Character of Vehicle－Pedestrian Impact in China

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Abstract: According to the needs of research on regulation and development of safer vehicle for pedestrian protection, pedestrian accident cases of several cities are collected. Different types of accidents are analysed, important information mainly include accident conditions, pedestrian age, human injury, vehicle injury source, impact speed.The outcome is compared with the research of IHRA, and it is found that the character of pedestrian accidents in China is similar to IHRA.
Keywords: pedestrian, accident analysis, injury pattern

1 Introduction

Nearly 1.2 million people die annually in road crashes around the world. Pedestrians are one of the most vulnerable road users in traffic. Pedestrian deaths are especially prevalent in low-income and middle-income countries because of the greater variety and intensity of traffic mix and lack of separation between pedestrian and vehicle [8].

Approximately 1/4 of traffic accidents deaths are pedestrian from 2000 to 2005 in China [1]. In 2005, total of 98,738 road user were killed and 469,911 are injured in China, resulting in substantial economic losses due to fatalities and long-term consequences. The safety issue of the pedestrian is therefore to be a priority in the research of vehicle traffic safety in China. Knowledge from in-depth accident investigations will be valuable for improving pedestrian safety.

2 Data Analysis

A total of 200 pedestrian cases are collected between 2005 and 2007, detail pedestrian accident data are mainly from Beijing city (North China)and Ningbo city of Zhejiang province、Nanjing city of Jiangsu province(Southeast of China). Pedestrian information mainly includes age, stature, gender, injured body region and injury severity. Vehicle information mainly includes vehicle type, pedestrian contact location, damage pattern, and impact speed. Character of these data is compared with the research of IHRA to find the correlation.

A total of 415 injuries of AIS2-6 severity were observed, and there were 235 AIS1 injuries observed. These minor (AIS=1) injuries are excluded in some following analysis because they are not believed to be crucial in test procedure development. Injury composition by China and IHRA is shown in Table 1 and Figure 1[3]. It can be seen that proportion of AIS1 injuries of China is slightly lower than IHRA, but proportion of AIS 4 + in China is very little, which is similar to other IHRA countries.

Table 1 Injury composition by each country（AIS 1-6）

	Cases	Injuries	AIS1	AIS2	AIS3	AIS4	AIS5	AIS6	AIS2-6
China	200	650	235	225	168	17	5	0	415
Australia	65	345	182	93	36	12	17	5	163
Germany	782	4056	2616	877	405	89	56	13	1440
Japan	240	883	523	182	94	29	47	8	360
USA	518	4179	2837	599	477	144	99	23	1342

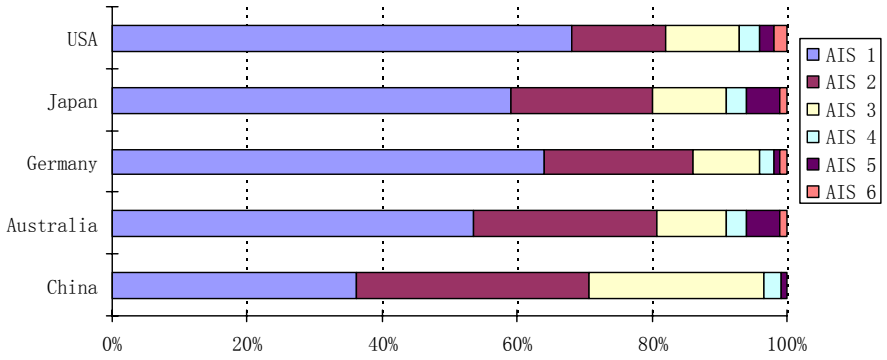

Figure 1 Injury composition by each country（AIS 1-6）

Distributions of pedestrian injury are shown in Table 2[3, 5]. Similar to other IHRA countries and Changsha city of China [5], head（38.6%）and lower extremities（27.2%）each accounted for about one-third of AIS2－6 pedestrian injuries in China, followed by chest and arms. This indicates that head and lower extremities is the leading part in pedestrian protection countermeasure.

