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In-Depth Investigation of Vehicle Traffic Injuries in Changsha of China[1]

Abstract

This study aimed to identify the occurrence, type and mechanisms of the traumatic injuries of the vulnerable road users in vehicle collisions, and to determine the effects of human, engineering, and environment factors on traffic accidents and injuries.

The pedestrian accident cases were collected in the years 2000 to 2005 from Changsha Wujing hospital China and Accident Research Unit at Medical University Hannover in Germany. A statistic analysis was carried out using the collected accident data. The results from analysis of Changsha data were compared with results from analysis of GIDAS data Hannover.

The injury severities were determined using AIS code and ISS values. The results were presented in terms of cause of injuries, injury distributions, injury patterns, injury severity. The factors influenced the injury outcomes were proposed and discussed for the vehicle transport environment and road users. The results were discussed with regard to accident data collection, accident sampling and injury distributions etc.

In the urban area of Changsha, motorcycles and passenger cars are most frequently involved in vehicle pedestrian accidents. Head and lower extremities injuries are the predominant types of pedestrian injuries. The pedestrian accidents were identified as vital issue in urban traffic safety and therefore a high priority should be given to this road user group in research of safe urban transportation. In Hannover area, cars are most frequently involved in traffic accidents, injured pedestrians are involved in road traffic of Germany in 13% of all causalities only in 2005 and have nearly the same number as motorcyclists, but the half of bicyclists.

1 Introduction

In China 107,000 road users are killed and 549,051 are injured in 2004, resulting in substantial economic losses due to fatalities and long-term consequences. The social cost was found as high as 3,090 millions RMB, which clearly demonstrates the urgent demand for preventive measures.

In Germany 440,000 road users were injured in 2004, the half of these were aged between 25 to 65 years old, 5,800 fatalities could be registered in that year, 14% were pedestrians [1].

Pedestrians represent a high risk population since they are unprotected in vehicle impacts, they are one of the most vulnerable road users in city traffic. About 25,000 pedestrians are killed in traffic accidents each year recently in China [2]. In the European Union (EU) 7,000 pedestrians are killed each year, 5,000 in the USA, about 3,000 in Japan. Within the EU countries, the relative frequency of the pedestrian fatalities varies remarkably from 14% in Sweden to 32% in UK. Pedestrian protection is therefore a priority item in traffic safety strategies of nearly all countries world-wide [3].

The objective of this study is to identify the occurrence and type of the traumatic injuries of the relatively unprotected vulnerable rod users especially the situation of the pedestrians in vehicle collisions, and to investigate the correlation of traffic injuries with human factor and engineering, environment factors, by using valid and reliable materials collected from local hospital and traffic administration authorities. The knowledge from the study is a prerequisite for developing guidelines to improve pedestrian safety and with this perhaps the safety for all other kind of vulnerable road users.

2 Method and Materials

A study of vehicle pedestrian accidents was conducted by using the collected accident data of different in-depth investigation activities in both the countries China and Germany. The data consists of two parts: one part of the data with 403 pedestrian

1 Natural Science Foundation of China (NSFC 10472031)
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accident cases was collected from Wujing Hospital in Changsha, China; another part of the data with 407 cases was collected from GIDAS database documented at the Accident Research Unit in the Medical University Hannover, Germany.

Firstly, a general statistic analysis was carried out using 403 cases from Changsha in terms of cause of injuries, injury distributions, injury patterns, and injury severity. Secondly, 72 cases of 403 pedestrian accidents were selected with detailed injury descriptions for analysis of pedestrian injuries using AIS code and ISS value. Thirdly, 407 pedestrian accident cases collected from the accident database GIDAS (German In-Depth Accident Study) Hannover were used for an in-depth analysis of pedestrian injuries. Finally, a comparison was carried out in terms of analysis results based on accident data from Changsha and Hannover. The factors influencing the injury outcomes were proposed and discussed in terms of vehicle transport environment and road users. The results were discussed with regard to accident data collection, accident sampling and injury distributions etc.

2.1 Accident data collection

2.1.1 Accident data from Wujing Hospital in Changsha

The Wujing hospital is located in urban area of Changsha (Figure 1) and specialized in dealing with emergency cases in traffic accidents. The hospital admits the patients with traffic trauma in the urban area in Changsha with a population of 2,060,000 (6,133,000 including residents in suburb) and registered vehicles of 255,599 in 2000.

