Empirical Analysis of Speeding Behaviour and Determining Speed Limits for Bicycles

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Abstract

Background

Electric bicycle (EB) has been increasing rapidly in China, and reached approximately 200 million in 2013 (Xinhua News, 2013). On the one hand, China has the strictest law for EBs with the lowest speed limit compared to the other countries. On the other hand, EB-related deaths and injuries have been very severe and up to 5,314 and 26,966 in 2012 (Ministry of Public Security in China, 2012). There has been little research on speed limit for bicycles, and resulting in the development of relevant laws and policies for speed limit of EB is difficult and no evidence-based.

Objectives

To describe potentially speeding riding behaviors for different types of bicycles, to investigate factors influencing the speeding practices in China, and to propose a model for determining the speed limits for EBs under different conditions.

Methods

Field bicycle data were collected from eleven sections of bicycle lanes in the urban district of Hangzhou, Zhejiang Province, China. The camera was carefully and covertly set up on the roadside of the separated bicycle lanes to record the operational behavior of both EB and regular bicycle (RB). The speed, bicycle type (RB, bicycle-style-electric-bicycle (BSEB), or shooter-style-electric-bicycle (SSEB)), gender (male or female), age (young, middle-aged, or elderly), and whether or not carrying something for each bicycle were collected and coded as binary (Jin et al., 2015). Mixed logistic regression models were applied to calculate adjusted odds ratio

(OR) and associated 95% confidence interval (CI) for the association between speeding and its influencing factors. Stepwise multiple regression models were then proposed for modeling the relationships between the 85th percentile speeds for different types of bicycles and their influencing factors. The speed limits under different widths of bicycle lanes can be calculated and determined using the 85th percentile speed models under free flow condition (Fitzpatrick et al., 2003).

Results

With an increase in widths of bicycle lane, the percentages of speeding bicycles increase quickly. For the speed limit of 20 km/h, the total percentages of speeding at site 1-4 (widths of lanes less than 3 m) are around 10%, whereas more than 30% for wider bicycle lane (greater than 3.5 m). Only 5.7% RBs exceed the designed speed limit of 20 km/h, however, there were still more than 30% EBs exceeding the speed limit. The results in Table 1 show that the original speed limit standards (15 or 20 km/h) are inconsistent with the actual situation, the speeding behaviors of bicycles are widespread in China. Therefore, the observed high prevalence of speeding for EBs (both BSEBs and SSEBs) implies a need for the improvement and change of speed limit policy.

For all sites, speeding was found to be associated with low bicycle volume. Meanwhile, six sites have been found that medium bicycle volume significantly elevated ORs (range from 1.60 to 3.61), and five sites no significant effect. BSEBs and SSEBs were associated with speeding. The maximum speeding risk (OR) for BSEBs and SSEBs are 12.97 (95% CI 8.30 to 12.59) at site 1 and 20.28 (95% CI 13.32 to 30.86) at site 2, respectively. Male cyclists were associated with of marginally elevated ORs (range from 1.51 to 2.12) at all sites. For the majority of sites, no statistically significant evidence have indicated that the existence of age and carrying factors were associated with elevated and reduced ORs of speeding, respectively. Detailed results are shown in Table 2.

The multiple regression results show that the width of bicycle lane and volume are two significant variables for all types of bicycles to estimate the 85th percentile speeds, whereas the gender-, age-, and carrying-related influencing factors have no significant effect on the 85th percentile speeds. The percentages of BSEBs and SSEBs have significant effect on the 85th percentile speeds for EB-related bicycle traffic flow. Figure 1 shows the estimated speed limits for different widths of bicycle lanes.

Table 1 Percentages of speeding bicycles under different speed limit.