Table 2 Distributions of Pedestrian Injury（AIS2－6）

Body Region	Distributions of Pedestrian Injury（%）						
	China (Beij.etc)	China (Changsha)	IHRA	USA	Germany	Japan	Australia
Head	38.6%	31.5%	31.4%	32.7%	29.9%	28.9%	39.3%
Face	0.7%	5.8%	4.2%	3.7%	5.2%	2.2%	3.7%
Neck	0.2%	0.8%	1.4%	0.0%	1.7%	4.7%	3.1%
Chest	11.6%	10.9%	10.3%	9.4%	11.7%	8.6%	10.4%
Abdomen	5.3%	6.2%	5.4%	7.7%	3.4%	4.7%	4.9%
Pelvis	5.1%	2.6%	6.3%	5.3%	7.9%	4.4%	4.9%
Arms	9.9%	9.4%	8.2%	7.9%	8.2%	9.2%	8.0%
Legs	27.2%	32.8%	32.6%	33.3%	31.6%	37.2%	25.8%
Unknown	1.4%	0.0%	0.2%	0.0%	0.4%	0.0%	0.0%
TOTAL	100%	100%	100%	100%	100%	100%	100%

Vehicle contact source for pedestrian injuries by different countries is shown in Table 3[3]. Similar to other IHRA countries, leading source for pedestrian injury is bumper, top surface of bonnet and windscreen glass in China. Slightly differs from IHRA, proportion of bonnet and windscreen in China is slightly higher while proportion of front bumper is slightly lower than IHRA.

Table 3 Vehicle Contact Source for Pedestrian Injuries by different Countries（AIS2－6）

	China	USA	Germany	Japan	Australia	IHRA
Front Bumper	18.2%	20.7%	21.0%	23.0%	23.5%	21.4%
Top surface of bonnet	22.7%	21.6%	15.1%	14.0%	15.0%	17.7%
Bonnet leading edge	7.0%	13.9%	9.7%	8.5%	20.9%	11.8%
Windscreen glass	20.8%	17.2%	16.0%	4.5%	5.9%	14.8%
Windscreen frame / A pillars	2.7%	8.7%	8.1%	7.7%	22.2%	9.0%
Front Panel	4.9%	4.4%	2.5%	5.0%	0.0%	3.4%
Others	2.0%	7.0%	4.3%	12.4%	8.5%	6.6%
Indirect contact	0.0%	0.6%	1.0%	6.9%	0.0%	1.4%
Road Surface	12.3%	5.9%	13.0%	9.8%	0.0%	9.2%
Unknown	9.4%	0.0%	9.4%	8.2%	3.9%	4.8%

A further breakdown of the injuries and vehicle contact sources for children and adults is shown in Table 4-5. Similar to IHRA, for children， top surface of bonnet is the leading cause of head injury. For adults, the windscreen glass is the leading cause of head injury, followed by top surface of bonnet. Not surprisingly, the bumper is the leading source for both child and adult pedestrian lower extremities injury [3]. These indicate that pedestrian test procedure of IHRA and GTR aimed at front bumper、top surface of bonnet and windscreen glass is suitable for China.

Table 4 Pedestrian Injuries by Body Region and Vehicle Contact Source (AIS2－6)

Contact \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Total
									Overall	Femur	Knee	Lower Leg	Foot	
Part of the vehicle	Front Bumper				1	6		3		6	9	53	1	79
	Top surface of bonnet	14	8		29	18	4	25	3					101
	Bonnet leading edge					7	2	5		11	1	2		28
	Windscreen glass	78	18		1			1						98
	Windscreen frame / A pillars	7		2	3	1								13
	Front Panel	3			7	1		2		4	1	1		19
	Others	2			2	2		1				4	6	17
	Sub-Total	104	26	2	43	35	6	37	3	21	11	60	7	355
Indirect contact														
Road Surface		16	5	1	1	1		8	2	1	1	5	6	47
Unknown		15	4		6	6		1		2			2	36
Total		135	35	3	50	42	6	46	5	24	12	65	15	438

Table 5 Pedestrian Injuries by Body Region and Vehicle Contact Source（Child, AIS2－6）

Contact \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Total
									Overall	Femur	Knee	Lower Leg	Foot	
Part of the vehicle	Front Bumper	1				1		1		2		2		7
	Top surface of bonnet	5						2						7
	Bonnet leading edge											1		1
	Windscreen glass													
	Windscreen frame / A pillars													
	Front Panel													
	Others											2	1	3
	Sub-Total													
Indirect contact														
Road Surface								1				2	1	7
Unknown			1											1
Total			1			1		4		2		7	2	26

Distribution of pedestrian age is shown in table 6[3]. Similar to other IHRA countries, the 21-60 year old age group has the highest frequency of accident involvement; proportion of elder is also similar to IHRA [3], while China has lower involvements in 0-15 year old age, which probably attribute to cases mainly from cities. It is notably that proportion of 6-10 year old is the highest for the

children in accidents of Beijing and Changsha, which is similar to other IHRA countries [3].