An in-depth study on the hospital clinical documentations for 622 traffic injury patients from 2000 to 2005 was carried out in cooperation between researchers and medical doctors. 403 cases were collected based on the study of the clinical report. The hospital data are summarized according to accident date, patient age, gender, and available information about pedestrian injuries, as well as type of accident vehicles. Pedestrian accident data were also collected from traffic administration authorities with information about accident sites and vehicles based on accident report. 72 pedestrian cases were selected from the well documented 403 cases with detailed description of the injury patterns, and injury severities. The GCS code and the AIS [4] code were used to determine the injury severity. The situation of treatment period and healing was studied based on hospital documentations to identify the consequence of accident.

Figure 1: The urban area of Changsha, the capital of Hunan Province located in the south middle of China

Furthermore, 825 pedestrian accident cases in 2005 were collected from the Traffic Police Station in Changsha. A preliminary statistics analysis was carried out to identify the type of pedestrian accidents in terms of involved vehicles.

2.1.2 GIDAS accident data from Hannover Medical University

In the district of Hannover a representative sampling of accidents was carried out by the order of German Government (Federal Highway Research Institute BASt) in cooperation with the car manufactures FAT since the year 1999 (OTTE et al., 2003). In the area of Hannover nearly 1,000 accidents with injured person are collected there annually in a continued and representative way. These accident cases were documented in the accident database GIDAS (German In-Depth Accident Study) by the Accident Research Unit at the Medical University of Hannover. The collected cases in the GIDAS database contain very detailed

information about pedestrian victims on age, gender, height/weight, injuries, speed determination and details of the accident cars as well as the accident scene issues.

Altogether 407 vehicle-to-pedestrian accident cases from the GIDAS database were collected based on the following standards: (1) the pedestrian should sustain at least an AIS 1 injury; and (2) the accident occurred during the period from 2000 to 2005.

3 Results and Analysis

3.1 Involvement of vehicles

Considering vehicle types involved in accidents, the pedestrians were struck in Changsha most frequently by motorcycle and passenger car. Figure 2a shows approximately 43.9% of the accidents are motorcycle-pedestrian collisions, and 34% car, 4.2% truck, and 3.5% bicycle. Figure 2b shows approximately 14.7% of the accidents are motorcycle-pedestrian collisions, and 58.4% car, 12.7% bus, 12.2% truck, and 1.3% bicycle. Compared to China´s situation for Germany there can be registered mainly car involvement in pedestrian collisions (80.6%) (Figure 2c).

3.2 Frequency of pedestrian accidents

An analysis of frequency of pedestrian accidents was conducted with the collected data in terms of age groups, gender and injured body parts.

3.2.1 Age distribution in pedestrian accidents

Figure 3a illustrates the age distribution in pedestrian accidents for Changsha. 7.9% of injured pedestrians are children under 15 years old. The pedestrians under 20 years old accounted for 18.1%. 71.9% of pedestrians involved in an accident were adults from 21 to 60 years old and formed the big group. Elderly pedestrians 60 years old and above accounted for 9.9% of all injured pedestrians.

Figure 3b illustrates the distribution in pedestrian accidents for Hannover in different age groups: 32,5% for child pedestrians under 15 years old, 42,3% for pedestrian under 20 years old, 36,4% for 21-60 age group, and 21,4% for older pedestrians >60 age group.

It can be seen that in Germany the highest risk exsiting for young and old pedestrians, compared to this in China the adult group of 20 to 50 years old is injured mainly.

