

Investigation in the Characters and Injury of Pedestrian or Non-motorized Vehicle Traffic Accident

Hongyan WANG¹, Zheci RONG², Xichan ZHU²

¹Institute of Automotive Safety Technology, Automotive College of
Tongji University, Shanghai, 201804,, ²Tongji University
why-sos@vip.sina.com

Abstract: Basing on the data collection of traffic accident between pedestrian、non-motorized vehicle and motor vehicle in Jiading District, Shanghai, discuss these accidents' road types and traffic participators' Composition, process a in-depth research on the accident between pedestrian、non-motorized vehicle and small motor vehicle and give some evidences for the investigation in the outer person's injury position and the relationship between injury reason and impact modality.

Keywords: Pedestrian, Non-motorized vehicle, Traffic accident, Impact, Traffic accident injury

1 Introduction

In 2005, there were 450254 traffic accidents in our country which caused 98738 persons dead, 469911 persons injured and 1880 million Yuan direct property losses. These data are already better than 2004, but China still has the most persons who die in traffic accidents. Compared to developed countries, the traffic accidents in China has a notable characteristic, that in every 4 traffic accident casualties there are 3 persons belong to vulnerable group: the death rate of motor vehicles' drivers is 13.4%, but 45% of traffic accident casualties are pedestrians, bicycle drivers or bicycle passengers.

There is close relationship between the high death rates of pedestrian and people in non-motorized vehicles and the traffic characters in China, such as few average road of traffic participants, low road grading, too many pedestrians and vehicles and high proportion of mix traffic. So it is a reality problem our road traffic researchers facing to, that to reduce the casualty rates of pedestrians and people in non-motorized vehicles, and to improve the road traffic condition.

This thesis is based on the "China road traffic accident research project" by Tongji University and Germany VW Company. Through the investigation on 90 traffic accidents between May 2005 and April 2007 which have pedestrians and non-motorized vehicles involved, to discuss these accidents' characters, participant components, impact form, the relationship between person injury and automobile engineering and so on. The definition of pedestrian and non-motorized vehicle in this thesis means pedestrian, bicycles (including two-wheel bicycle, tri-wheel bicycle and other manpower vehicles) and electric vehicles (including electric two-wheel bicycle, electric tri-wheel bicycle, electric vehicle for disable person and other electric vehicles).

2 Analysis on pedestrian, non-motorized vehicle and motor vehicle accidents

2.1 Road type

These 90 traffic accidents happen at three kinds of road types: 42 accidents happen at straight road which occupy 47%, 40 accidents happen at crossroad which occupy 44%, and 8 accidents happen at t-shaped crossing which occupy 9%.

