IHRA/PS-WG PEDESTRIAN TRAFFIC ACCIDENT DATA

At the first meeting of the IHRA pedestrian safety-working group, it was agreed that development of harmonized test procedures would be based upon real world crash data. Pertinent pedestrian and vehicle information contained in accident survey databases was accumulated. Pedestrian information included age, stature, gender, injured body region, and injury severity. Vehicle information included vehicle type, make, and year, mass, pedestrian contact location, damage pattern, and impact velocity. Other general accident information such as pedestrian crossing pattern, weather conditions, vehicle and pedestrian trajectories, alcohol use, etc. were also of interest if collected. Bicycle or motor-driven cyclists were not included in the study. Four injury databases from Australia, Germany, Japan, and United States were identified as containing much of this information. Multiple injuries per case were included in the dataset.

In Japan, pedestrian accident data collected by JARI between 1987 and 1988 and in-depth case study data of pedestrian accidents conducted by ITARDA between 1994 and 1998 were combined for inclusion into the IHRA accident dataset. A total of 240 cases were acquired in the cities surrounding the Japan Automobile Research Institute (JARI).

In Germany, investigation teams from both the Automotive Industry Research Association and Federal Road Research Institute collected accident information in a jointly conducted project called the German In-Depth Accident Study (GIDAS). A total of 783 cases collected between 1985 and 1998 were included from the cities of Dresden and Hanover and their surrounding rural areas. Accident investigation took place daily during four six-hour shifts in two-week cycles. The respective police, rescue services, and fire department reported all accidents continuously to the research teams. The teams then selected accidents according to a strict selection process to avoid any bias in the database. Accidents where a passenger car collided with more than one pedestrian or one pedestrian collides with more than one passenger car were not considered. Furthermore, accidents in which the car ran over the pedestrian or the impact speed could not be established were not considered. The study included information such as environmental conditions, accident details, technical vehicle data, impact contact points, and information related to the people involved, such as weight, height, etc.

Detailed information from pedestrian crashes was collected in the United States through the Pedestrian Crash Data Study (PCDS)[i,ii]. In this non-stratified study, a total of 521 cases were collected between 1994 and 1999. Cases were collected from six urban sites during weekdays. If, within 24 hours following the accident, the pedestrian could not be located and interviewed or the vehicle damage patterns documented, the case was eliminated from the study. In order for a case to qualify for the study, the vehicle had to be moving forward at the time of impact; the vehicle had to be a late model passenger car, light truck, or van; the pedestrian could not be sitting or lying down; the striking portion of the vehicle had to be equipped with original and previously undamaged equipment; pedestrian impacts had to be the vehicle's only impact; and the first point of contact between the vehicle and the pedestrian had to be forward of the top of the A-pillar.

The Australian data is from at-the-scene investigations in 1999 and 2000 of pedestrian collisions in the Adelaide metropolitan area, which has a general speed limit of 60 km/hr. Ambulance radio communications were monitored from 9 am to 5 pm, Monday to Friday, and from 6 pm to midnight on two nights per week. Ambulance attendance at a pedestrian accident was the only criterion for entry into the study. The sample consists of 80 pedestrian/vehicle collisions, including 64 with passenger cars, SUV and 1-box type vehicles, where the pedestrian was standing, walking, or running, and where the main point of contact with the pedestrian on the vehicle was forward of the top of the A-pillar. Pedestrians and drivers were interviewed, wherever practicable, as part of the investigation process. The reconstruction of the impact speed of the vehicle was based on physical evidence collected at the scene. Injury information was obtained from hospital and coronial records, the South Australian Trauma Registry and, in minor injury cases, from an interview with the pedestrian.

Data from these four studies were combined into a single database for further analysis to develop a better basis for worldwide pedestrian impact conditions. From each of these studies, seven fields of information were identified which were common to all four studies and were crucial to providing guidance in test procedure development. For each injury, these seven fields of data were collected and input into the unified pedestrian accident database. The seven fields were country, case number, pedestrian age, impact speed, AIS injury level, body region injured, and vehicle source causing the injury (Table 3.1). Injury body region and vehicle source were categorized as shown in Table 3.2.