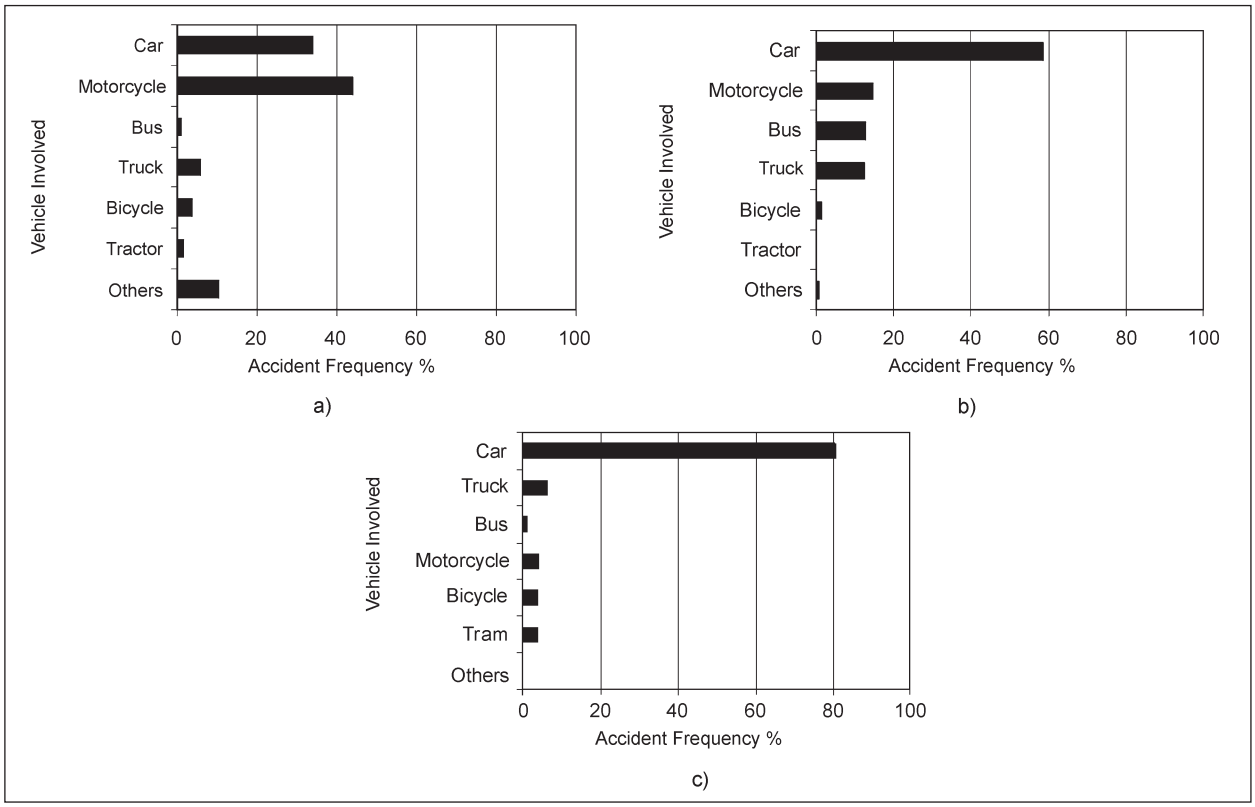

Figure 2: Frequency distribution of vehicle type in pedestrian accident: (a) 825 cases from Changsha Traffic Police Station, (b) 403 cases from Changsha Wujing hospital, and (c) 407 cases from GIDAS Hannover

3.2.2 Gender distribution in pedestrian accidents

Table 1A and 1B present the results for the age distribution of injured pedestrians in terms of gender. Of the Changsha pedestrians, 67% of the pedestrians are male and 33% are female. Of the Hannover pedestrians, 51.9% are male and 48.1% are female. We noted that the male pedestrians encounter in both countries for higher risks than that for females in vehicle accidents.

3.2.3 Distribution of injury frequency by body parts

Figure 4a presents the results for the distribution of injured body parts from Changsha cases. The head and lower extremities were found to be the most frequently injured [4]. Of the total pedestrian patients, 31.5% suffered head injuries. The lower extremity injuries accounted for 32.8%, and upper extremities 9.4%. In pedestrian accidents chest and pelvis injuries also took a significant proportion of