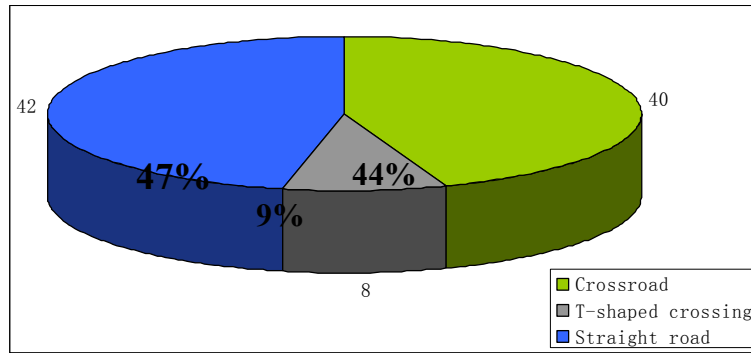


Figure 1 Road types of pedestrian and non-motorized vehicle

Pedestrian and on-motorized vehicles would break into the motorway because of their maneuverability, so the straight road accident which mainly happens at the process of crossing occupies the most proportion. This accident's form are: in different roads conditions, pedestrian and non-motorized vehicle cross the motorway whose main reasons are that the pedestrian and non-motorized vehicle haven't given way to motor vehicle driving straightly, or they haven't gone along zebra crossing or they haven't gotten off to walk, or motor vehicle hasn't given way to the pedestrian or non-motorized vehicle who have priority, or it hasn't insured safety, or it is speeding. The crossroad which has complex traffic condition is accident prone area, so many pedestrian and non-motorized vehicle accident happens at crossroad. This accident has two forms. 47% accidents are that accident participants driving straightly along different roads impact at crossroad. In these accidents one of participants hasn't complied the traffic lights, so these accidents can reduce by crossroad control, traffic lights assembly, road construction and traffic regulation compliance. 43% accidents happen during the process of one participant turning at the crossroad. These accidents happen because the participant hasn't paid attention and insured the safety. So these accidents can reduce by advance of participants' safety consciousness, full observation, speed control, reasonable operation and safety insurability. The number of t-shaped crossings is small, and its condition is also simple. So the number of accidents at t-shaped crossing is small. This accident, which is similar to the accident at crossroad, happens between vehicles driving straightly from different directions.

2.2 Participant type

Pedestrian and non-motorized vehicle have same characters, such as they belong to vulnerable group in traffic accident, they don't have the protection of cabin, they are non-motorized, and they have close speeds in traffic accidents. So they could be investigated in same way, and at the same time they could also be investigated according to their own characters.

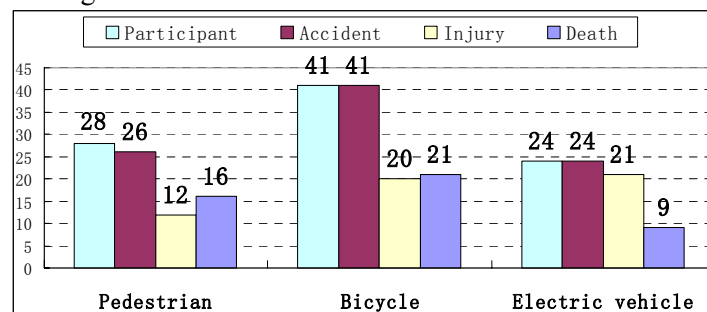


Figure 2 Participant types of pedestrian and non-motorized vehicle

In 90 accidents, there are 28 pedestrians who cause 26 accidents involved (28.9% of total number). 12 of them are injured and 16 are dead. There are 41 bicycles involved (45.6% of total number). 20 persons are injured and 21 persons are dead. There are 24 electric vehicles involved (26.7% of total number. One accident, which is between bicycle and electric vehicle, is counted twice.) 21 persons are injured and 9 persons are dead.

The injured rate of pedestrian accident is 46.15%, and the death rate is 61.54%. The injured rate of bicycle accident is 48.78%, and the death rate is 51.22%. Pedestrian and person in bicycle would always be injured seriously in accident and the death rate is higher than injured rate. In traffic management and motor vehicle design, the protection for these people should be strengthened. The injured rate of electric vehicle accident is 87.50%, and the death rate is 37.50%. So the electric vehicle accident with high injured rate and low death rate is different from the pedestrian accident and bicycle accident. Pedestrian accident rarely happens at crossing, but 69.2% pedestrian accident happens at straight road. Bicycle accident and electric vehicle accident mainly happen at crossroad, which occupies 51.22% and 54.17%. So the emphases of the pedestrian, bicycle and electric bicycle managements are different. It should be paid attention, that in 25% electric vehicle accidents the electric vehicles carry person.

