk of severe injury.[43] The best practice for a helmet law covers all users, roads and engine types as well as requires riders to wear a standard fastened helmet while riding the vehicle.

In China, the enforcement and promotion of helmet use is impeded by the classification of ebikes as NMVs. The fundamental solution is changing this classification in the national law so that existing laws on motorcycles would apply; without this, local governments have limited legislative power over ebike management. A positive change occurred in early 2015 when the National People's Congress of China revised the legislation which regulates the process of creating national laws, government regulations and local laws as well as defines legislative powers in the country. A notable change in the revision is that it expanded the number of cities with legislative power from 49 to 288, empowering their legislatures to make local laws.[44] As a result, many provinces and cities have passed local legislations on ebike management.

Shanghai is not alone in facing the challenge related to ebikes; a similar situation has been found in other major cities. Statistics from transportation authority of Beijing show that 31 404 ebike-related traffic crashes occurred in 2015, causing 113 deaths and 21 423 injuries and accounting for 37% of all traffic crash injuries in the city.[45] In another developed Chinese city, Suzhou, more than a quarter (26.6%) of ebike users did not comply with the road rules.[13] Data from a hospital in the same city show that hospitalised ebike injuries accounted for more than half (57.2%) of road traffic hospitalisations over the study period.[14] The findings from this study may be useful for parts of China, though caution is warranted given potential differences in traffic modes, regulations and socio-economic development between Shanghai and other cities.

As an observational study conducted in a complex setting, this paper has several limitations. First, although the selection of observation sites was intended to be random and therefore representative of the city's overall situation, we were not able to use a statistically rigorous random selection strategy due to implementation challenges. Second, despite our effort to cover major types of location, days and times, our study still missed certain locations and times. We could not conduct observations at later night or in early morning due to safety concerns. Third, no causal inference could be made based on observational data. Fourth, many indicators were based on observations, which might be affected by an observer bias, though there is no reason to believe that bias is substantial or systematic. It is unlikely that observers tend to systematically mis-categorise males as females or vice versa.

Targeted policy and enforcement responses within a systems approach are urgently needed to reduce the prevalence of risk factors in Shanghai. Valuable experience in ebike regulation from high-income countries could be learnt.[46 47] An effective intervention package may include passing legislation on mandatory helmet use for ebike riders, strengthening enforcement on speed limits and regulating the production and sale of ebikes.

Funding

This study was funded by Bloomberg Family Foundation (http://dx.doi.org/10.13039/100007500).

