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Analysis of the Risk Behavior and Decision-making Loss of Electric Bicycle Crossing Based on Traffic Conflict Technology

Yuwei Gu[1, a]

[1]College of Transport and Communications, Shanghai Maritime University, Shanghai 200000, China.

[a]gywjssz@163.com

Abstract

The analysis and modeling of the effects of electric bicycle traffic characteristics, traffic conflicts, and interference are relatively mature, but there are few studies on the relevant influencing factors of electric bicycle crossing behaviors and the analysis of selection decisions. In order to strengthen the management of the dangerous behavior of electric bicycles crossing the streets, this phenomenon has been reduced. In view of the above problems, this article takes electric bike riders as the research object, through design analysis experiments, the real collection of dangerous behavior of electric bicycles and the actual feelings of cyclists, through statistical principles and related research, analysis of various types of electric bicycles Factors affecting street behavior. Using SPSS software, a binary Logistic regression model was introduced to define the street selection behavior as a dependent variable, to further screen the influencing factors that have a significant effect on the electric bike crossing behavior, and to construct a decision loss function for electric bike riders using the Hosmer-Lemeshow. The degree of fit of the model is tested, and the illegal behavior of the cyclist is quantified to achieve the purpose of reducing the traffic accident rate at the intersection.

Keywords

Traffic conflict technology; Street crossing behavior; Safety; Decision analysis.

1. Introduction

With the rapid development of China's economy, the urban transportation system has undertaken more and more transportation tasks, and non-motor vehicles occupy an important position in the urban transportation system. With the entry of a large number of electric bicycles, urban traffic has become increasingly chaotic. Especially at intersections, electric bicycles often run through red lights. At present, Zhengzhou has more than two million electric vehicles, and daily traffic accidents involving electric vehicles account for about 80% of all traffic accidents. Traffic violations caused by pedestrians and non-motorized vehicles account for about 70% of the total number of violations. At the signalized intersections with the most complicated traffic environment, the electric bicycle crossing behavior is dangerous, so the electric bicycle crossing behavior is worth our research.

In urban transportation systems, traffic conflicts often occur because of the traffic characteristics of the traffic components. With the rapid development of electric bicycles, there are more and more traffic accidents caused by traffic conflicts between electric bicycles and other vehicles. Bai et al. [1] compared the impact of dangerous behaviors of electric bicycles and cyclists on the safety of signalized intersections. Use traffic conflict technology to estimate the safety benefits of electric bikes and bicycles. It is concluded that running a red light is the main cause of traffic accidents. In order to improve traffic safety, Richard et al. [2] analyzed the traffic conflicts of non-motorized vehicles on urban roads by using the DOCTOR observation

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method according to different types of driving behaviors of cyclists. Weinert et al. [3] analyzed in detail the sources of conflicts of electric bicycle riders during the entire riding process. Werner and Thorsten et al. [4] used traffic conflict technology to analyze and study the impact of electric bicycles on intersection delays.

The traffic efficiency of intersections often affects the traffic situation of the whole city, and the safety and traffic efficiency of intersections are inseparable. Autey and Sayed et al.[5] used traffic conflict technology to evaluate the degree of traffic safety at the intersection before and after the right-turn lane optimization of motor vehicles. It is found that the number of traffic conflicts and turning angles of motor vehicles and non-motor vehicles are different, which can improve the degree of traffic safety at the intersection. Pridavani et al. [6] evaluated the degree of traffic safety under different conditions by calculating the PET value of traffic conflicts at intersections as an evaluation index of traffic safety at intersections. Zhuang et al. [7] studied and analyzed the choice of pedestrians to reach the intersection at the end of the green light, evaluated the safety of selection, established a mathematical model to determine the predictive factors of pedestrian choice, and evaluated the safety of pedestrian decision-making.

This article takes electric bicycle riders as a research object. Through the design and analysis experiments, the dangerous behaviors of electric bicycles and the actual feelings of the riders are collected. The purpose is to reduce the traffic accident rate at intersections.