Table 3.1 IHRA Dataset Illustrations

COUNTRY	CASE_NO	AGE	AIS	Body Region	Vehicle Region	Impact Velocity
Australia	PED005-99-p1	19	2	1	5	100
Japan	9710067	43	6	13	11	50
Germany	8292	37	2	7	10	90
USA	97-90-628	18	2	11	1	58
Germany	9654	54	4	1	2	65
Japan	9810079	23	6	1	4	95

Table 3.2 Injury Body Regions and Sources

Injury Body Regions
Head
Face
Neck
Chest
Abdomen
Pelvis
Arms
Leg Overall (Specific part not identified)
Femur
Knee
Lower Leg
Foot
Unknown Injury

Injury Sources
Front Bumper
Top Surface of Bonnet/Wing
Leading Edge of Bonnet/Wing
Windscreen Glass
Windscreen Frame/A-Pillars
Front Panel
Other Vehicle Source
Indirect Contact Injury (Non-Vehicle)
Road Surface
Unknown Source

The number of cases and total injuries represented in this combined database are shown in Table 3.3. Throughout the remainder of this report, this dataset is denoted as the IHRA Pedestrian Accident Dataset. It is recognized that pedestrian injuries in developing countries are not represented in this dataset; however, this data is the most comprehensive pedestrian accident database available to guide pedestrian safety test procedure development. A total of 3,305 injuries of AIS 2-6 severity were observed, and there were 6,158 AIS=1 injuries observed (Table 3.3). These minor (AIS=1) injuries were excluded in the following analysis because they were not believed to be crucial in test procedure development.

Table 3.3 IHRA Pedestrian Accident Dataset

Region	Cases	Injuries	AIS 1	AIS 2	AIS 3	AIS 4	AIS 5	AIS 6	AIS 2-6
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
Australia	65	345	182	93	36	12	17	5	163
TOTAL	**1605**	**9463**	**6158**	**1751**	**1012**	**274**	**219**	**49**	**3305**

IHRA pedestrian injuries of AIS 2-6 severity are shown in Table 3.4 according to the part of the body that was injured. As shown in this table, head (31.4%) and legs (32.6%) each accounted for about one-third of the AIS 2-6 pedestrian injuries. Of the 3,305 AIS 2-6 injuries, 2,790 (84%) were caused by contact with portions of the striking vehicle, with head and legs being the most frequently injured (Table 3.5). Head injury accounted for 824 occurrences, and legs a total of 986 injuries when combining overall, femur, knee, lower leg, and foot body regions. Windscreen glass was the most frequent vehicle source of head injury, with the windscreen frame/A-pillars and top surface of bonnet/wing both being substantial additional sources of injury to the head. A further breakdown of the injuries and vehicle sources for children and adults is shown in Tables 3.6 and 3.7. For children, the top surface of the bonnet is the leading cause of head injury, while a substantial number of child head injuries also occur from windscreen glass contact. For adults, the windscreen glass is the leading source of head injury, followed by windscreen frame/A-pillars and top surface of the bonnet and wing. Not surprisingly, the bumper was the leading source for both child and adult pedestrian leg injury.

Table 3.4 Distributions of Pedestrian Injuries (AIS 2-6) by Body Region and Country

Body Region	USA	Germany	Japan	Australia	TOTAL
Head	32.7%	29.9%	28.9%	39.3%	31.4%
Face	3.7%	5.2%	2.2%	3.7%	4.2%
Neck	0.0%	1.7%	4.7%	3.1%	1.4%
Chest	9.4%	11.7%	8.6%	10.4%	10.3%
Abdomen	7.7%	3.4%	4.7%	4.9%	5.4%
Pelvis	5.3%	7.9%	4.4%	4.9%	6.3%
Arms	7.9%	8.2%	9.2%	8.0%	8.2%
Legs	33.3%	31.6%	37.2%	25.8%	32.6%
Unknown	0.0%	0.4%	0.0%	0.0%	0.2%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**

Table 3.5 IHRA Pedestrian Injuries by Body Region and Vehicle Contact Source – All Age Groups; AIS 2-6

