Analysis of injury factors in car-bicycle collision

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Abstract. Bicycles are popular among the people as a new way of healthy travel. However, bicycle cyclists, as a vulnerable group of road safety, still have many problems in terms of safety. This paper analyzes the car-bicycle accidents in different scenes and objects, and proposes corresponding suggestions for the main factors causing the accident to reduce the cyclist's casualty rate.

1. Introduction

Road traffic accidents investigation is the basis of the automotive passive safety research and provides data for safety regulations amendment and accident reconstruction based on investigation, analysis and research of the accident.

Scholars have recognized the importance of analyzing vehicle-bicycle accidents. Otte concludes that the impact velocity threshold of the speed when serious injury of the bicyclist happens is 30km/h. Kröyer finds that cyclists' risk of injuries will increase over the age of 45 and road accident rates will be highest at the average speed of less than 30 km/h. Moore concludes that there are five factors influence on the rate of cyclist casualties, such as collision rate, car type, collision form, cyclists age and helmets. But the study of car-bicycle collision accidents is not mature in China. Fortunately, the research work on real bicycle accidents has been focused by multilateral institutions and has been made considerable development in the depth of the research. Many statistical analysis work based on real traffic accidents in the case of data research direction has been carried on by some domestic scholars. Zhao Jian and Wang Hongyan make three aspects statistics analysis such as person’s subjective factors, vehicle’s objective factors and personnel injury characteristics. Yang Zhen systematically analyzes the cars - bicycle accidents reappearance method combining with the accident data. This paper will count vehicle - bicycle accident distribution rule, the accident inducements and casualty of bicyclist and analyze the occurrence regularity and the influence mechanism in detail.

This paper researches car-bicycle accidents, and the case samples come from Traffic Accident Database in Weihai City. The main information includes map of the accident, record of inquiry, the vehicle accident information, personnel injury information. We also get the detailed information such as reconnaissance vehicle and the technical evaluation report based on the Institute of Traffic Accident...
2. Statistical analysis of the overall accident distribution
This paper analyzes 317 bicycle accidents based on Weihai City, which mainly discuss the vehicle-bicycle accident.

2.1 Distribution of accidents at different forms of collision
The car-bicycle collision accidents form can be divided into positive impact collision, side impact collision, crash, scratch and other collision forms (such as rolling) according to the relative positional relationship between the car and the bicycle in accidents. The amount and percentage of different accidents are shown in Table 1. Data shows that the side collision is a typical form of the vehicle-bicycle accident account for 54.7% of all the cases.

Table 1 Distribution of different forms of collision accidents

| Collision form       | Amount | Percentage |
|----------------------|--------|------------|
| The frontal collision| 53     | 19.9%      |
| The side collision    | 146    | 54.7%      |
| The rear-end collision| 22     | 8.2%       |
| The scrape collision  | 38     | 14.2%      |
| Others               | 8      | 3.0%       |

2.2 Distribution of first contact position of vehicle
Table 2 shows the first contact position of vehicles to bicycles. According to statistics, the most common collision position in accidents is the vehicle hood which involves in the front collision, the side collision and the rear-end collision, accounting for 68.5% of the total number of accidents.

Table 2 Distribution of first contact position of vehicle

| First contact position | Amount of accidents | Percentage of accidents |
|------------------------|---------------------|------------------------|
| Left hood              | 65                  | 24.3%                  |
| Frontal hood           | 47                  | 17.6%                  |
| Right hood             | 71                  | 26.7%                  |
| Left back              | 11                  | 4.1%                   |
| Back                   | 8                   | 3.0%                   |
| Right back             | 7                   | 2.6%                   |
| Left body              | 26                  | 9.7%                   |
| Right body             | 32                  | 12.0%                  |

3. Statistical analysis of accident causes
There are all kinds of causes for accidents, and they can be classified into three types: the car driver, the vehicle and the environment.