2. Methodology

2.1. Research Method of Electric Bicycle Crossing Behavio

2.1.1. Traffic Conflict Analysis

Traffic Conflicts Technique (TCT) is a non-accident index evaluation method commonly used in the field of international traffic safety. Traffic conflict technology can use different methods to achieve effective traffic safety evaluation based on specific field conditions.

The riding behavior of electric bicycle riders is the performance under the influence of various factors such as people, cars and roads during the driving process. The influencing factors mainly include the rider's own factors and external factors. In China's traffic management, electric bicycles belong to non-motorized vehicles. In the control of signalized intersections, they usually use street lights dedicated to non-motorized vehicles or follow pedestrian signals. Because of their own mobility, flexibility, and psychological factors for cyclists, electric bicycles usually do not follow the traffic lights at signalized intersections, make dangerous crossing behaviors, and cause traffic conflicts.

2.1.2. Electric Bike Crossing Behavior Choice

As a special type of traffic participant, electric bicycles have obvious randomness in their crossing behavior. The crossing behavior of electric bicycles is much more complicated than that of motor vehicles, and its individuality is stronger, which means that its analysis of crossing behavior is more complicated and difficult.

During the red light phase of signalized intersections, some cyclists fail to comply with traffic rules and perform dangerous behaviors of crossing red lights, which will cause other vehicles to blindly follow, which will cause more conflicts and cause traffic accidents.

In addition to herd mentality, cyclists also have chances when crossing the street. When the traffic flow in the cross direction is small, there will be a passable gap, and the rider will use this gap stage to perform the crossing behavior. Gap crossing behavior not only affects the running efficiency of traffic in the direction of the intersection, but also generates more conflicts and reduces the safety of signalized intersections.

Dangerous behaviors of vehicles are the result of the combined effects of different external and psychological factors. In order to have a deeper understanding of their behaviors, different factors need to be studied.

The survival analysis method is an analysis method used to reflect the duration of a certain state, and the dangerous behavior in the crossing behavior can be regarded as a crossing condition. In the study by Guo Hongwei et al. [37], the probability of the time-risk behavior needs to be calculated first:

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{p(t \le T \le t + \Delta t | T \ge t)}{\Delta t} \tag{1}$$

Where T is the waiting time for crossing.

Based on this, the waiting probability model under the influence of different factors can be obtained:

$$s(t,x) = [s_0(t)]^{\exp(x^T \beta)} \tag{2}$$

x is the influencing factor or independent variable, β is the independent variable coefficient; s0 is the baseline waiting probability, which can be expressed as:

$$s(t,x) = \exp[-\int_0^t \lambda_0(s) ds] \tag{3}$$

Through traffic survey and corresponding variable parameter estimation, the influencing factors of dangerous behavior of electric bicycle crossing can be obtained.

2.2. Logistic Model

At signalized intersections, whether or not electric bikes choose to cross the street is a matter of binary selectivity. There are only two results that can be selected. One is to cross a red light, and the other is to wait until the next phase is a green light. That is, the dependent variable of the electric bicycle crossing behavior decision can only be crossing (1) and not crossing (0). However, in the selection process of the street crossing, it was found in the above analysis that the dangerous crossing behaviors of electric bicycle riders in the intersection traffic system will not only be affected by the rider's own factors, but also be affected by the vehicle's arrival. The influence of the traffic environment and the speed of crossing when choosing to cross the street makes the safety of choosing the crossing behavior complicated.

Aiming at the characteristics of the duality of street selection, a Logistic model was used to model the behavior of electric bicycles crossing the street. Binomial Logistic model is an ideal model to solve the binary selection problem. The model has simple results and strong practicability. Logistic regression model, also called Logistic regression analysis, is a very commonly used linear regression analysis model for data collection and mining.

The dependent variable of the model is the selection behavior of crossing the street. Let the probability of selecting the crossing behavior be P, that is, the probability of selecting the waiting behavior is 1-P. The basic expression of the model is as follows:

$$P = \frac{e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}}{1 + e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n)}} \tag{4}$$

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Where P is the probability of the vehicle choosing to cross, β_i is the regression coefficient, and Xi is the independent variable.