Contact \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Unknown	Total
									Overall	Femur	Knee	Lower Leg	Foot		
Part of the Vehicle	Front Bumper	24	2		3	5	3	6	19	59	76	476	31	1	705
	Top surface of bonnet/wing	223	15	2	139	44	43	86	23	3	1	1	2	1	583
	Leading edge of bonnet/wing	15	2	4	43	78	85	35	50	40	6	30	1		389
	Windscreen glass	344	56	12	30	5	12	23	2			1	1	1	487
	Windscreen frame/A pillars	168	28	5	35	7	14	31	5	1				2	296
	Front Panel	5	1		9	13	7	6	9	14	11	35	3		113
	Others	45	7	1	38	12	13	15	15	9	5	39	18		217
	Sub-Total	824	111	24	297	164	177	202	123	126	99	582	56	5	2790
	Indirect Contact Injury	13		17	1	1	7	1		3		1	2		46
	Road Surface Contact	171	22	2	22	2	9	42	6	4	3	5	15	1	304
	Unknown	27	6	3	19	10	16	25	1	7	9	32	3	7	165
	Total	1035	139	46	339	177	209	270	130	140	111	620	76	13	3305

Table 3.6 IHRA Pedestrian Injuries by Body Region and Vehicle Contact Source – Ages > 15; AIS 2-6

Contact Location \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Unknown	Total
									Overall	Femur	Knee	Lower Leg	Foot		
Part of the Vehicle	Front Bumper	20	2		2	3	3	3	16	29	69	429	29		605
	Top surface of bonnet/wing	140	9	1	122	39	35	73	21	3	1	1	2	1	448
	Leading edge of bonnet/wing	7	2	1	36	65	80	28	46	33	5	24	1		328
	Windscreen glass	303	52	11	28	3	10	22	1			1	1		432
	Windscreen frame/A pillars	159	28	5	34	7	14	29	5	1				2	284
	Front Panel		1		8	13	6	5	9	9	10	32	3		96
	Others	33	7		29	9	12	11	6	4	5	26	13		155
	Sub-Total	662	101	18	259	139	160	171	104	79	90	513	49	3	2348
	Indirect Contact Injury	12		16	1		7			3		1	2		42
	Road Surface Contact	125	18	2	21	2	8	32	6	4	3	5	14	1	241
	Unknown	19	6	3	18	9	16	20	1	4	9	28	3	6	142
	Total	818	125	39	299	150	191	223	111	90	102	547	68	10	2773

Table 3.7 IHRA Pedestrian Injuries by Body Region and Vehicle Contact Source – Ages < 16; AIS 2-6

Contact Location \ Body Region		Head	Face	Neck	Chest	Abdomen	Pelvis	Arms	Legs					Unknown	Total
									Overall	Femur	Knee	Lower Leg	Foot		
Part of the Vehicle	Front Bumper	4			1	2		3	3	30	7	47	2	1	100
	Top surface of bonnet/wing	83	6	1	17	5	8	13	2						135
	Leading edge of bonnet/wing	8		3	7	13	5	7	4	7	1	6			61
	Windscreen glass	41	4	1	2	2	2	1	1					1	55
	Windscreen frame/A pillars	9			1			2							12
	Front Panel	5			1		1	1		5	1	3			17
	Others	12		1	9	3	1	4	9	5		13	5		62
	Sub-Total	162	10	6	38	25	17	31	19	47	9	69	7	2	442
	Indirect Contact Injury	1		1		1		1							4
	Road Surface Contact	46	4		1		1	10					1		63
	Unknown	8			1	1		5		3		4		1	23
	Total	217	14	7	40	27	18	47	19	50	9	73	8	3	532

Distribution of pedestrian accident victims by age (all AIS levels) is shown in Table 3.8 and illustrated in Figure 3.1. When broken into five-year age segments, Table 3.8 indicates that the 6–10 year old age group has the highest frequency of accident involvement at nearly 14% of all cases. In Japan, this age segment accounts for 20% of the cases, while the other three regions have lower involvements in this age group. The percentage involvement in the 11-15 year old group for Japan, however, drops considerably and is lower than for Germany, the U.S., or Australia. It is unclear why this sudden drop occurs in Japan and not in the other regions. In summary, over 31% of all cases involved pedestrians age 15 and younger. This percentage is 13% higher than the average overall population of individuals in this age group in the four countries (18%), which demonstrates the magnitude of the child pedestrian problem[iii].