Site	Speed limit 15 km/h				Speed limit 20 km/h				Speed limit 25 km/h			
	RB	BSEB	SSEB	Total	RB	BSEB	SSEB	Total	RB	BSEB	SSEB	Total
1	18.3%	41.1%	42.1%	34.4%	1.8%	14.1%	14.5%	10.5%	0.1%	1.1%	2.3%	1.4%
2	14.3%	34.4%	36.4%	28.9%	0.6%	7.8%	12.0%	7.6%	0.0%	1.6%	1.9%	1.3%

3	15.2%	41.7%	48.4%	33.9%	1.2%	10.0%	17.1%	9.6%	0.0%	1.3%	1.8%	1.0%
4	22.5%	44.3%	47.2%	39.4%	2.8%	15.7%	20.1%	14.3%	0.2%	0.7%	3.9%	2.3%
5	30.6%	59.5%	55.4%	45.4%	5.8%	31.1%	31.3%	20.1%	0.8%	7.4%	11.2%	5.9%
6	54.6%	83.5%	85.0%	74.5%	8.8%	42.4%	52.1%	35.6%	0.7%	9.0%	15.6%	9.3%
7	64.5%	84.8%	89.4%	78.5%	12.2%	45.8%	58.5%	37.7%	0.8%	7.9%	16.7%	9.0%
8	25.5%	58.8%	62.7%	53.5%	3.8%	28.4%	33.8%	26.0%	0.5%	6.5%	10.4%	7.4%
9	47.1%	70.1%	78.0%	68.9%	6.0%	34.1%	42.4%	31.7%	0.2%	7.5%	12.8%	8.8%
10	48.9%	76.2%	78.9%	69.0%	6.4%	37.4%	47.9%	33.2%	0.5%	6.8%	17.1%	10.2%
11	50.2%	81.5%	83.8%	76.9%	8.8%	44.4%	50.1%	41.3%	1.3%	11.8%	16.1%	12.6%
Total	37.2%	64.4%	68.6%	58.5%	5.7%	30.8%	38.1%	27.2%	0.5%	6.5%	11.5%	7.4%

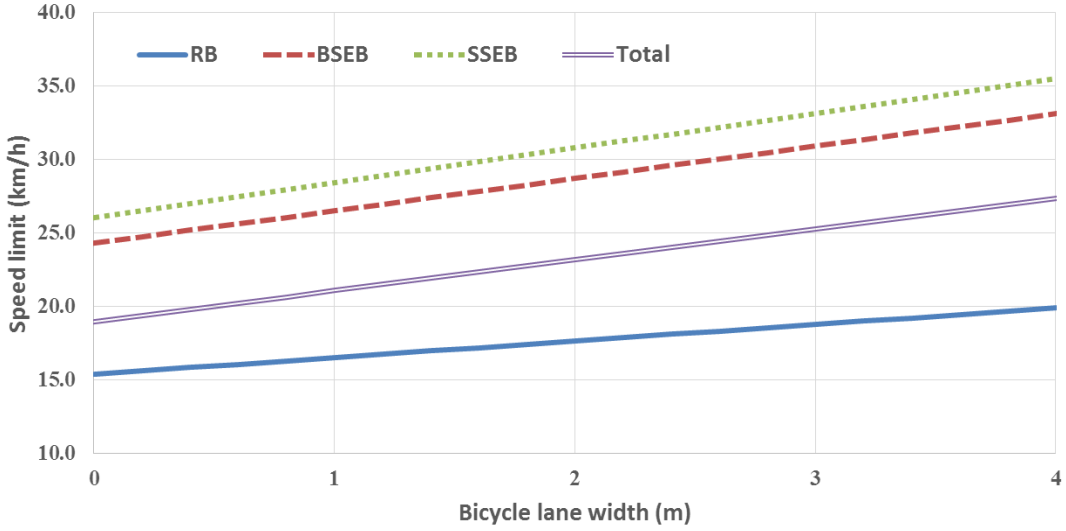

Fig. 1 Estimated speed limits for different widths of bicycle lanes.

Table 2 Logistic regression results for individual speeding.