3. Crossing Behavior and Decision Analysis of Cyclists

3.1. Data

In the research of this article, we select video capture methods to collect relevant parameters to analyze their decision-making and related security behaviors. The collected video can be used repeatedly, which can improve the survey accuracy and obtain more detailed parameters.

The survey selected Zhengzhou City's Lianhua Street-Shinan Road intersection and Science Avenue-Ruida Road intersection as the most investigated objects. The level of Lianhua Street-Shinan Road is expressway, with a large motor vehicle flow, and there are multiple schools and residential areas near the intersection to ensure the amount of non-motorized traffic, and the road conditions meet the above-mentioned intersection selection conditions.

According to the behavior and signal status of the vehicle, the variables are finally divided into three categories: the individual characteristics of the electric bicycle rider include personal factors such as the rider's gender, age, and waiting time; the environmental factors on arrival include the signal, vehicle and environment upon arrival State; Cyclists' decision-making behavior includes choosing to cross related behaviors or behavior consequences.

Table 1. Variable and definitions

Category	Variable	Definitions
Rider characteristics	Gender	Male:1; Female:0
	Generation	Divided into four age groups: juvenile, young, middle-aged and elderly
Decision-making behavior	Choice	Whether the rider chose to run through the red light Crossing: 1; Waiting: 0
State upon arrival	Number of vehicles waiting	Number of other vehicles to wait for when an electric bike arrives
	Number of vehicles crossing	Number of other vehicles that have chosen to cross when the electric bike arrives
Crossing behavior	Speed	Speed when crossing=Crossing distance/Crossing time
	Cconflict	The number of times an electric bicycle or motor vehicle changed operating conditions in an interweave
	Waiting time	Waiting time for electric bikes on the road when the signal is red

3.2. Behavior and Decision Analysis of Electric Bicycles under the Influence of Multiple Factors

Crossing behavior is mainly the result of the combined effect of its own factors and environmental factors. In order to have a deeper understanding of the dangers of electric bicycles crossing the street, it is necessary to classify different influencing factors and combine the specific survey results to quantitatively analyze the impact of each factor. It can provide a certain reference for reducing dangerous behaviors and improving safety performance.

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3.2.1. Crossing Behavior Choices

Table 2. Crossing behavior choice

Choice behavior	Quantity(per car)	Proportion(%)
Run a red light	453	58.68
Waiting	186	24.10
Waiting-Run a red light	133	17.22
Number of conflicts	228	29.53
Total observations	772	100

In this field survey, the behavior of electric bike crossing selection at signalized intersections is shown in Table 2. As of the end of the observation period, a total of 722 electric bicycles reached the signalized intersection during the red light period. In general, in the sample of this survey, the number of vehicles that directly chose to run through red lights accounted for 58.68% of the total number of observations. After waiting, the number of vehicles that chose to cross the intersection accounted for 17.22% of the total number of observations. The number of vehicles that committed violations accounted for 75.90% of the total. In addition, during the process of crossing the street, vehicles that made dangerous behaviors found that they would cause traffic conflicts with motor vehicles, which led to a decrease in traffic efficiency at intersections. The proportion of collisions in dangerous behaviors was 38.91%. However, only 24.10% of the total number of vehicles were fully selected to wait at the red light stage.

3.2.2. Impact Analysis of Rider Characteristics

The road traffic system is a whole composed of people, cars, roads, and the traffic environment. As the main body of road traffic, his traffic characteristics play a decisive role in the entire road traffic.

Table 3. Classification based on selected rider information

Rider characteristics	Category	Passing		Waiting	
		Quantity (per car)	Proportion(%)	Quantity (per car)	Proportion(%)
Gender	Male	310	76.17	97	23.83
	Female	276	75.62	89	24.38
Generation	Juvenile	19	79.17	5	20.83
	Youth	316	77.64	91	22.36
	Middle aged	222	77.35	65	22.65
	Elderly	29	53.70	25	46.30

In the above survey information, it was found that 76.17% of male cyclists chose to run through the red light, and 75.62% of female cyclists chose to run through the red light. Regardless of the gender of the cyclist, the proportion of those who chose to cross the red light to cross the intersection was not much different. It can be seen that whether a rider chooses to engage in a red light dangerous behavior has nothing to do with gender.