REFERENCEs

1. Zhou M, Wang H, Zhu J, et al. Cause-specific mortality for 240 causes in China during 1990–2013: a systematic subnational analysis for the global burden of Disease Study 2013. Lancet 2016;387:251–72. [PubMed: 26510778]
2. 2018. Available: http://society.people.com.cn/n1/2018/0116/c1008-29768316.html [Accessed 3 Apr 2018].
3. 2017. Available: http://news.sina.com.cn/c/2017-03-15/doc-ifychhuq4656690.shtml [Accessed 3 Apr 2018].
4. Weiss M, Dekker P, Moro A, et al. On the electrification of road transportation – a review of the environmental, economic, and social performance of electric two- wheelers. Transp Res D Transp Environ 2015;41:348–66. [PubMed: 32288595]
5. Fyhri A, Fearnley N. Effects of e-bikes on bicycle use and mode share. Transp Res D Transp Environ 2015;36:45–52.
6. Kroesen M.To what extent do e-bikes substitute travel by other modes? Evidence from the Netherlands. Transp Res D Transp Environ 2017;53:377–87.
7. Jones T, Harms L, Heinen E. Motives, perceptions and experiences of electric bicycle owners and implications for health, wellbeing and mobility. J Transp Geogr 2016;53:41–9.
8. Siman-Tov M, Radomislensky I, Peleg K, et al. The casualties from electric bike and motorized scooter road accidents. Traffic Inj Prev 2017;18:318–23. [PubMed: 28166412]
9. Johnson M, Rose G. Extending life on the bike: electric bike use by older Australians. J Transp Health 2015;2:276–83.
10. Winslott Hiselius L, Svensson Åse. E-bike use in Sweden – CO 2 effects due to modal change and municipal promotion strategies. J Clean Prod 2017;141:818–24.
11. Bai L, Liu P, Guo Y, et al. Comparative analysis of risky behaviors of electric bicycles at signalized intersections. Traffic Inj Prev 2015;16:424–8. [PubMed: 25133656]
12. Schepers JP, Fishman E, den Hertog P, et al. The safety of electrically assisted bicycles compared to classic bicycles. Accid Anal Prev 2014;73:174–80. [PubMed: 25238296]
13. Du W, Yang J, Powis B, et al. Understanding on-road practices of electric bike riders: an observational study in a developed city of China. Accid Anal Prev 2013;59:319–26. [PubMed: 23877004]
14. 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;20:128–33. [PubMed: 23728530]
15. 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.
16. Schleinitz K, Petzoldt T, Franke-Bartholdt L, et al. The German naturalistic cycling study – comparing cycling speed of riders of different e-bikes and conventional bicycles. Saf Sci 2017;92:290–7.
17. NPsCo C. Road traffic safety law of China, 2010. Available: http://www.npc.gov.cn/npc/xinwen/2011-04/23/content_1653570.htm [Accessed 18 Mar 2018].
18. Regulation SAfM. Safety technical specification for electric bicycle, 2018GB17761–2018.
19. Bhalla K, Mohan D. Safety of young children on motorized two-wheelers around the world: a review of the global epidemiological evidence. IATSS Research 2015;38:83–91.
20. GL L, LP L, Cai QE. Motorcycle helmet use in southern China: an observational study. Traffic Inj Prev 2008;9:125–8. [PubMed: 18398775]
21. Xuequn Y, Ke L, Ivers R, et al. Prevalence rates of helmet use among motorcycle riders in a developed region in China. Accid Anal Prev 2011;43:214–9. [PubMed: 21094316]