Distribution of pedestrian age and gender is shown in Table 7, 42.1% of pedestrians are female and 57.9% are male. We noted that the male pedestrian encounter for higher risks than that for females in vehicle accidents. In contrast, of Changsha pedestrians, 67% are male and 33% are female. Of German pedestrians, 51.9% are male and 48.1% are female[7]，which are all similar to China (Beijing etc).

Table 6 Distributions of Pedestrian Impact by Ages and Countries（AIS1－6）

	China(Beijing.etc)	China(Changsha)	IHRA	USA	Germany	Japan	Australia
0－5	2%	1%	7.3%	4%	9%	9%	5%
6-10	4%	4%	14.1%	11%	15%	20%	14%
11-15	1.5%	4%	9.7%	11%	10%	5%	14%
16-20	6%	10%	6.6%	7%	7%	3%	6%
21-60	66.3%	73%	41.1%	51%	36%	39%	29%
60+	20.2%	10%	21.3%	16%	23%	23%	32%

Table 7 Distribution of pedestrian age and gender

	0-15yr		16-60yr		>60yr		Total	
	Number	%	Number	%	Number	%	Number	%
Female	3	20	59	41.5	21	52.5	83	42.1
Male	12	80	83	58.5	19	47.5	114	57.9
Total	15	100	142	100	40	100	197	100

As shown in Figure 2, cumulative frequency of impact velocities（AIS2-6）in China is slightly higher than other IHRA countries [3], which probably attribute to proportion of slightly injured cases slightly less when the cases are collected. Cumulative frequency of 40km/h is about 60% for the severe and fatal accidents, that is to say, impact velocities of most accidents is lower than 40km/h, which is similar to other IHRA countries.

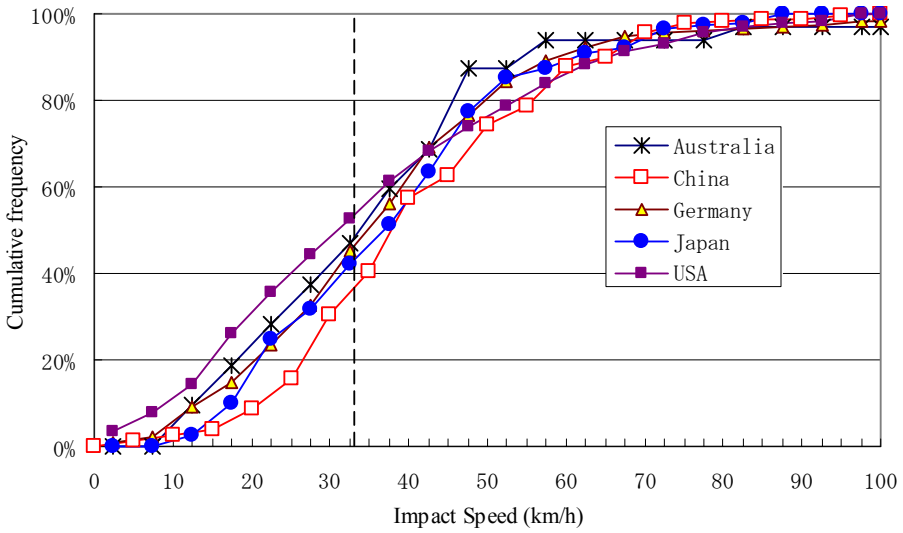

Figure 2 Impact Velocities by Country (MAIS=2-6)

As shown in Figure 3，there is little difference between average impact velocity of different age group. Average impact velocity of children is slightly lower than adult in China, but the character is

not very notable. In the statistics of IHRA, younger children tend to be involved in pedestrian impact with lower impact velocities, average impact velocities for children aged 0-14 is approximately 5km/h lower than for the other age groups [3].