And some of the characteristics of the riders are related to the choices they make. Age has a certain effect on cyclists' crossing choices. The survey results show that the proportion of people who run red lights gradually decreases with age, from 79.1% of young riders to 53.70% of older riders. Probably because of age, the rider's awareness of traffic conditions is insufficient. Young people are more likely to violate traffic rules, and as they get older, fewer riders

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eventually choose to pass at the red light stage. Older cyclists are more likely to make safe behavioral decisions and choose lower-risk travel modes.

On the whole, age has a greater impact on making dangerous behavior decisions on electric bikes than gender.

3.2.3. Impact of Environmental Factors

The choice of electric bike riders is also related to their environmental factors upon arrival. The traffic environment will affect the psychology of the cyclists, which will affect their traffic behavior choices. Table 4 is a partial survey of the state of the environment when the vehicle arrived.

Table 4. Vehicle Arrival Status Questionnaire

Number	Number of vehicles waiting	Number of vehicles crossing	Whether to choose to cross
1	0	0	0
2	1	0	1
3	6	0	0
4	1	4	1
5	3	2	1
6	0	1	1
7	1	0	0
8	4	0	0
9	5	3	1
10	4	3	1

In the last column, "1" indicates that the electric bicycle chose to cross the signalized intersection during the red light phase, and "0" indicates that it selected to wait.

Table 5. Vehicle arrival status

The state of the environment upon arrival	Mean	Standard deviation
Number of waiting vehicles	1.4	1.70340
Number of vehicles crossing	0.9	1.18881

Correlation analysis of arrival status was performed by SPSS software, and Spearman rank correlation coefficient was used to test the correlation between non-parametric variables. The correlations between the factors obtained after sorting are as follows for the rider's decision to cross the street.

Table 6 shows whether the vehicle chooses to cross the street at the red light stage is related to the environment when it reaches the intersection. When there are already vehicles on the road choosing to cross the red light to pass the intersection, it is easier to influence the rider's choice and make dangerous behavior decisions (ρ= 0.489). The more vehicles making dangerous behaviors, the more likely the current vehicles will arrive to choose the traffic. Bigger. There is a negative correlation between vehicle waiting and vehicle selection, and the influencing factors are relatively low compared to traffic (ρ= -0.293). It also proves that the rider is unwilling to wait for too much red light time, so even in the red light period, breaking the red light is illegal. As long as someone chooses to violate the rules, the latter will be more likely to make the same choice. The reality is also consistent.

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Table 6. Correlation coefficient

					Number of waiting vehicles	Number of vehicles crossing	Vehicle selection
Spearman's correlation coefficient	Number of waiting vehicles	Correlation coefficient			1.000	-.152	-.293**
		Sig.(Both sides)			.	.128	.003
		N			101	101	101
		Bootstrapc	Deviation		.000	-.001	.002
			Standard error		.000	.102	.103
			95% confidence interval	min	1.000	-.347	-.496
				max	1.000	.055	-.098
	Number of vehicles crossing	Correlation coefficient			-.152	1.000	.489**
		Sig.(Both sides)			.128	.	.000
		N			101	101	101
		Bootstrapc	Deviation		-.001	.000	-.002
			Standard error		.102	.000	.062
			95% confidence interval	min	-.347	1.000	.358
				max	.055	1.000	.609
	Vehicle selection	Correlation coefficient			-.293**	.489**	1.000
		Sig. (Both sides)			.003	.000	.
		N			101	101	101
		Bootstrapc	Deviation		.002	-.002	.000
			Standard error		.103	.062	.000
			95% confidence interval	min	-.496	.358	1.000
				max	-.098	.609	1.000

**. The correlation is significant at a confidence level (double test) of 0.01.

*. The correlation is significant at a confidence level (double test) of 0.05.

c. Unless otherwise noted, bootstrap results will be based on 1000 bootstrap samples.