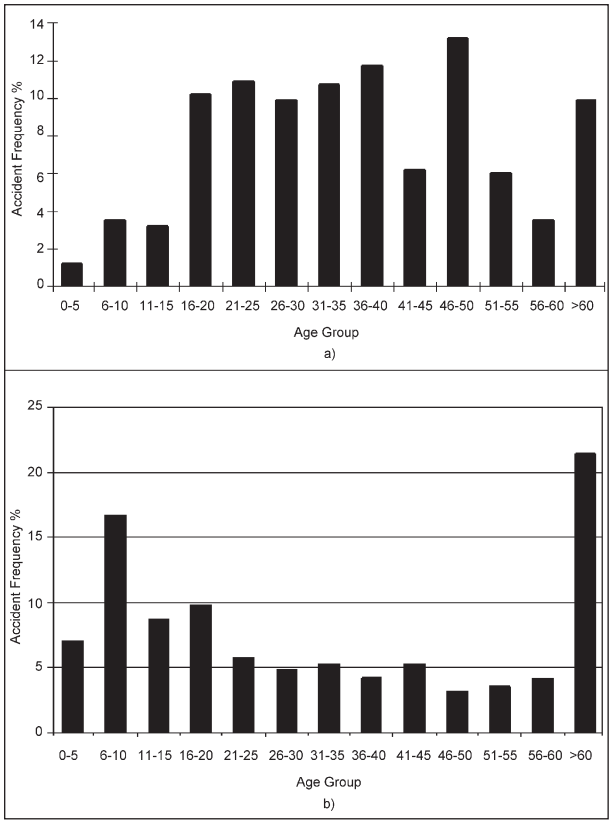

Figure 3: Frequency distribution of age group in pedestrian accident (a) 403 cases from Changsha Wujing hospital, and (b) 206 cases from GIDAS Hannover

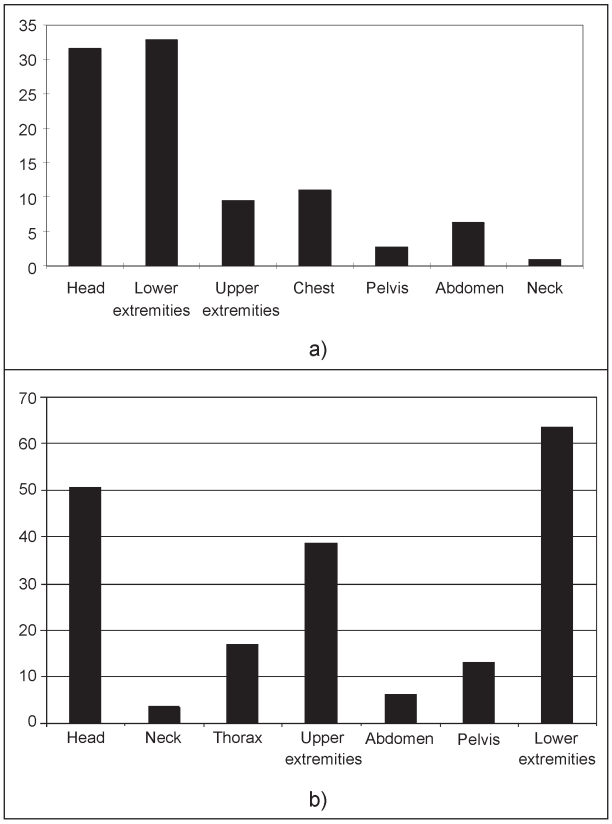

Figure 4: Distribution of injury by pedestrian body regions (a) Changsha, and (b) GIDAS Hannover

Age	0-15yr		16-60yr		>60yr		Total	
Gender	Number	%	Number	%	Number	%	Number	%
Female	13	40.6	101	30.5	19	47.5	133	33.0
Male	19	59.4	230	69.5	21	52.5	270	67.0
Total	32	100	331	100	40	100	403	100

Table 1A: Distribution of pedestrian age and gender in traffic accidents (Changsha)

Age	0-15yr		16-60yr		>60yr		Total	
Gender	Number	%	Number	%	Number	%	Number	%
Female	49	38.3	89	48.7	56	61.6	194	48.1
Male	79	61.7	97	51.3	37	38.4	213	51.9
Total	128	100	186	100	93	100	407	100

Table 1B: Distribution of pedestrian age and gender in traffic accidents (GIDAS Hannover)

13.5% of all injuries. Abdominal injuries were found in 6.2%, and neck injuries were relatively rare, in 0.8%.