22. Johnson M, Newstead S, Charlton J, et al. Riding through red lights: the rate, characteristics and risk factors of non-compliant urban commuter cyclists. Accid Anal Prev 2011;43:323–8. [PubMed: 21094330]
23. Pai C-W, Jou R-C. Cyclists' red-light running behaviours: an examination of risk-taking, opportunistic, and law-obeying behaviours. Accid Anal Prev 2014;62:191–8. [PubMed: 24172086]
24. Guo Y, Liu P, Bai L, et al. Red light running behavior of electric bicycles at Signalized Intersections in China. Transportation Research Record: Journal of the Transportation Research Board 2014;2468:28–37.
25. Johnson M, Charlton J, Oxley J, et al. Why do cyclists infringe at red lights? An investigation of Australian cyclists' reasons for red light infringement. Accid Anal Prev 2013;50:840–7. [PubMed: 22840440]
26. 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. Accident Analysis & Prevention 2012;49:186–92. [PubMed: 23036395]
27. Zhang Y, Wu C. The effects of sunshields on red light running behavior of cyclists and electric bike riders. Accid Anal Prev 2013;52:210–8. [PubMed: 23348101]
28. Guo Y, Li Z, Wu Y, et al. Exploring unobserved heterogeneity in bicyclists' red-light running behaviors at different crossing facilities. Accid Anal Prev 2018;115:118–27. [PubMed: 29558688]
29. Yang X, Huan M, Abdel-Aty M, et al. A hazard-based duration model for analyzing crossing behavior of cyclists and electric bike riders at signalized intersections. Accid Anal Prev 2015;74:33–41. [PubMed: 25463942]
30. Richardson M, Caulfield B. Investigating traffic light violations by cyclists in Dublin city centre. Accid Anal Prev 2015;84:65–73. [PubMed: 26320736]
31. Larson K, Bavinger R, Henning K. The Bloomberg initiative for global road safety 2015–2019: addressing road traffic fatalities in low-and middle-income countries. J Australas Coll Road Saf 2016;27.
32. Li G-l LL-p, Q-e C. Motorcycle helmet use in southern China: an observational study. Traffic Inj Prev 2008;9:125–8. [PubMed: 18398775]
33. Akaateba MA, Amoh-Gyimah R, Yakubu I. A cross-sectional observational study of helmet use among motorcyclists in WA, Ghana. Accid Anal Prev 2014;64:18–22. [PubMed: 24316503]
34. Boyko EJ. Observational research — opportunities and limitations. J Diabetes Complications 2013;27:642–8. [PubMed: 24055326]
35. Hamed MM. Analysis of pedestrians' behavior at pedestrian crossings. Saf Sci 2001;38:63–82.
36. Guo H, Gao Z, Yang X, et al. Modeling pedestrian violation behavior at signalized crosswalks in China: a hazards-based duration approach. Traffic Inj Prev 2011;12:96–103. [PubMed: 21259179]
37. Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. J Am Stat Assoc 1958;53:457–81.
38. Cox DR. Regression models and Life-Tables. J R Stat Soc Series B 1972;34:187–202.
39. Bai L, Liu P, Chen Y, et al. Comparative analysis of the safety effects of electric bikes at signalized intersections. Transp Res D Transp Environ 2013;20:48–54.
40. Dozza M, Werneke J. Introducing naturalistic cycling data: What factors influence bicyclists' safety in the real world? Transp Res Part F Traffic Psychol Behav 2014;24:83–91.
41. Ackaah W, Afukaar FK. Prevalence of helmet use among motorcycle users in Tamale Metropolis, Ghana: an observational study. Traffic Inj Prev 2010;11:522–5. [PubMed: 20872309]
42. Ritter N, Vance C. The determinants of bicycle helmet use: evidence from Germany. Accid Anal Prev 2011;43:95–100. [PubMed: 21094302]
43. WHO. Global status report on road safety 2015. World Health Organization, 2015.
44. 2015. Available: http://news.xinhuanet.com/english/2015-03/15/c_134067515.htm [Accessed 5 Apr 2018].
45. Bureau BTM. Ebike-related traffic crashes in Beijing, 2015. Available: http://www.chinanews.com/sh/2016/04-05/7822709.shtml [Accessed March 18, 2018].
46. Fishman E, Cherry C. E-bikes in the mainstream: reviewing a decade of research. Transp Rev 2016;36:72–91.

47. Papadakaki M, Tzamalouka G, Orsi C, et al. Barriers and facilitators of helmet use in a Greek sample of motorcycle riders: which evidence? Transp Res Part F Traffic Psychol Behav 2013;18:189–98.

What is already known on this subject?

- Road traffic crashes cause more than 300,000 deaths everyyear in China.
- As one of the most vulnerable groups on the road, electricbike (ebike) users are exposed to an increased risk for traffic crashes due to their ability to reach high speeds.
- Speeding, not wearing helmets, and red-light running are important risk factors for ebike users.

What this study adds?

- This study is among the first comprehensive investigation of road using behaviors for ebike users in China.
- Most ebikes (95.5%) run over 15 km/h, the legal speed limit for ebikes per Chinese traffic laws; only 13.5%of ebike riders and 9.4% passengers were wearing helmets.
- An effective intervention package that regulates ebike production and strengthens speed limit enforcement is urgently needed.

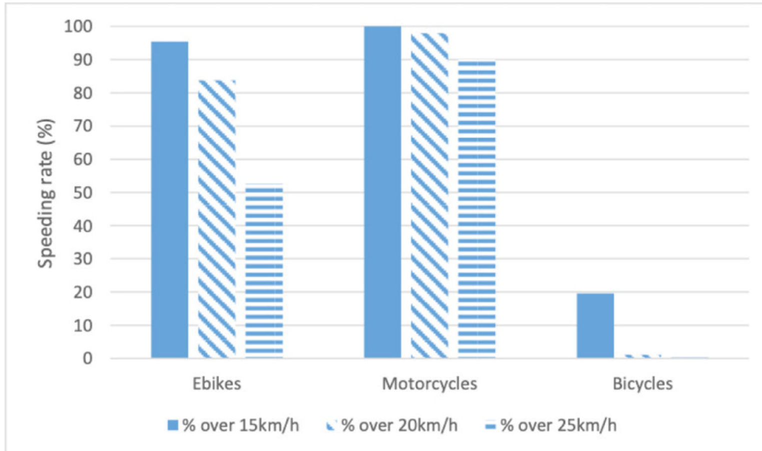

Figure 1.
Proportion of non-motorised vehicles and motorcycles over speed limits in Shanghai.