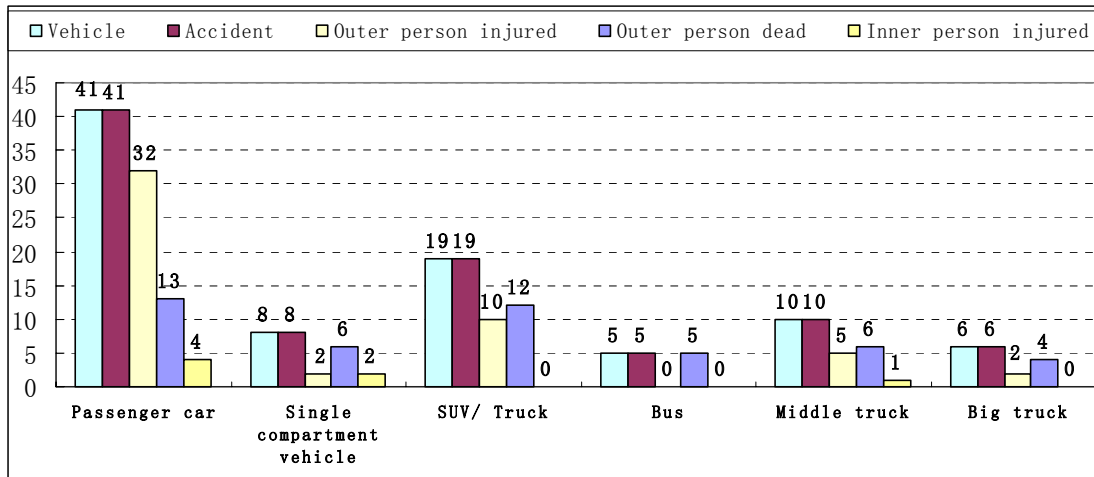


Figure 3 Participant types of motor vehicle

There are 2 kinds of motor vehicle: small vehicle and large vehicle. Small vehicles include 41 passenger cars, which cause 41 accidents, 32 outer persons injured, 13 outer persons dead and 4 inner persons injured, 8 single-compartment vehicles, which cause 8 accidents, 2 outer persons injured, 6 outer persons dead and 2 inner persons injured, and 19 SUVs or small trucks, which cause 19 accidents, 10 outer persons injured and 12 outer persons dead. Large vehicles include 5 buses, which cause 5 accidents and 5 outer persons dead, 10 middle trucks, which cause 10 accidents, 5 outer persons injured, 6 outer persons dead and 1 inner person injured, and 6 big trucks, which cause 6 accidents, 2 outer persons injured and 4 outer persons dead.

The protectors of outer persons on single-compartment vehicle, SUV and small truck, which are weightier than passenger car, are too simply to protect persons. These vehicles' death rate is 66.6%, which is close to large vehicle's level. Most accidents are passenger car accident which occupies 46.1%. But passenger car's death rate is lowest that is 31.71%. So the protection design for outer person on passenger car is mature and has good compatibility.

Relative to small vehicle, the large vehicle is much stronger than pedestrian or non-motorized, so the damage of outer person made by large vehicle is more serious than small vehicle. If large vehicle grinds

outer person, the damage is fatal. The anti-drilling equipment on the sides or rear side of trucks, which is used to prevent to grind, is mainly designed for vehicles. This equipment would impact with bicycle's handlebar and turn person down. So the danger of grinding is still there. If the large vehicle accident, whose death rate is 71.43%, happens, there is rare passive measure to reduce outer person's damage.

Because the difference between accident participants, the damage of motor vehicle is smaller, and by the energy-absorbing structure and human restraint system, the casualty rate of inner person is small too. So in all the accidents, there are only 7 inner persons injured lightly. 6 persons of them are injured by the impact between chest and steering wheel, and 1 person is injured by the impact between head and front windshield. So the protection for outer person is the emphases of human protection in accident of pedestrian and non-motorized vehicle vs. motor vehicle.

3 Investigation on Small vehicle VS pedestrian or non-motorized vehicle

In all the accidents, small vehicle accidents are more than large vehicle accidents. And small vehicle is the main part of civilian vehicles. So to reduce the casualty rate of small vehicle accident will safeguard the interests of the people and ensure social stability and unity. At the same time, the large vehicle is too strong for pedestrian and non-motorized vehicle, and the outer person's casualty couldn't be reduced if only to change large vehicle's construction. So we analyse 68 small vehicle accidents farther.

3.1 Impact position

Impact conformation could be understood by the investigation of impact position. Then the emphases of pedestrian and non-motorized vehicle protection design could be ensured. The following picture is the clock sketch map of motor vehicle's impact position o.