3.2.4. Research on traversal behavior

Although choosing an electric bicycle that violates the rules will adjust its speed according to the situation at the intersection, and judging by the general vehicle's perception of the danger, the closer the motor vehicle is to the dangerous electric bike, the more the rider makes The stronger the response, the faster the way to cross the street. Conversely, the further away from an electric bike, the weaker the response to danger. However, traffic conflicts still exist for vehicles with the right of way, reducing the capacity of intersections.

Table 7. Crossing behavior

Behavioral results	Mean	Standard deviation
Crossing speed	3.51	1.422
Number of conflicts	0.39	

As shown in Table 7, the average speed of the electric bikes selected for crossing is only 3.51m / s, but the speed fluctuation range is large, reflecting that the traffic conditions when vehicles

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choose to cross the street are not always selected at the red light stage with a large crossing gap, there are many Vehicles choose to traverse at high speed in small gaps with high danger.

P-P diagram and Q-Q diagram are used to test the normal distribution of the velocity distribution.The results show that, with the exception of a small part of the velocity distribution, the scattered point distribution of velocity is basically located near the diagonal of the P-P diagram and Q-Q diagram. Excluding special cases, it is more in line with the normal distribution. Fit the velocity distribution through the normal distribution (Fig3.).

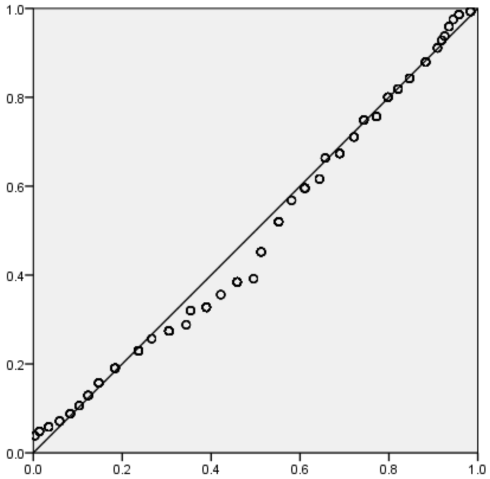

Fig 1. P-P diagram

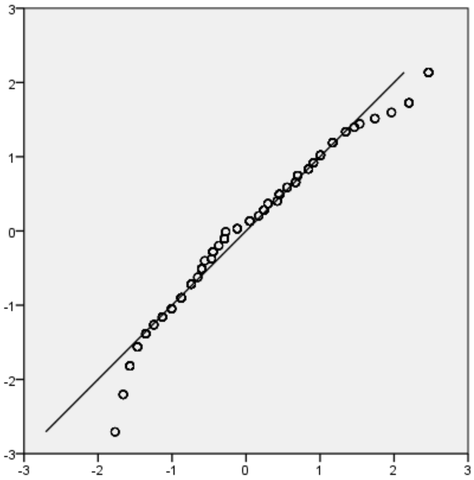

Fig 2. Q-Q diagram

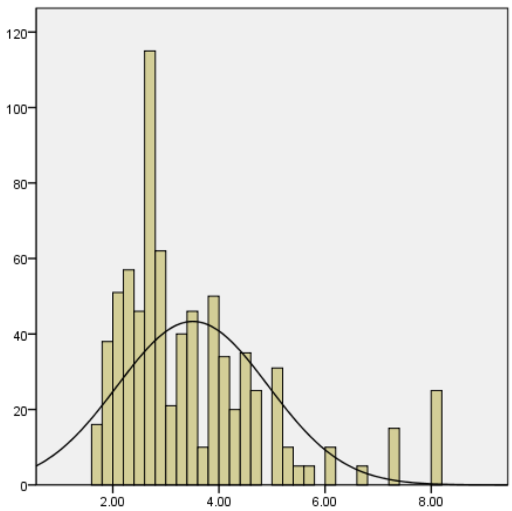

Fig 3. Velocity distribution histogram (Frequency-Speed)