Figure 4b presents the distribution of injured body parts for Hannover GIDAS data. 50.7% suffered head injuries. The lower extremity injuries accounted for 63.5%, and upper extremities 38.7%. In pedestrian accidents chest and pelvis injuries also took a significant proportion of 17.1% for the thorax and 13.0% for the pelvis. Abdominal injuries were found in 6.3%, and neck injuries were relatively rare, in 3.6%. The injury distribution is similar between China and Germany, the head and the legs are the major exposed injured body parts, in Germany a higher injury risk of the arms can be seen in the diagrams.

3.3 Severity and distribution of pedestrian injuries

For an in-depth study of pedestrian injuries 72 Changsha cases were selected from the Wujing Hospital with a sampling defined as follows: (1) the injuries were described with very detailed information which can be used to determine the injury severity with AIS code; (2) the pedestrian should sustain at least an AIS 1 injury; and (3) accident occurred during the period from 2000 to 2005.

3.3.1 AIS coding and analysis

The severity of injury sustained by individual body area is given in Table 2. The percentage is that the number of body segment injuries refer to the total number of registered injuries by injury severity. With the detailed information of 72 cases from Wujing hospital, the injuries are rated on the AIS scale [5]. The overall injury severity classified with AIS code is summarized in Table 2A. 59.7% of the cases with AIS 1 and 2 minor/moderate injuries, and 25% with serious injuries, the severe and critically injured pedestrians are 9.7% and 5.6%, respectively. It was found that head and lower extremities were, again, the body parts most frequently injured. From the clinical documentation in Wujing hospital we noted that the head injury patterns are skull fractures and brain injuries, including cerebral concussion, lacerations, contusion, and intracranical hematoma. The common thorax injury patterns are rib fractures with hemoth and pneumoth. The leg injuries are more frequent than upper thigh fractures including the toe, tibia, fibula fracture. The pelvis injuries are parenchyma contusion.

Injury Severity	MAIS	Number	%
Minor	1	3	4.2
Moderate	2	40	55.5
Serious	3	18	25.0
Severe	4	7	9.7
Critical	5	4	5.6
Fatal	6	0	0
Total	_	72	100

Table 2A: Injury severity of pedestrians in 72 selected cases (Changsha)

Injury Severity	MAIS	Number	%
Minor	1	231	68.3
Moderate	2	116	22.5
Serious	3	36	6.2
Severe	4	7	1.0
Critical	5	13	1.6
Fatal	6	4	0.5
Total	-	407	100

Table 2B: Injury severity of pedestrians in 206 collected cases (GIDAS Hannover)

With the detailed information of GIDAS Hannover, the overall injury severity classified with AIS code is summarized in Table 2B, 90.8% of the cases with MAIS 1 and 2 minor/moderate injuries, and 6.2% with MAIS 3 serious injuries. The severe and critically injured pedestrians (MAIS 5/6) are 2.1%.

The compared injury distribution between Changsha/Hannover shows the different sampling criteria, the data of Hannover consider the whole injury distribution in a statistical manner (minor to fatal). Changsha cases are representing the situation of a hospital, therefore directly died persons at the scene (MAIS 6) are not included.

3.3.2 ISS value and analysis

The ISS value was calculated for the selected 72 cases from Changsha and 206 cases from GIDAS. Table 3 presents the calculated ISS values.

The injury severity grade ISS is a good predictor for the whole severity of the injured body related to the complexity of treatment and the outcome of survival. It can be seen that the german injured pedestrians have a better injury outcome, 91.7% suffered ISS <10. A polytraumatized victim with risky treatment starts at ISS values above 15. In

Germany those cases can be seen in 3.3% compared to China in 16.6%.

ISS	Changsha data		GIDAS data		Severity
	N	%	N	%	
< 10	53	73.6	350	91.7	Minor
10-15	7	9.7	28	5.0	Moderate
16-19	7	9.7	5	0.8	Serious
20-39	5	6.9	11	1.4	Severe
40-66	0	0	5	0.6	Critical
75	0	0	4	0.5	Fatal
Sum	72	100	403	100	-

Table 3: Correlation of injury severity with ISS value

3.3.3 Analysis of injury severity by body regions

Injury severity	Slight, AIS<3 (N=43)		Serious, AIS=3 (N=18)		Fatal, AIS>3 (N=11)		Total (N=72)	
Body segment	Injury	%	Injury	%	Injury	%	Injury	%
Head	23	67.6	2	5.9	9	26.5	34	100
Face	9	100	0	0	0	0	9	100
Lower extremities	24	66.7	12	33.3	0	0	36	100
Upper extremities	3	100	0	0	0	0	3	100
Chest	6	66.7	3	33.3	0	0	9	100
Pelvis	3	100	0	0	0	0	3	100
Abdomen	3	60	2	40	0	0	5	100
Neck	0	0	0	0	0	0	0	0