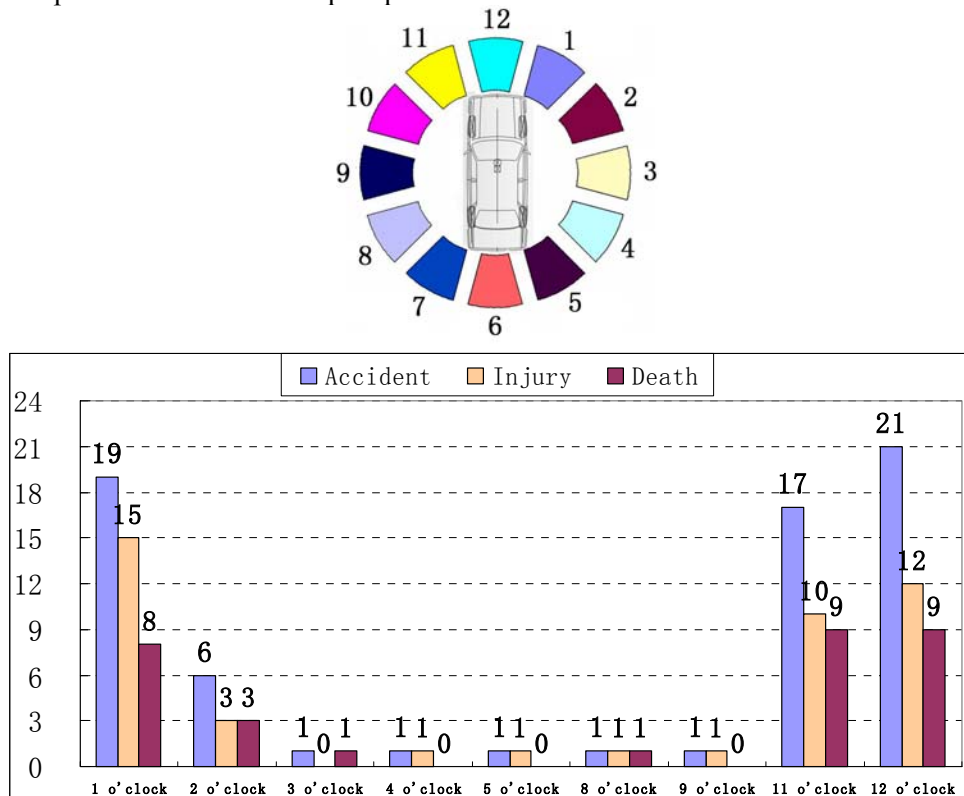


Figure 4 Small vehicle's impact position

In 68 small vehicles, 57 vehicles impact with pedestrians or non-motorized vehicles at the position of front side (including 11, 12 and 1 clock positions) which is the most regular position where impact happens, and cause 37 persons injured and 26 persons dead. 2 vehicles impact at the position of left side (including 8, 9 and 10 clock positions), and cause 2 persons injured and 1 person dead. 8 vehicles impact at the position of right side (including 2, 3 and 4 clock positions), and cause 4 persons injured and 4 persons dead. 1 vehicle impacts at the position of rear side (including 5, 6 and 7 clock positions), and cause 1 persons injured.

Small vehicle is much stronger than pedestrian and non-motorized vehicle, so it is always that small vehicle impacts with pedestrian or non-motorized vehicle, and pedestrian or non-motorized vehicle rarely impact with small vehicle. So the front side is the most regular impacting position of small vehicle. 10 side impact accidents are made up by 2 kinds accident, each of them has 5 accidents. One is that the small vehicle turns at the crossing before it ensures the safety, and the pedestrian or non-motorized vehicle hasn't find the situation and take measure in time to avoid accident. The other is that during the process that pedestrian or non-motorized vehicle crosses motorway, they impact with small vehicle driving straightly. There are more right side impact accidents than left side. In the turning accidents at crossing, small vehicle is more regular to impact with pedestrian or non-motorized vehicle when it turns right, because the no-motorized way is at the right side of motor way, and small vehicle has more space and time to avoid accident when it turns left. In the straight road accident, small vehicle's driver has better left side vision than right. Small vehicle's speed is higher than pedestrian or non-motorized vehicle, so the rear side impact happens rarely. The only one rear side impact happens at a crossroad that the bicycle riding straightly hasn't found the turning small vehicle, and impact at its rear side.