Distribution of MAIS levels by age is shown in Figure 4. For children, proportion of slight injury is higher than severe and fatal injury, but it is contrary to elder(aged 60 years and older), which probably dues to those aged 60 years and older generally more frail and less resilient, leading to higher severity injury for a given impact velocity.

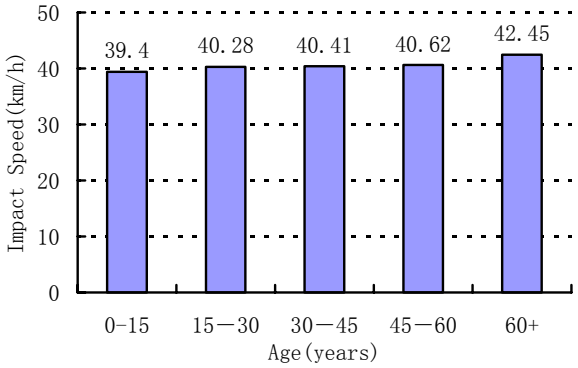

Figure 3 Average Impact Velocities by Age Group（MAIS1-6）

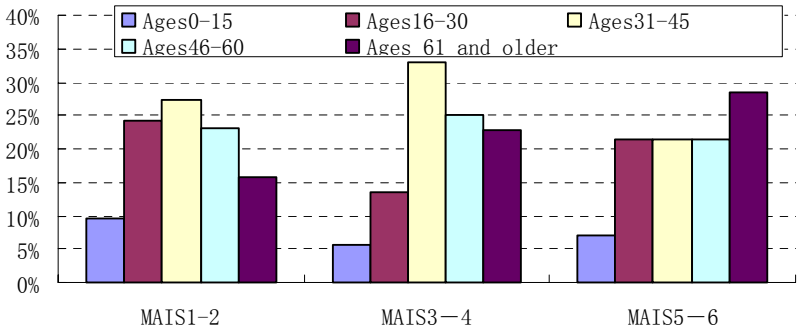

Figure 4 Distributions of MAIS Levels by Age

The final WAD value derived from the accident data is 1400mm to 2330mm for adults and 1000mm to 1660mm for children, which is similar to IHRA where the value of WAD is 1400mm to 2400mm for adults and 1000mm to 1700mm for children [3].

The proportion of vehicle category in accident is shown in figure 5. It can be seen that sedan is the primary group which nearly occupies 3/4, 1 Box is in the next place, about 23%, SUV is the least, which is basically consistent with the proportion of vehicle category in market.

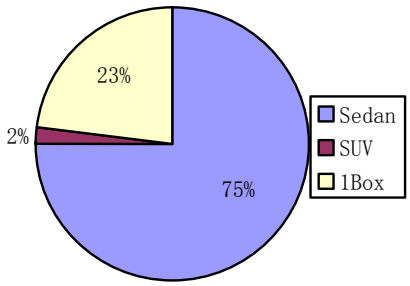

Figure 5 Proportion of Vehicle Category in Accident

The statistical result about road environment of pedestrian accident is shown in Figure 6. The proportion of accidents which occur in day and night is basically consistent in China, America and

Japan. It needs to explain that actually in some cases of China it is rather dark though there is lamp in night.

Figure 7 shows the action types of vehicle and pedestrian. Whether in China (Beijing.etc) or America and Japan, the accident rate of crossing street is the most. The proportion of pedestrian bursting in is a little high in China (Beijing .etc) and America.

Figure 8 shows the pedestrian responsibility in accident. It indicates that pedestrian should take on certain responsibility at about 72% accident. The typical fault of pedestrian is not walking on crosswalk or overpass. Thus it is of great importance to popularize civic traffic safety in order to decrease pedestrian accident.