Table 4A: Distribution of injury severity by pedestrian body regions (Changsha)

Injury severity	Slight, AIS<3 (N=347)		Serious, AIS=3 (N=36)		Fatal, AIS>3 (N=24)		Total (N=407)	
Body segment	Injury	%	Injury	%	Injury	%	Injury	%
Head	192	94.0	7	1.9	15	3.1	214	100
Lower extremities	232	92.2	30	7.5	1	0.3	263	100
Upper extremities	144	97.5	6	2.5	0	0	150	100
Chest	62	85.8	6	5.2	13	9.0	81	100
Pelvis	54	97.7	1	0.4	2	1.9	57	100
Abdomen	24	91.7	1	1.0	3	7.3	28	100
Neck	15	87.4	0	0	3	12.6	18	100

Table 4B: Distribution of injury severity by pedestrian body regions (GIDAS Hannover)

3.3.4 Analysis of injury severity in age groups

Age	0-15yr		16-60yr		>60yr		Total	
MAIS	Number	%	Number	%	Number	%	Number	%
1	1	16.7	2	3.4	0	0	3	4.2
2	1	16.7	35	60.3	3	37.5	39	54.2
3	1	16.7	12	20.7	5	62.5	18	25
4	2	33.3	6	10.3	0	0	8	11.1
5	1	16.7	3	5.2	0	0	4	5.6
6	-	-	-	-	-	-	-	-
Total	6	100	58	100	8	100	72	100

Table 5A: Distribution of injury severity by age group (Changsha)

Age	0-15yr		16-60yr		>60yr		Total	
MAIS	Number	%	Number	%	Number	%	Number	%
1	81	72.4	110	71.6	40	54.8	231	68.3
2	40	23.2	47	18.8	29	29.3	116	22.5
3	6	4.0	17	6.0	13	10.0	36	6.2
4	0	0	3	0.9	4	2.6	7	1.0
5	1	0.4	7	2.1	5	2.3	13	1.6
6	0	0	2	0.5	2	1.1	4	0.5
Total	128	100	186	100	93	100	407	100

Table 5B: Distribution of injury severity by age group (GIDAS Hannorver)

In all age groups the injury risk is very high for the China situation compared to the German situation. Nearly three-quarter of the Hannover pedestrians suffered injury severity grades MAIS 1 only, except the older age group of >60 years old (54.8%). 26.0% were MAIS 3+ injured. Compared to this 62.5% of the > 60 years old pedestrians were MAIS 3+ injured in Changsha. A very low number of minor injured pedestrians could be registered there in all age groups.

4 Discussion

4.1 Causation of injuries

The vehicle traffic accidents steeply increased in the past decade world-wide therefore in China as well as in Germany. But the injury situation related to traffic accidents seems to have different pictures for Germany and China. The annually fatalities in the reported accidents of China increased from 49,271 in 1990 to 107,000 in 2004. The road traffic authority made large efforts to control the incidence of the accidents, but the tendency of the accident growth is still a critical issue in China. Particularly, the fatalities of vulnerable road users formed a

Body region	China (Changsha) (%)	GIDAS (%)	Europe (%)	Australia (%)	Japan (%)	USA (%)
Head	31.5	26.4	29.8	39.3	28.6	32.7
Face*	5.8	-	5.3	3.7	2.4	3.7
Neck	0.8	2.2	1.8	3.1	4.5	0.0
Chest	10.9	10.0	11.6	10.4	8.5	9.5
Abdomen	6.2	3.5	3.8	4.9	4.8	7.7
Pelvis	2.6	7.0	7.9	4.9	4.5	5.3
Upper extremities	9.4	18.5	8.1	8.0	9.0	7.9
Lower extremities	32.8	32.4	31.3	25.8	37.2	33.3
Unkown	0.0	-	0.5	0.0	2.1	0.0
Total	100	100	100	100	100	100
* not distinguished from head injuries						

Table 6: Comparison of percentage distribution of pedestrian injuries by body region

main proportion of all reported fatalities in traffic accidents. For instance about 12,500 pedestrians were killed in 1990, and 26,000 in 2001, which accounted for about 26% of all traffic fatalities annually. Compared to this, for Germany the number of causalities could be reduced over the last 30 years continuously to a total number of currently 5,361 in 2005. The percentage of fatal pedestrians built 13% on that total number.