3.2 Influence of small vehicle's speed on the casualty of pedestrian and non-motorized vehicle

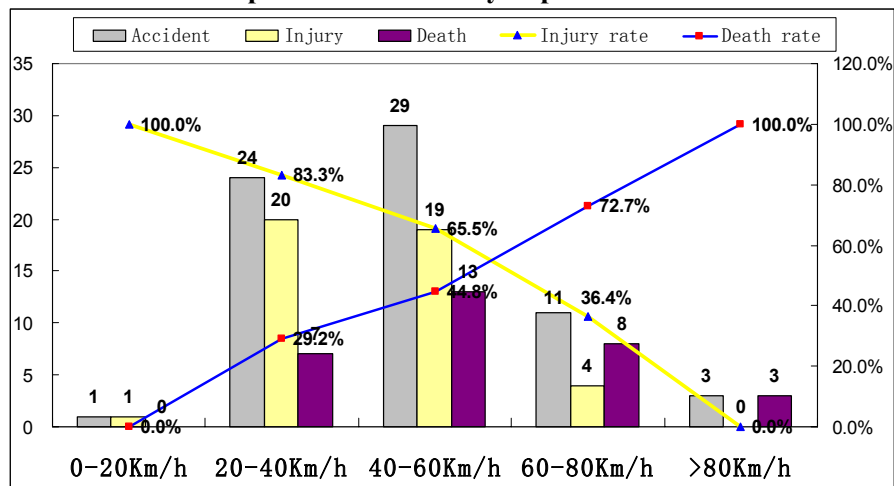


Figure 5 Influence of small vehicle's speed on the casualty of pedestrian and non-motorized vehicle

Motor vehicle's speed is between 0-20Km/h in 1 accident, which causes 1 person injured. The injury rate is 100% and the death rate is 0%. Motor vehicle's speed is between 20-40Km/h in 24 accidents, which cause 20 persons injured and 7 persons dead. The injury rate is 83.3% and the death rate is 29.2%. Motor vehicle's speed is between 40-60Km/h in 29 accidents, which cause 19 persons injured and 13 persons dead. The injury rate is 65.5% and the death rate is 44.8%. Motor vehicle's speed is between 60-80Km/h

in 11 accidents, which cause 4 persons injured and 8 persons dead. The injury rate is 36.4% and the death rate is 72.7%. Motor vehicle's speed is above 80Km/h in 3 accidents, which cause 3 persons dead. The injury rate is 0% and the death rate is 100%.

When motor vehicle's speed is low, the traffic accident happens rarely, and the injury of outer person isn't serious. So there is only 1 accident, in which the motor vehicle's speed is below 20Km/h. In this accident, front side of passenger car impacts at the side of outer person, and it causes light lower limbs impact injury and skin parenchyma contusion. Motor vehicle's speed is between 20-40Km/h and 40-60Km/h in most accidents, which occupy 77.9%. the number of accident decreases sharply as the motor vehicle's speed is between 60-80Km/h. Higher the motor vehicle's speed is, fiercer the impact process is, and worse the outer person's injury is. At the same time, the injury rate keeps on decreasing and the death rate rising.

Relative to at crossing, motor vehicle tends to drive at a higher speed at straight road. Three accidents, in which passenger cars at above 80Km/h impact with pedestrians or non-motorized vehicles crossing motor way at straight road, cause all the outer persons dead, and the death rate is 100%. The high speed accident is a big threat for outer person's safety, especially the pedestrian without any protection. Pedestrian's death rate is 100%, as the small vehicle's impact speed is above 60Km/h.