	Site	Bicycle volume			Bicycle type			Gender			Age			Carrying	
		Low	Medium	High	BSEB	SSEB	RB	Male	Female	Young	Middle-aged	Elderly	Passenger	Oversized cargo
	OR	***2.45***	***1.60***		***9.54***	***8.68***		***1.70***		1.64	1.56		0.76	0.67
1	95% CI	***(1.91 3.15)***	***(1.41 1.82)***		***(7.22 12.59)***	***(6.72 11.23)***		***(1.48 1.97)***		(1.12 2.40)	(1.04 2.35)		(0.61 0.95)	(0.49 0.91)
	p-value	***0.000***	***0.000***		***0.000***	***0.000***		***0.000***		0.199	0.271		0.209	0.197
	OR	***6.72***	***3.61***		***12.97***	***20.28***		***1.80***		1.91	1.61		***0.31***	0.64
2	95% CI	***(5.49 8.22)***	***(3.02 4.31)***		***(8.30 20.28)***	***(13.32 30.86)***		***(1.52 2.13)***		(1.12 3.27)	(0.93 2.78)		***(0.22 0.44)***	(0.44 0.94)
	p-value	***0.000***	***0.000***		***0.000***	***0.000***		***0.001***		0.229	0.385		***0.001***	0.248
	OR	***2.63***	***2.38***		***10.18***	***16.89***		***2.05***		1.39	1.00		0.62	0.90
3	95% CI	***(2.25 3.08)***	***(2.05 2.75)***		***(7.06 14.68)***	***(12.28 23.22)***		***(1.71 2.45)***		(1.11 1.75)	(0.79 1.27)		(0.44 0.87)	(0.66 1.24)
	p-value	***0.000***	***0.000***	Reference	***0.000***	***0.000***	Reference	***0.000***	Reference	0.145	0.994	Reference	0.156	0.746
	OR	***2.89***	***1.46***		***7.86***	***9.22***		***1.62***		0.89	0.95		***0.54***	***0.47***
4	95% CI	***(2.45 3.42)***	***(1.30 1.64)***		***(6.30 9.81)***	***(7.59 11.21)***		***(1.45 1.80)***		(0.73 1.08)	(0.78 1.17)		***(0.41 0.72)***	***(0.33 0.67)***
	p-value	***0.000***	***0.001***		***0.000***	***0.000***		***0.000***		0.558	0.806		***0.031***	***0.037***
	OR	***5.20***	0.98		***6.73***	***6.65***		***1.51***		***2.14***	1.68		0.81	1.14
5	95% CI	***(4.49 6.03)***	(0.85 1.13)		***(5.76 7.85)***	***(5.81 7.62)***		***(1.36 1.69)***		***(1.63 2.83)***	(1.26 2.25)		(0.68 0.95)	(0.91 1.43)
	p-value	***0.000***	0.898		***0.000***	***0.000***		***0.000***		***0.006***	0.074		0.202	0.563
	OR	***3.87***	0.89		***8.64***	***11.31***		***1.64***		1.37	1.38		0.81	0.65
6	95% CI	***(3.38 4.44)***	(0.83 0.94)		***(7.38 10.11)***	***(9.87 12.96)***		***(1.48 1.82)***		(1.13 1.66)	(1.13 1.68)		(0.70 0.94)	(0.50 0.84)
	p-value	***0.000***	0.91		***0.000***	***0.000***		***0.000***		0.103	0.104		0.160	0.096
7	OR	***3.24***	1.37		***8.67***	***11.07***		***2.12***		***2.51***	***2.05***		***0.19***	***0.41***