Table 3.8 Distribution of Pedestrian Crashes by Age and Country

Age	US	Germany	Japan	Australia	IHRA
0-5	4.6%	9.0%	9.2%	4.3%	7.3%
6-10	13.8%	14.6%	20.0%	10.6%	14.1%
11-15	13.8%	9.8%	5.0%	11.0%	9.7%
16-20	6.2%	7.3%	3.3%	7.2%	6.6%
21-25	6.2%	4.5%	1.7%	8.7%	5.5%
26-30	4.6%	4.7%	1.7%	10.1%	6.0%
31-35	4.6%	4.2%	5.4%	5.8%	4.9%
36-40	3.1%	4.5%	5.0%	7.2%	5.4%
41-45	3.1%	3.6%	3.8%	6.2%	4.4%
46-50	3.1%	4.6%	5.4%	6.2%	5.2%
51-55	3.1%	5.4%	6.7%	3.3%	4.8%
56-60	1.5%	4.5%	10.0%	3.7%	4.9%
61-65	6.2%	5.8%	6.7%	3.9%	5.3%
66-70	7.7%	3.7%	3.8%	3.3%	3.7%
71-75	4.6%	3.8%	4.2%	3.7%	3.9%
76-80	3.1%	5.0%	2.5%	3.3%	4.0%
81-85	6.2%	3.8%	3.3%	0.8%	2.9%
86-90	4.6%	1.2%	2.1%	0.4%	1.2%
91-95	0.0%	0.1%	0.0%	0.6%	0.2%
96-100	0.0%	0.0%	0.4%	0.0%	0.1%

The age distribution data contained in Figure 3.1 also provides an opportunity to demonstrate that the IHRA Pedestrian Accident Dataset is representative of the pedestrian crash situation in the United States. In addition to the Germany, Japan, U.S., and Australian pedestrian datasets, data from the FARS and GES are also included. FARS is the Fatal Analysis Reporting System, which contains every fatal traffic accident in the U.S. The GES is the General Estimates System, and is obtained from a nationally representative sampling of police-reported crashes. In general, the age distribution of the GES data is similar to the others in Figure 3.1. Since the GES is designed to be a statistically representative sample, and since the U.S. PCDS and GES distributions are similar, this would imply that the PCDS is fairly statistically representative despite the non-stratified sampling scheme used to collect PCDS cases. However, the FARS distribution differs significantly from any of the others in Figure 3.1. Because FARS contains only fatal accidents, this may be an indication that the distribution of fatal and non-fatal injuries differs from each other. An ideal comparison for the FARS data would have been with the IHRA pedestrian fatalities. But since the number of fatal cases is quite limited in the IHRA data, the FARS distribution was compared to the serious and fatal AIS≥4 injuries as shown in Figure 3.2. Although there is considerable variability remaining in this distribution due to small sample sizes, the FARS distribution has reasonable agreement with the IHRA data.