The speed distribution is related to the interference of other vehicles on electric bicycles. It is assumed that when an electric bicycle chooses to cross the street at a high speed, it has a traffic conflict with other motor vehicles, and the rider feels danger and accelerates the crossing behavior. During the investigation, the number of conflicts was 228, accounting for 39% of the total number of violations. On average, each red-light crossing would cause 0.39 traffic conflicts. According to the fitting of the normal distribution to the velocity, the velocity defining the violation is predicted to be 4.54m / s. When an electric bicycle crosses a street at a red light, speeds higher than 4.54m / s are more likely to cause traffic conflicts with other motor vehicles; on the other hand, when an electric bicycle crosses a street at a red light speed below 4.54m / s, the probability of traffic conflicts is very small.

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4. Decision Modeling of Electric Bicycle Crossing Behavior

4.1. Parameter Calibration

The established Logistic model is mainly to study the influence relationship between the respective variables and the dependent variables. By combining the results of the investigation and analysis in Chapter 3 of this paper, it can be considered that the influencing factors of the risky decision-making behavior of electric bicycle crossing include the age of electric bicycle riders, the traffic environment when the vehicle arrives (including the number of waiting vehicles and the number of passing vehicles), and Speed of a bicycle crossing. The above factors are calibrated and defined as independent variables X1, X2, X3, X4. Then, a binomial Logistic regression model can be used to obtain a decision model for the dangerous behavior of electric bicycle crossing. The expression is as follows:

$$P=\frac{e^{(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4)}}{1+e^{(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4)}}=\frac{1}{1+e^{-(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4)}} \tag{5}$$

In this survey, 772 valid data sets were investigated at the intersection. In order to determine the value of the above formula, 100 samples were randomly selected from the results of this traffic survey, which satisfies the conditions of use of the logistic regression model.

Similar to common linear regression, in Logistic regression, independent variables that have a significant effect on the dependent variable should be selected as much as possible. Therefore, we should exclude some factors that have little or no effect on the dependent variable based on the selection of the Logistic model. And choose the method of likelihood ratio test to model the data.

Table 8. Randomly sampled data

Number	Age	Number of vehicles waiting	Number of passing vehicles	Whether the speed exceeds a critical value	Whether to make a dangerous decision
1	0	0	0	0	0
2	1	1	1	0	0
3	1	6	0	0	0
4	1	1	4	1	1
5	2	3	2	1	1
6	2	1	1	1	1
7	1	5	3	1	1
8	3	0	0	0	0

"0" is recorded for young cyclists, "1" is recorded for young people, "2" is recorded for middle-aged people, and "3" is recorded for old age; "1" is recorded when the speed exceeds the critical threshold, and "0" is recorded when the speed exceeds the critical threshold ".

When no independent variable enters the model, it is predicted that during the red light period of the intersection, electric bikes that choose to run through the intersection with dangerous behaviors of crossing the red light account for 65% of the total. And in Table 9, the degree of influence of each parameter on the model is tested using the Sig value, and through the goodness of fit of each parameter, the parameters that have a significant impact on the model are selected. When Sig is greater than 0.05, it means that the parameter is not statistically significant in this model, and this parameter is excluded from the model. Otherwise, it is retained. As can be seen from Table 10, the age variable is excluded from the model.

Table 9. Variable-free selection prediction table

Observed			Predicted: Whether to make dangerous behavior decisions 0	Predicted: Whether to make dangerous behavior decisions 1	Percentage correction
Step 0	Whether to make dangerous behavior decisions	0	0	35	.0
		1	0	65	100.0
	Total percentage				65.0

Table 10. Goodness of fit test

			Score	df	Sig.
Step 0	Variable	Age	2.121	1	.145
		Number of vehicles waiting	6.282	1	.012
		Number of passing vehicles	20.816	1	.000
		Whether the passing speed exceeds a critical value	18.919	1	.000
	Presidential measurement		40.560	4	.000

In the table, df is the degree of freedom; Sig. Is the significance level P value. The smaller the value is, the better the model is. Generally speaking, the requirement is less than 0.05. "Steps" in the table means adding variables to the model step by step, as shown in Table 11. Step 1 is to add the variable "number of passing vehicles" to the model, step 2 is to add "whether the threshold is exceeded", and step 3 is to add "the number of waiting vehicles."