	95% CI	***(2.52 4.15)***	(1.07 1.76)	***(7.47 10.07)***	***(9.92 12.36)***	***(1.92 2.35)***	***(1.87 3.36)***	***(1.51 2.77)***	***(0.15 0.26)***	***(0.33 0.52)***
	p-value	***0.000***	0.198	***0.000***	***0.000***	***0.000***	***0.002***	***0.018***	***0.000***	***0.000***
	OR	***5.48***	1.57	***12.17***	***13.92***	***1.75***	1.50	1.36	***0.49***	0.69
8	95% CI	***(4.17 7.20)***	(1.22 2.03)	***(9.83 15.08)***	***(11.42 16.96)***	***(1.60 1.92)***	(1.18 1.91)	(1.06 1.74)	***(0.42 0.58)***	(0.52 0.91)
	p-value	***0.000***	0.077	***0.000***	***0.000***	***0.000***	0.087	0.212	***0.000***	0.176
	OR	***1.59***	1.57	***8.44***	***10.64***	***1.83***	***2.79***	***2.16***	1.22	0.84
9	95% CI	***(1.42 1.78)***	(1.22 2.03)	***(6.79 10.48)***	***(8.84 12.80)***	***(1.60 2.10)***	***(2.03 3.83)***	***(1.55 2.99)***	(0.90 1.66)	(0.71 0.99)
	p-value	***0.000***	0.125	***0.000***	***0.000***	***0.000***	***0.001***	***0.019***	0.508	0.296
	OR	***7.72***	***2.18***	***11.47***	***13.31***	***1.68***	***1.94***	***1.78***	0.67	***0.68***
10	95% CI	***(6.64 8.99)***	***(1.89 2.53)***	***(9.99 13.16)***	***(11.83 14.97)***	***(1.55 1.82)***	***(1.68 2.24)***	***(1.52 2.08)***	(0.55 0.83)	***(0.59 0.79)***
	p-value	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	0.059	***0.010***
	OR	***3.08***	***2.01***	***9.89***	***11.27***	***1.61***	***1.56***	1.14	***0.66***	***0.82***
11	95% CI	***(2.70 3.50)***	***(1.91 2.10)***	***(8.93 10.95)***	***(10.31 12.33)***	***(1.53 1.69)***	***(1.39 1.76)***	(1.01 1.29)	***(0.61 0.71)***	***(0.74 0.91)***
	p-value	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	0.265	***0.000***	***0.047***

Note: Significant results are highlighted in bold italics

Conclusions

For RBs, the original speed limit (15 or 20 km/h) in China is reasonable. For the bicycle lanes where have great majority of EBs, it is recommended that the speed limit of EBs is 25-30 km/h for the width of bicycle lane less than 3 m, and 30-35 km/h for that larger than 3 m. For the bicycle lanes with heterogeneous bicycles traffic, it is recommended to maintain the existing 20 km/h speed limit for the width of bicycle lane less than 3 m, meanwhile it is considered to increase the speed limit to 25 km/h for the width larger than 3 m. The study findings indicate that there should be a need to change the speed limit policy for EBs in China.

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Response to Review Comments on Manuscript (JACRS-D-15-00114)

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We wish to express our gratitude to Assisting Editor and the anonymous reviewer for their valuable suggestions and comments on this manuscript. Since receiving the comments, we have carefully addressed the issues raised and made the corresponding changes. The following is the detailed response to the comments from the reviewer.

Response to Comments of Reviewer 1

General Comment:

The paper summarises speeding and speed thresholds for bicycles. For such a short paper the authors should put a bit more effort into completeness;

Response:

We appreciate your comments. Because this manuscript is an extended abstract, the method and conclusions are simple. We have added some conclusions and references according to the reviewer's suggestion.

Comment 1-1: *the title says electric bicycle but the paper addresses all bicycles*

Response: According to the suggestion, we use "bicycle" replaced of "electric bicycle"

Comment 1-2: *the front abstract is entirely different to the paper abstract*

Response: The front abstract is the first version, we have revised the new abstract in the revision.

Comment 1-3: *there is not sufficient detail of results to understand your conclusions (you don't even have any counts) - either add a reference to the full results or provide more detail eg you discuss 85th percentile speed results with no data*

Response: We are sorry for unclear detail of results, due to the length of extended abstract. We have added some reference and conclusions in the revised manuscript.

Comment 1-4: *Table 1 and Fig 1 aren't referred to*

Response: Table 1 and Fig 1 are cited in the paper.

Comment 1-5: *there are no references*

Response: Some important references have added in the revision.

Comment 1-6: *please justify the conclusion that because you found large numbers of cyclists exceeding the speed limit the speed limit should therefore be raised*

Response: In this paper, we used 85^{th} percentile speed of bicycle as the speed limit. The results show that the estimated limit speed exceeds the existing speed limit. Therefore, it is recommended to increase the speed limit.