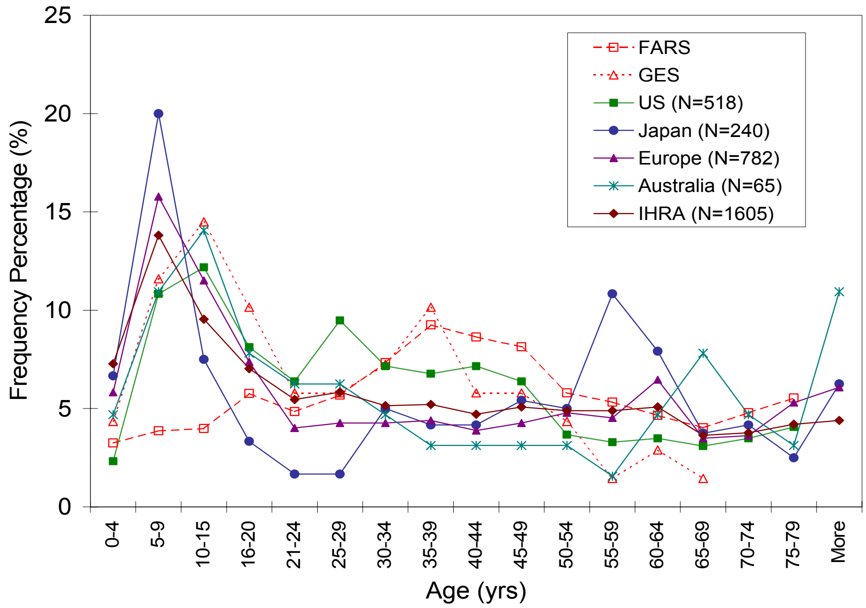

Figure 3.1 Frequency of Accidents by Age and Country

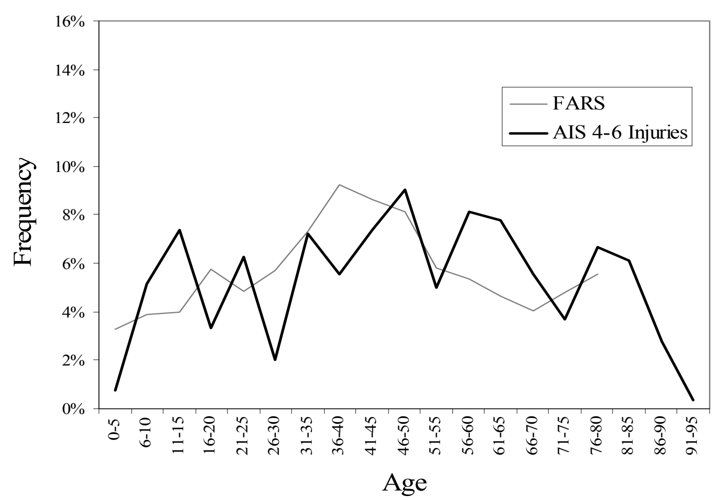

Figure 3.2 IHRA AIS 4-6 Injuries vs. FARS Data by Age

Analysis of the injury level by age group is shown in Figure 3.3. This figure shows that children aged 15 and younger tend to have a higher proportion (25%) of AIS 1 and 2 injuries than adults, and persons aged 61 and older have the highest proportion (near 30%) of moderate and serious injuries. These observations are likely the result of two factors. First of all, exposure levels may differ for the various age groups. For example, younger children tend to be involved in pedestrian collisions with lower impact velocities. As shown in Figure 3.4, the average impact velocity for children aged 0-15 is about 28 km/h. This is approximately 5 km/h lower than for the other age groups. A second cause of the injury distribution observed in Figure 3.3 may be that those aged 61 years and older are generally more frail and less resilient, leading to higher severity injury for a given impact velocity.

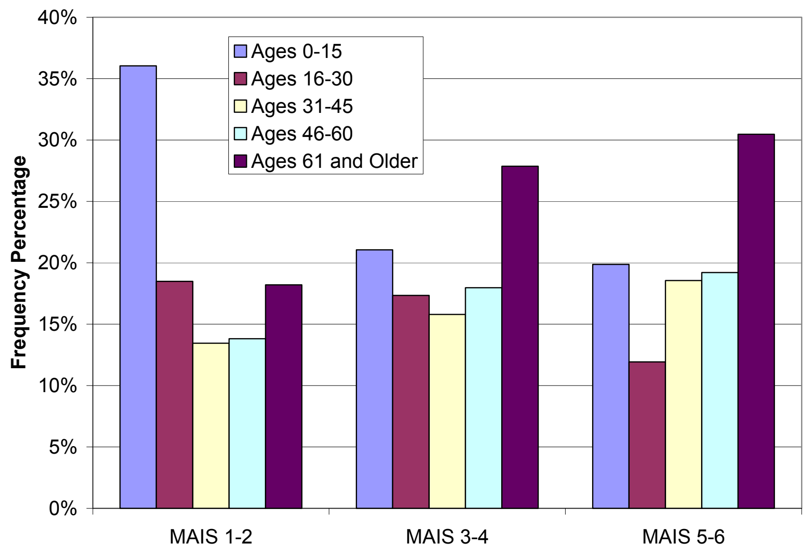

Figure 3.3 Distributions of MAIS Levels by Age

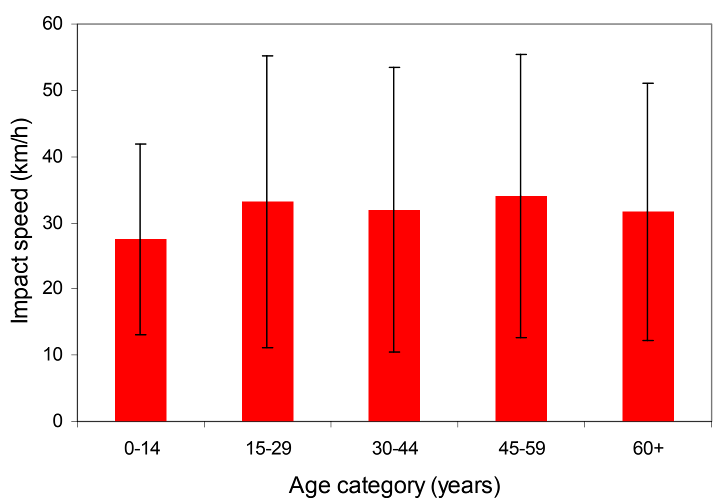

Figure 3.4 Average Impact Velocities by Age Group (MAIS 1-6)