In nearest years, the dissemination rate of electric vehicle rises sharply, and the electric vehicle's accident and its characters should be paid more attention. The death rate of electric vehicle accident is low, as motor vehicle's speed is low or middle (less than 60Km/h). But electric vehicle's speed is higher than pedestrian or bicycle, the injury rate is higher. Because of the higher speed of electric vehicle, the danger is still there, as motor vehicle's speed is high (more than 60km/h). So its death rate is higher than pedestrian or bicycle accident.

3.3 Injury position of pedestrian and person in non-motorized vehicle

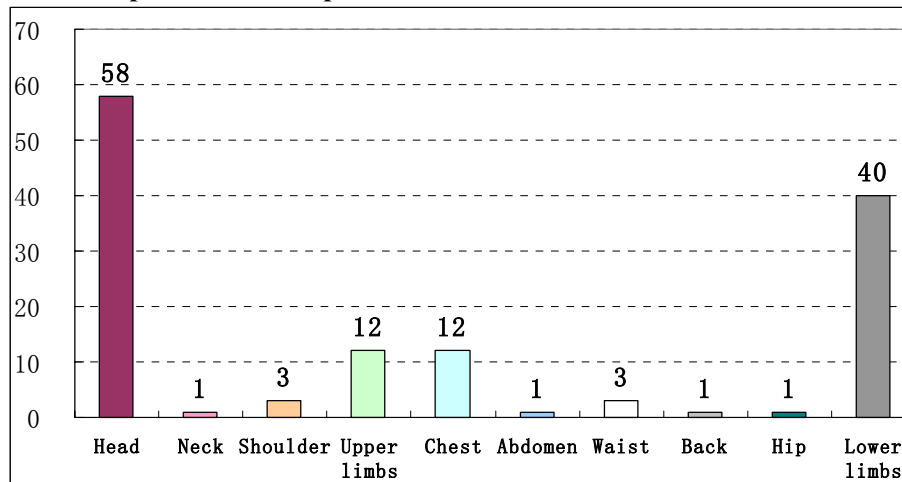


Figure 6 Injury position of pedestrian and person in non-motorized vehicle

The injury position with most possibility of pedestrian and person in non-motorized vehicle is head, which has 58 samples. Following is the lower limbs injury, which has 40 samples. The samples of upper limbs and chest injury are both 12. Injuries at other positions are less, with 3 samples of shoulder injuries and waist injuries, 1 sample of neck injury, abdomen injury, back injury and hip injury.

According to the discussion before, the front impact is the main impact form of small vehicle

accident, which occupies 83.8%. In small vehicle accident of front impact, because of the different between participants, no matter the small vehicle impacts with the outer person, the impact positions of outer person is almost the same. Relative to pedestrian, the heights of body positions of person in non-motorized vehicle haven't changed a lot, so their impact positions are close to pedestrians'. So the impact forms of small vehicle vs. pedestrian or person in non-motorized vehicle have same characters: the front Bumper of small vehicle and the lower limb of person are first impact positions. Then the outer person falls on the vehicle, head impacts with the front windshield or front cover. Or he rebounds on the ground, and the head impacts with ground. The upper limb and chest could impact with front cover or front wing, and the other body positions could also get injured.

3.4 Pedestrian and person in non-motorized vehicle COD analysis

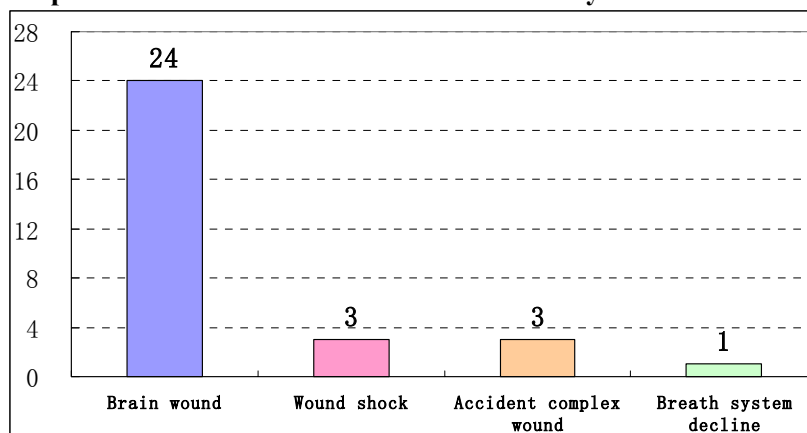


Figure 7 COD of pedestrian and person in non-motorized vehicle

In 31 decedents, 24 persons die of brain injury, which occupy 77.4%, 3 persons die of wound shock, 3 persons die of traffic accident complex wound, and 1 person dies of breath system decline.