The present study is based upon an analysis of 403 accidents in urban area of Changsha in China and the area of Hannover in Germany. The evaluation method was described and the available accident data were analyzed. The used samples are small, but as a preliminary study the presented methodology for an comparison of different in-depth accident studies could be used for comparison of the injury risk and injury outcome for different countries. Such methodology can be used for further studies with new collection of accident data in the area and special research issues.

It was found that the present results are quite comparable to results from studies by other researchers. For instance, the pedestrian accident is a common problem in both motorized countries and motorizing countries, which occur frequently in city build up areas, but the injury risk for pedestrians in Germany can be seen as much less dangerous as in China. On the other hand the combined results of the in-depth analysis of the two different areas of China and Germany shows major resources for further countermeasures on car safety developments, i.e. young and old pedestrians need to be focussed on in Germany, adult pedestrians 20 to 50 years old need to protected more in China. The finding of the frequency in age distribution is quite different from that in other motorized countries. Child pedestrian accidents accounted for 25.3% in the USA, 33.1% in Europe, and 34.2% in Japan. A further study is needed to identify the factors which affect the different results.

Pedestrian accident analyses have been conducted worldwide in the past four decades [5-10]. Pedestrian impact conditions and injury outcomes were identified from these studies. The findings of the distribution of pedestrian injuries to different body segments are compared between the results from this study and results from published studies by other researchers world-wide as presented in Table 6, showing the distribution of injured body regions (100%). As a common tendency, the head and the lower extremities have been found to be the most frequently injured body regions.

The analysis of pedestrian accidents in Changsha indicated that motorcycles and passenger cars are most frequently involved in vehicle-pedestrian accidents compared to Germany where the major collision partner of a pedestrian is a car (80.6%). 43.9% of the accidents in Changsha are motorcycle-pedestrian collisions, and 30.3% passenger-cars. In the EU countries, the number of pedestrians struck by passenger cars is around 60% to 85% of the reported vehicle-pedestrian accidents [5], and 56% of the reported pedestrian accidents are caused by passenger cars in the USA. Due to the difference of involved vehicles from country to country, the priority of safety countermeasures should be given considering the frequency of involved vehicles [12-15].

4.2 Countermeasures

Even that for Germany a good reduction of the number of fatalities and severe injured pedestrians can be registered over the last decade further measurements for safety can be seen as important, the head injury risk and the risk of lower extremities should be focused on in the future.

There is great potential of reduction of the accidents and fatalities in China by enhancing the safety consciousness of all road users, improving the traffic administration, and strictly implementing traffic laws.

It is necessary to point out that a large amount of the accidents resulted from people's mistakes. The accidents and accident casualties mainly attributed to the causation factors. This study considered not the aspects of causation, but in-depth analyses could be also a good tool for such research in different countries.

4.3 Limitations

It is also noticed that limitations existed in this study. The data sources partly reflect the real situations of pedestrians in traffic accidents in Changsha and Hannover and not in the whole countries of China and Germany. On the other hand, the used samples are influenced by their specific sampling criteria being different for Changsha and Hannover. For Changsha in some cases the medical records were not complete due to that the injured pedestrians left the hospital without continual cure and the reports could not point out whether they have healed and in the sample those fatalities were not included which died directly on the scene. Another problem existed in Changsha on the medical records providing comprehensive data on the injuries, they seldom provided exact details of the locations and extent of the injuries, and this brings up a difficulty to classify the injuries according to the AIS code. Compared to this the data of GIDAS Hannover are comprehensive and give information on every issue of accident and injury details [5].

5 Conclusions

Pedestrian accidents represent a group of vulnerable road users to high risk of unprotection, and in relation with the importance of pedestrians within the traffic of a country therefore a high priority should be given to this road user group in research of safe urban transportation.