3.1 Statistical analysis of accidents caused by the car driver
After the statistical analysis of the driver’s gender, it can be found that there are 233 accidents that male driver involves, which accounts for 83.5% of the total. The main causes of accidents induced by the driver are listed in Table 3, including speeding, fatigue driving, running red lights, drinking, and overload.

Table 3 The causes of accidents induced by the driver

| Causes                | Amount of accidents | Percentage of accidents |
|-----------------------|---------------------|------------------------|
| Speeding              | 42                  | 33.1%                  |
| Fatigue driving       | 16                  | 12.6%                  |
| Running red lights    | 20                  | 15.7%                  |
| Drinking              | 15                  | 11.9%                  |
| Overload              | 8                   | 6.3%                   |
| Driver’s error        | 5                   | 3.9%                   |
Retrograde 7 5.5%
Illegal lane change 4 3.1%
Illegal overtaking 3 2.4%
Illegal parking 1 0.8%
Other illegal acts 6 4.7%

According to the Table 3, the causes for most accident rates are speeding, fatigue driving, running red lights and drinking. In addition, accidents caused by speeding account for 42 cases.

3.2 Statistical analysis of accidents caused by the performance of the vehicle
Accidents caused by performance of the car account for 49 cases, as shown in Figure 1. It can be found from statistics that the vehicle brake system failure is the most common cause, accounting for 53.1% of all the accidents. In addition, in the second place is the lighting system problem, accounting for 28.6% in the all cases.

![Figure 1. Causes by performance of cars.](image1)

3.3 Statistical analysis of accidents caused by the environment
There are plenty of environmental factors in accidents and some main factors are analyzed in this section, including the road type, road conditions, weather conditions and lighting conditions.

Weather conditions are shown in Figure 2. According to statistics, 70.8% of the accidents happen in sunny days and 15.7% of the accidents happen in overcast days while other weathers account for low percent. Lighting conditions are shown in Figure 3. It can be found from the figure that 46.4% of the accidents happen during the day and lighting condition, accidents in good lighting conditions at night account for 28.5% and accidents in bad lighting conditions at night account for 25.1%.

![Figure 2. Weather conditions.](image2)  
![Figure 3. Lighting conditions.](image3)
4. Statistical analysis of bicyclist injury

4.1 Statistical analysis of injured sites

The injury sites of the bicyclist are shown in Figure 4. It can be found from the figure that lower limb and head of the bicyclist are the most common sites, accounting for 31.7% and 29.6%. The most common injury of the head and lower limb are brain injury and fracture, while neck and spine injuries account for lowest percent. Head injury is the main cause leading to death of the bicyclist and lower limp injury is the most common factor causing morbidity.

![Injuries of bicyclist.](image)

4.2 Cross-analysis of injury and accident factors

AIS2005 standard is applied to describe injury of bicyclist. According to the severity of the injury, the damage is classified from 1 to 6 and MAIS as the maximum injury level of a bicyclist.

1. Analysis of injury with different collision forms

According to Figure 5, the frontal collision causes the most serious injury and highest death rate of the bicyclist. The rear-end collision causes serious injury as well. The scrape collision, however, causes the lowest death rate or fatal injuries.

![Cross-analysis of injury and collision form.](image)

2. Analysis of injury with different age groups

According to Figure 6, bicyclists over 60 suffer from the highest death rate and fatal injuries in a collision. The second comes to 51-60. Bicyclists from 11-20 suffer from high rate of death and fatal injuries as well while bicyclist from 21-30 suffer from the lowest rate.
5. Conclusion
This paper studies the occurrence characteristics and injury based on 267 vehicle-bicycle accidents from distribution, causal factors and casualty of bicyclist. Practical suggestions are made from the research. High mortality rates due to side impacts and different contact locations require improvements in automotive and road design. At the same time, because the bicycle rider's lower limbs and head are vulnerable, it is recommended to consider the passive safety design of the car to reduce the bicycle rider's casualty rate.

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