Head and lower limb have the most possibility to get injury, but lower limb injury isn't serious enough to result in death. The possibility of chest or abdomen injury is small. So the head injury is the main cause of death. In some area of other country, the bicycler would wear helmet. So it is an important matter, that if the bicycler and electric vehicle driver need to wear helmet and if the helmet would play a role in traffic accident.

3.5 Cause of head injury of pedestrian and person in non-motorized vehicle

The biggest factor causes head injury is the impact between the head and small vehicle's front windshield. There are 36 accidents of this kind, which occupy 62.1%. Other positions, as A pole (6 accidents), frames of front windshield (6 accidents), outer rearview mirror (1 accident) and rain wiper (3 accidents) cause less accidents, but these positions have high rigidity, and these accidents' death rate is high. There are 11 decedents in these 16 head injury accident.

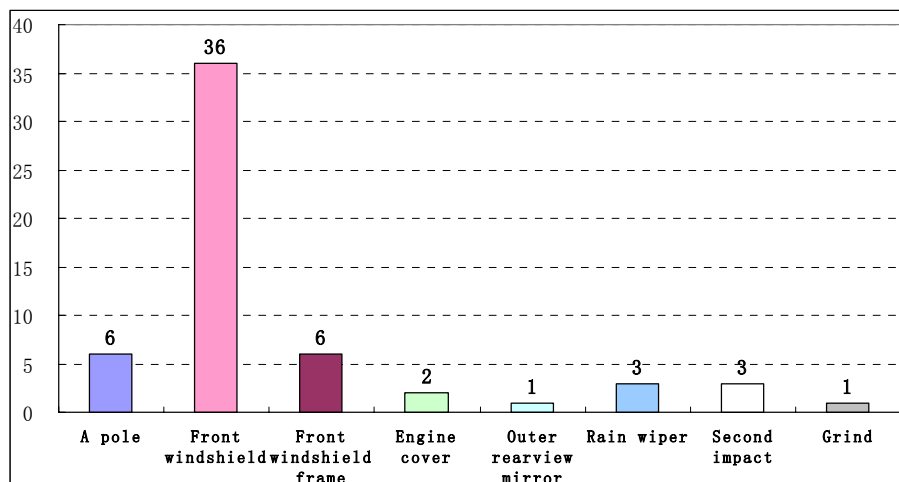


Figure 8 Head injury cause of pedestrian and person in non-motorized vehicle

By vehicle structure design, the damage of head injury could be reduced: to improve the engine cover to make some regions soft and some regions hard, to widen the buffer region in SUV engine cover and reduce its height, to put the engine lower and make a buffer region under the cover, to use machine system of engine cover, which can rise cover's position after impact and reduce the impact to outer person, to develop front round air bag system, which can covers the whole width between two A poles, including the bottom of front windshield, waving axes of rain wipers and holder of front engine cover.