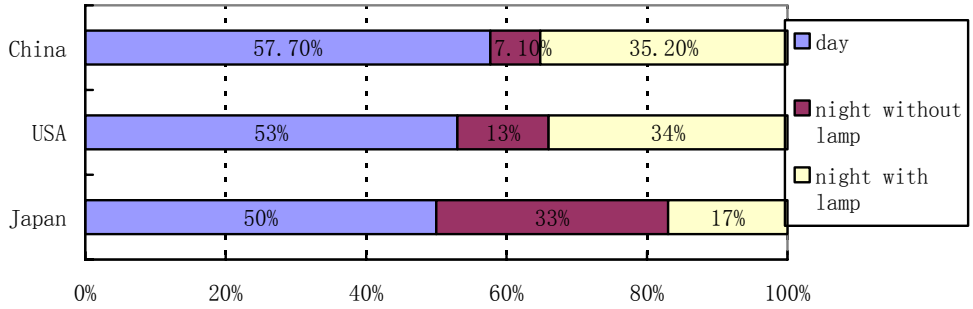

Figure 6 Pedestrian impact in different countries by day and night（AIS2-6）

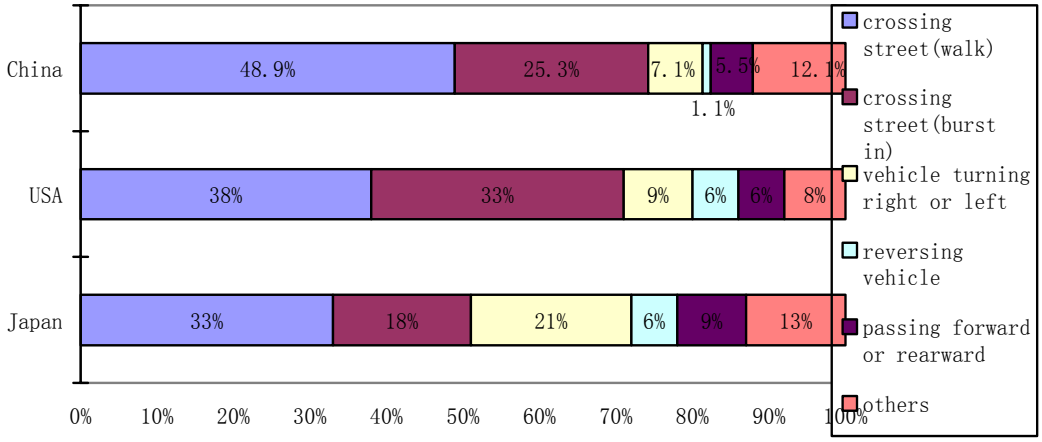

Figure 7 Action types of vehicle and pedestrian（AIS2-6）

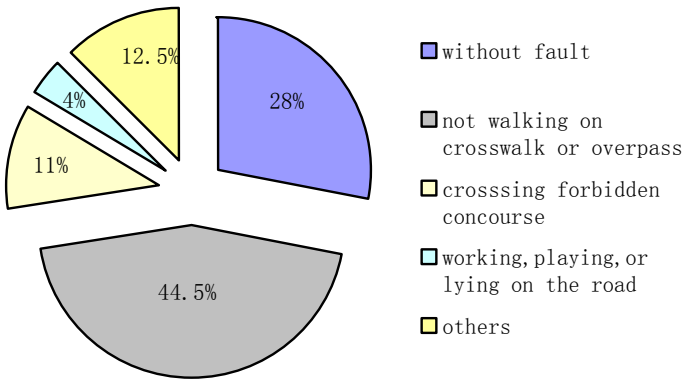

Figure 8 Pedestrian responsibilities in accident

3 Conclusions

1) Similar to other IHRA countries, head（38.6％）and lower extremities（27.2％）each accounted for about one-third of pedestrian injuries in China.

2) Similar to other IHRA countries, leading source of vehicle for pedestrian injuries is bumper、top surface of bonnet and windscreen glass in China. For children, top surface of bonnet is the leading cause of head injury. For adults, the windscreen glass is the leading cause of head injury, followed by top surface of bonnet. The bumper is the leading source for both child and adult pedestrian lower extremities injury.

3) Cumulative frequency of impact velocities of China is slightly higher than other IHRA countries, but cumulative frequency of 40km/h is about 60% for the severe and fatal accidents, which is similar to other IHRA countries.

4) As far as the proportion of vehicle category in accident is concerned, sedan is the primary group which nearly occupies 3/4, 1 Box is in the next place, about 23%, SUV is the least. It is basically consistent with the proportion of vehicle category in market.

5) The proportion of accidents which occur in day and night is basically consistent in China, American and Japan.

6) Similar to American and Japan, the accident rate of pedestrian crossing street is the most in China.

7) Pedestrian should take on certain responsibility at about 72% accident. The typical fault of pedestrian is not walking on crosswalk or overpass. Thus it is of great importance to popularize civic traffic safety in order to decrease pedestrian accident.

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