About over two thirds of injured pedestrians are male pedestrians. The exposure of injury risks to elderly people is much higher than that to younger pedestrians. This seems to be relevant for the German situation where the major injured pedestrians could be seen. In Changsha the main focus has to be given to the adults in the age of 20 to 50 years of age. In the urban area of Changsha motorcycles and passenger cars are most frequently involved in vehicle pedestrian accidents.

The head and lower extremities injuries are the predominant types of pedestrian injuries. Chest and pelvis were frequently injured, then followed by abdomen injuries, whereas injuries to upper extremities and neck were relatively infrequent. It is necessary to give the priority of injury prevention to the head and lower extremities. Meanwhile in China many European cars are driven, therefore it can be expected that in some years the same safety standard and injury risk will be approached. Further in-depth studies may identify this common approach.

6 Acknowledgment

This study is sponsored by the Natural Science Foundation of China (NSFC 10472031). The authors would like to thank Mr. Zhimin Liu, the Director of Changsha Traffic Police, and Prof. Dietmar Otte, Hannover Medical University, for provided accident data.

References

[1] Statisitcal Data of the Statistical Bureau Germany, Wiesbaden 2005

[2] Z.G. WANG: Mechanisms for Occurance of Road Traffic Injuries. Chinese Journal of Traumatology. 1999. 15AF85-86

[3] J.K. YANG (1997): Injury Biomechanics in Car–Pedestrian Collisions: Development, Validation and Application of Human-Body Mathematical Models. Thesis for the Degree of Doctor of Philosophy. Department of Injury Prevention, Chalmers University of Technology, Gothenburg, Sweden

[4] AAAM (1998): Abbreviated Injury Scale – 1990 Revision. Association for the Advancement of Automotive Medicine, Des Plaines, IL, U.S.A

[5] EEVC (1982): Pedestrian Injury Accidents. Proc. of the 9th Int. Tech. Conf. on Experimental Safety Vehicles, Kyoto, Japan. Nov. 1-4, 1982. US Dept. of Transportation, NHTSA, USA. pp. 638-671

[6] NHTSA (1993): Pedestrian injury reduction research, Report, National Highway Traffic Safety Administration, US Dept. of Transportation, Washington DC, U.S.A

[7] D. OTTE, C. KRETTEK, H. BRUNNER, H. ZWIPP (2003): Scientific Approach and Methodology of a New In-Depth-Investigation Study in Germany so called GIDAS, Proceedings of the 18th ESV Conference, Nagoya, Japan, Paper No. 161

[8] D. OTTE (1999): Severity and Mechanism of Head Impacts in Car to Pedestrian Accidents, Proceedings of International IRCOBI Conference on Biomechanics Impacts, Barcelona, Spain, pp. 329-341

[9] D. OTTE, T. POHLEMANNN (2001): Analysis and Load Assessment of Secondary Impact to Adult Pedestrians after Car Collisions on Roads, Proceedings of the International IRCOBI Conference on the Biomechanics of Impacts, Isle of Man, United Kingdom, pp. 143-157

[10] Y. MIZUNO, H. ISHIKAWA (2001): Summary of IHRA Pedestrian Safety WG Activities-Proposed Test Methods to Evaluate Pedestrian Protection Afforded by Passenger Cars. The 17th ESV Conference, June 4-7, 2001, Amsterdam, The Netherlands

[11] M. DANNER, K. LANGWIEDER, W. WACHTER: Injuries to Pedestrians in Real Accidents and Their Relation to Collision and Car Characteristics. Department of Automotive Engineering Association of German Automobile Insureranse

[12] L. Li, J.K. Yang, W.Q. Li, H.F. FANG: A Study of Pedestrian Injuries in Traffic Accidents in Changsha of China. Journal of Hunan University. 2002. Vol. 29:15-23

[13] NHTSA (1999): Traffic safety facts – pedestrian, Report, National Highway Traffic Safety Administration, Department of Transportation, Washington DC, U.S.A.

[14] EEVC (1994): Proposals for Methods to Evaluate Pedestrian Protection for Passenger Cars. Report, European Experimental Vehicle Committee, working group 10

[15] ETSC (1997): A Strategic Road Safety Plan for the European Union. European Transport Safety Council, Brussels