Table 11. Variables in the equation

		B	S.E,	Wals	df	Sig.	Exp (B)	95% C.I. of EXP (B) Min	95% C.I. of EXP (B) Max
Step 1	Number of passing vehicles	1.680	.452	13.843	1	.000	5.365	2.214	12.999
	Constant	-.242	.267	.817	1	.366	.785		
Step 2	Number of passing vehicles	1.713	.475	12.998	1	.000	5.546	2.185	14.073
	Whether the passing speed exceeds a critical value	20.887	6928.671	.000	1	.998	1177336844.277	.000	
	Constant	-.778	.315	6.116	1	.013	.459		
Step 3	Number of vehicles waiting	-.568	.221	6.592	1	.010	.567	.367	.874
	Number of passing vehicles	1.704	.499	11.642	1	.001	5.494	2.065	14.619
	Whether the passing speed exceeds a critical value	21.633	6688.585	.000	1	.997	2483687972.020	.000	
	Constant	-.075	.393	.037	1	.848	.927		

In Table 11, B is the coefficient of each variable; S.E. represents the standard error; Wals represents the Wald statistic, and it is known when df =1, $Wald = (B / S.E.)^2$; Exp (B) is the odds ratio of the corresponding variable, also known as the OR value.

The variable Wald selected in the first step of the table is larger, and the Sig value is less than 0.05, which passes the test. In the second and third steps, the Wald value of the variable "passes the critical value" is small, and the Sig value is far greater than 0.05, which fails the test, indicating that the variable is not important to the model, so the variable is continuously eliminated. Although the P value of the constant is greater than 0.05, it has no effect because the constant does not have statistical significance. Therefore, there are statistical tests of the above models, and the variables that have an important influence on the model are "number of waiting vehicles" and "number of passing vehicles".

From the iterative data in Table 11, we can get the final results of the calibration of each parameter. Substituting the above calibration values into the Logistic regression model, we can get the probability model of the electric vehicle crossing risk behavior selection as follows:

$$P = \frac{1}{1+e^{0.75+0.568X_1-1.704X_2}} \tag{6}$$

X_1 and X_2 respectively represent the variables "number of waiting vehicles" and "number of passing vehicles".

Table 12. Selection prediction table after adding parameters

Observed			Predicted: Whether to make dangerous behavior decisions 0	1	Percentage correction
Step 1	Whether to make dangerous behavior decisions	0	31	4	88.6
		1	24	41	63.1
	Total percentage				72.0
Step 2	Whether to make dangerous behavior decisions	0	31	4	88.6
		1	14	51	78.5
	Total percentage				82.0
Step 3	Whether to make dangerous behavior decisions	0	32	3	91.4
		1	15	50	76.9
	Total percentage				82.0

a. Cut value 500

As shown in Table 12, the accuracy rate of predicting electric bicycles that make dangerous crossing behaviors in this model is 82%.

4.2. Goodness-of-fit test

After the probabilistic model of the dangerous behavior of electric bicycle crossing is successfully obtained, the model should continue to be tested to verify the applicability of the model. Use SPSS to test the comprehensive coefficient of the model, as shown in Table 13.

Table 13. Comprehensive test of model coefficients

		Chi-square	df	Sig.
Step 1	Step	30.091	1	.000
	Model	30.091	1	.000
Step 2	Step	23.131	1	.000
	Model	53.222	2	.000
Step 3	Step	8.352	1	.004
	Model	61.574	3	.000

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In addition, it can be seen from Table 14 that the maximum likelihood squared logarithmic value in the third step is 67.915 greater than the critical chi-square value ($\chi^2_{0.05}(3) = 7.81$), and the corrected goodness-of-fit index asks 0.733, which also shows that Good degree.