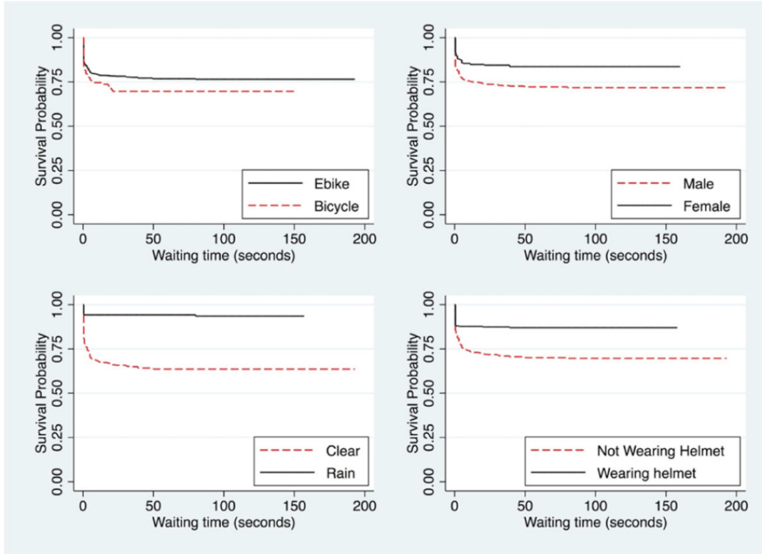

Figure 2.

Kaplan-Meier survival curve for running a red light among ebike versus bicycle riders (top-left), male versus female rider (top-right), clear versus other weather (bottom-left) and helmet user versus nonuser (bottom-right).

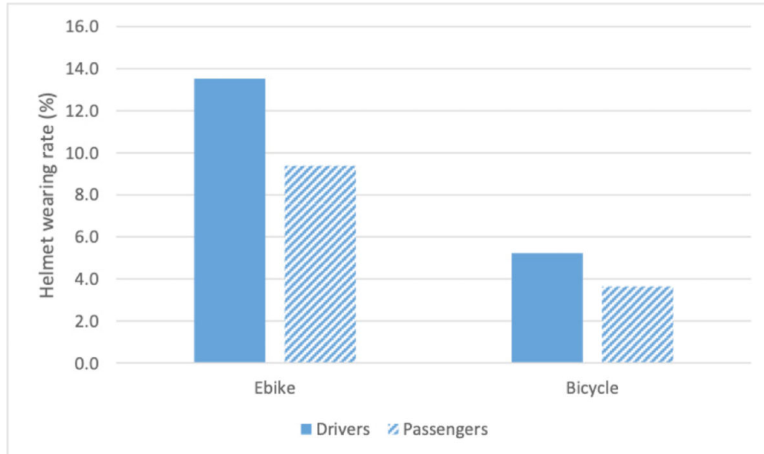

Figure 3.
Helmet wearing rate for drivers and passengers of non-motorised vehicles in Shanghai.