3.6 Cause of lower limb injury of pedestrian and person in non-motorized vehicle

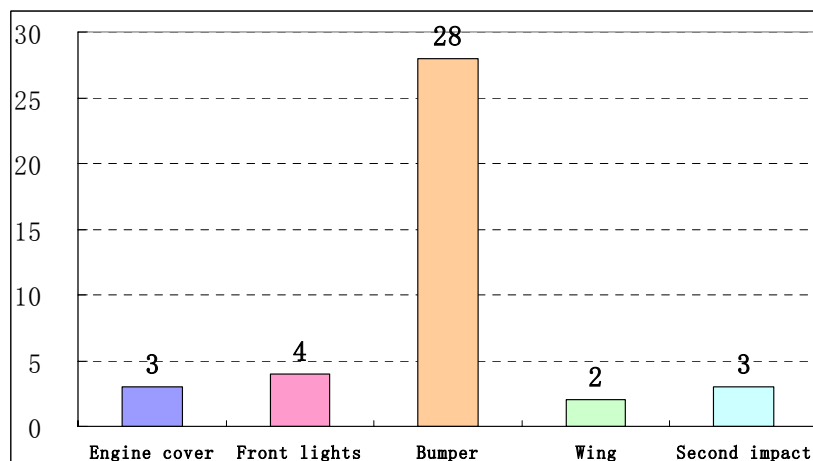


Figure 9 Cause of lower limb injury of pedestrian and person in non-motorized vehicle

There are 28 lower limb injury accident caused by the impact between pedestrian or person in non-motorized vehicle and the Bumper of small vehicle, and these accidents occupy 70%. The lower limb injuries caused by front cover, front lights, front wing and second impact are few and stay in a steady situation. Although lower limb injury isn't the main threat of outer person's safety, but it would affect wounded person's life in futul.

By research of protection design for outer person, the lower limb injury could be reduced effectively: to produce front lights by soft material to decrease the impact degree, to produce Bumper by high

consistency foam with new design structure to increase buffer region and control the impact of lower limb, to develop the front engine cover air bag, which can cover the surface of engine cover and ensure the safety of child's head and adult's leg.

3.7 Introduction of principle about pedestrian and person in non-motorized vehicle

In order to protect the outer person, many principles are made, and the test on head and lower limbs of outer person is the main task.

The Euro 74/483/EEC took effect in 1998 and was suitable for new vehicles. Until October 2001, this principle is suitable for all vehicles on the road. This principle checks the pedestrian protection by test all the parts join in the impact with pedestrian. Main tests include test of Bumper impacted by calf impacting hammer, test of front edge of engine cover impacted by thigh impacting hammer and test of upper surface of engine cover by child's head impacting hammer.

2003/102/EC released by EU in 2003 puts in to practice by two steps, and each step must include head test, thigh test and calf test. It prescribes that the anti-impact intension must ensure the wallop of the impact between pedestrian's head or lower limbs at the speed of 40Km/h and Bumper or engine cover under a limit.

The EURO—NCAP pedestrian safety test of establishing Euro pedestrian safety principle makes up by 3 tests: the test simulating the impact between calf and Bumper, the test simulating the impact between thigh, pelvis and engine cover, and the test simulating the impact between head and engine cover. These tests' condition is that the pedestrian impacts at the front side of vehicle at the speed of 40km/h.

ISO/TR 15766—2000 released on April 2000 is called biology fidelity assess objective of road vehicle- pedestrian protection- pedestrian leg test setting. This principle regulate the lab test process of pedestrian protection, the impact test setting of pedestrian calves, thighs and knees and the mathematics model of pedestrian protection.

ISO 11096—2002 released on July 2002 is called impact test method of road vehicle, pedestrian protection, pedestrian's thighs, calves and knees impact. This principle regulates the simulation test method of side impact between vehicle from regulated by ISO3833 to total weight 3.5T and adult, and try to reduce the injury of thigh, knee and calf. Investigation shows that the advancement of pedestrian protection also gives the benefit to motorcyclist and bicyclist.

ISO 14513—2006 released on 15th May 2006 is called road vehicle, pedestrian protection and head impact test method. This principle regulate the test method of impact simulation between adult's head and the passenger car and light truck from regulated by ISO3833 to total weight 3.5T, and try to reduce the injury possibility of adult's head.

4 Sum-up

The characters of mix traffic in our country are the most important reason cause the pedestrian and non-motorized vehicle accidents. These accidents' distributing under different road situation is a valuable reference for traffic administration. The weak positions of pedestrian and non-motorized vehicle in traffic accident make themselves become the emphases of traffic protection. The traffic condition could be improved by the advantage of traffic consciousness of traffic participants, the road construction and the vehicle protection design.

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