Table 14. Model summary

Step	-2lnL	Cox & Snell R2	Nagelkerke R2
1	99.398	.260	.458
2	76.267	.413	.668
3	67.915	.460	.733

-2lnL in the table is the maximum likelihood squared logarithmic value; Cox & Snell R2 is an indicator of goodness of fit; Nagelkerke R2 is an indicator of goodness of fit after correction.

Because the likelihood ratio function is naturally more sensitive to the number of samples in the survey sample, we introduce Hosmer-Lemeshow statistics to test the model.

Hosmer-Lemeshow goodness-of-fit index is a goodness-of-fit test method based on Logistic model. When its value is less than the critical value, it means that the test has passed; when its value is greater than the critical value, it means that the test has failed.

Table 15. Hosmer-Lemeshow inspection

Step	Chi-square	df	Sig.
1	.299	2	.861
2	.226	5	.999
3	11.933	7	.103

In this model, the degree of freedom df is 7, the chi-square value is 11.933 (less than), and the Sig. Value is 0.103 (more than 0.05), which indicates that the assumption of no significant error is accepted. Through Hosmer-Lemeshow test, the model in this paper is overall The degree of fit is better.

In this model, the dependent variables are defined as 1 and 0. When P = 1, the selection result is "crossing", that is, the electric bicycle chooses dangerous crossing behavior at the red light stage; when P = 0, it indicates the selection result. It is "waiting", that is, the safety behavior of electric bicycles choosing to wait for the next green light during the red light stage. When the value of the number of waiting vehicles is larger, the value of the denominator in the model is larger, which means that the probability of crossing is smaller; when the value of the passing vehicle and the passing speed is larger, the value of the denominator in the model is larger. Smaller, the greater the probability of crossing. The laws reflected by this model are consistent with the traffic conditions in real life.

5. Conclusion

In the study of this paper, it was found that among urban signalized intersections, electric bikes arriving at the red light stage are more inclined to "cross" rather than "wait" (crossing: 75.9%; waiting: 24.1%). Although at the red light stage, only waiting choices are legal.

Based on the investigation and analysis of traffic data of electric bicycle crossing behaviors at actual intersections in Zhengzhou City, further research was conducted on the dangerous behavior and decision-making of electric bicycle crossing behaviors. To sum up, the research results of this paper can be summarized into the following two aspects:

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(1) Analysis of factors affecting electric bicycle crossing behavior and decision-making

A detailed traffic survey was conducted on the crossing situation of electric bicycles at a signalized intersection in Zhengzhou through the video collection survey method. The statistical data, Spearman rank correlation coefficient, and normal fitting were used to analyze the collected data After processing, we finally got the main influencing factors of electric bicycle crossing behavior.

(2) Modeling of electric bicycle behavior decision under the influence of multiple factors

Combined with the multiple influential factors that influence the decision of electric bicycle crossing selection obtained above, through data analysis, a binary logistic regression model is used to model the influencing factors, and the main influencing factors of electric bicycle crossing selection are further obtained. The Hosmer-Lemeshow test verified the parameters and proved the accuracy and applicability of the model. The related parameters can be used to calculate the probability of dangerous behaviors of electric bicycles crossing the street.

The above research results have proposed a new model for studying the micro-analysis of electric bicycle crossing behavior, and have certain reference value for solving the common street crossing problem at urban signalized intersections. However, in actual urban transportation, the traffic environment is complex and changeable, and the impact on the electric bicycle crossing behavior may be more complicated. Therefore, for more impacts, the vehicle crossing behavior of urban signalized intersections in different environments remains to be further studied To study.

As a decision on the behavior of crossing streets at the red light stage, there is a certain error in collecting data only through video observation methods. As a psychological process, although the decision results of the rider can be found through the behavior choices made, further experiments and investigations are still needed to distinguish potential problems in information processing, risk perception, and attitude in order to be more systematic to understand the decision-making mechanism of electric bicycle vehicles at the red light stage.

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