Table 1

Description of observed speeds of ebikes in Shanghai

Category	sample size	Average speed (SD)	Maximum speed	% over 15 km/hour	% over 25 km/hour	% over 25 km/hour
Driver sex						
Male	6877	25.5 (5.8)	57.6	95.8	84.9	54.4
Female	1329	23.9 (5.4)	46.0	93.7	77.9	43.4
Driver age						
≤16 years	14	24.6 (4.8)	35.4	100.0	85.7	42.9
17–60 years	8150	25.3 (5.7)	57.6	95.5	83.8	52.7
>60 years	42	23.9 (4.8)	36.1	95.2	83.3	45.2
Observation time						
07:30–09:00	2136	24.85 (6.2)	51.10	92.70	80.71	50.80
10:30–12:00	1530	25.63 (5.4)	45.00	97.39	86.93	54.05
15:30–17:00	2284	25.37 (5.8)	57.60	95.80	83.49	53.50
17:30–19:00	2256	25.30 (5.4)	46.80	96.50	84.88	52.44
Usage						
Personal	7974	25.3 (5.7)	57.6	95.5	83.8	52.6
Commercial	232	25.5 (6.0)	45.0	94.8	84.1	53.4
Has passenger						
No	7772	25.4 (5.7)	57.6	95.7	84.4	53.3
Yes	434	23.5 (6.1)	41.4	91.5	72.4	40.3
Weather						
Clear	4916	25.6 (6.1)	57.6	94.9	83.1	55.6
Cloudy	1647	25.6 (5.2)	52.1	97.1	87.7	57.0
Rainy	1098	23.8 (5.0)	45.0	95.8	79.3	38.9
Snowy	545	24.2 (5.0)	46.0	94.9	87.5	40.6
Driver helmet						
Wearing	896	26.1 (6.5)	57.6	96.3	83.7	55.1
Not wearing	7310	25.2 (5.6)	54.3	95.4	83.8	52.3

Table 2

Proportion of non-motorised vehicles running a red light at signalised intersections in Shanghai

Indicator	sample size	% running a red light
Type of vehicle		
Ebike	964	22.4
Bicycle	148	28.4
Others	7	14.3
Sex		
Male	758	26.6
Female	361	15.8
Age		
≤16 years	1	100.0
17–60 years	1111	23.1
>60 years	7	14.3
Usage		
Personal	1073	22.9
Commercial	46	28.3
Observation time		
07:30–09:00	369	37.4
10:30–12:00	299	31.4
15:30–17:00	292	5.5
17:30–19:00	159	6.9
Weather		
Clear	668	34.7
Other	451	6.0
Driver helmet		
Wearing	384	12.8
Not wearing	735	28.6

Table 3

Proportion of obeying a red light at signalised intersections

	% waiting by seconds after arrival			
Indicator	**1 s**	**5 s**	**10 s**	**30 s**
Total	0.85	0.80	0.79	0.77
Type of vehicle				
Ebike	0.85	0.80	0.79	0.78
Bicycle	0.82	0.76	0.75	0.71
Sex				
Female	0.90	0.86	0.85	0.85
Male	0.82	0.77	0.75	0.74
Weather				
Clear	0.78	0.70	0.68	0.66
Other	0.94	0.94	0.94	0.94
Helmet				
Wearing	0.88	0.88	0.88	0.87
Not wearing	0.83	0.76	0.74	0.72

Table 4

Hazard ratios for red-light running from the Cox proportional hazard model

Covariate	HR	95% CI
Type of vehicle		
Ebike (vs bicycle)	0.89	0.64 to 1.24
Sex		
Female (vs male)	0.60 ***	0.45 to 0.81
Weather		
Clear (vs other)	6.00 ***	4.02 to 8.95
Helmet		
User (vs nonuser)	0.56 ***	0.40 to 0.76
Sample size	1112	

*** P<0.001

Table 5

Helmet use for non-motorised vehicle users

Category	N	Helmet wearing proportion
Type of user		
Driver	11 305	13.5
Passenger	533	9.4
Age		
≤16 years	60	1.7
17–60 years	11 368	13.8
>60 years	410	2.7
Observation time		
07:30–09:00	3508	9.7
10:30–12:00	2861	11.1
15:30–17:00	2814	15.8
17:30–19:00	2655	18.0
Usage		
Personal	11 536	12.8
Commercial	302	33.8
Weather		
Clear	7684	12.3
Cloudy	1714	3.0
Rainy	1878	30.4
Snowy	562	2.8