Figures 3.5 and 3.6 provide insight into the impact velocity distribution associated with pedestrian impacts. In Figure 3.5, the cumulative frequency of impact velocities on a per case basis for each country is similar although the U.S. has a larger percentage of injuries at lower velocities than the other three countries. This is broken down further in Figure 3.6, where lower MAIS injuries occur at lower velocities for all four countries. In Figure 3.7, the MAIS injuries are broken into three categories for the four countries. For MAIS 1-2 injuries, Japan has the lowest frequency (55%) and Germany has the highest (77%). For MAIS 3-4 injuries, Australia has the lowest frequency percentage (9%) and Japan has the highest (24%). Finally, for the most severe injuries (MAIS 5-6), Germany has the lowest frequency (4%) and Japan has the highest likelihood of a life-threatening injury (20%).

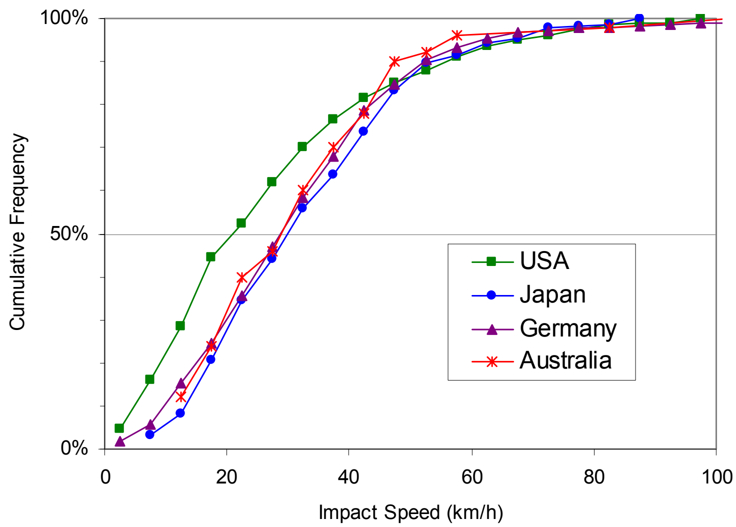

Figure 3.5 Impact Velocities by Country

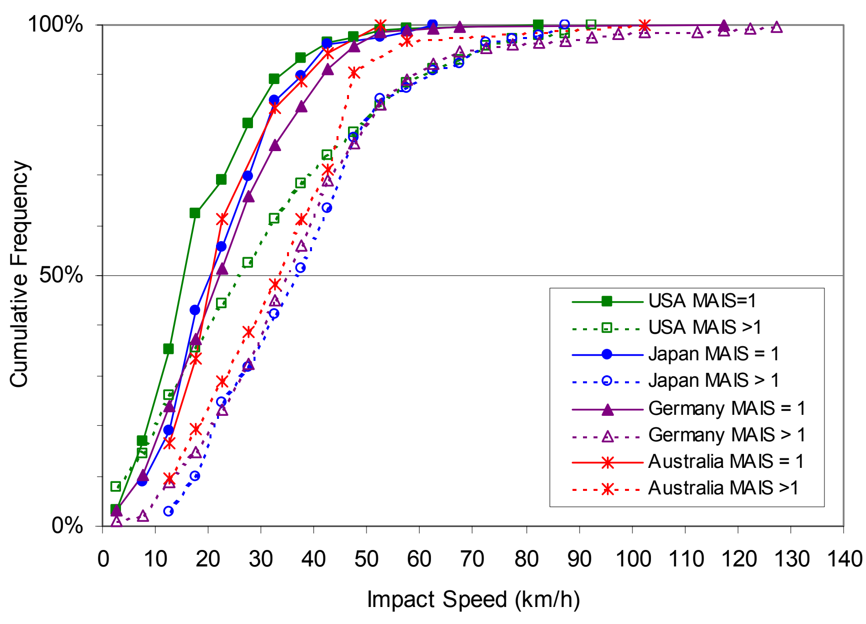

Figure 3.6 Impact Velocity by MAIS Level

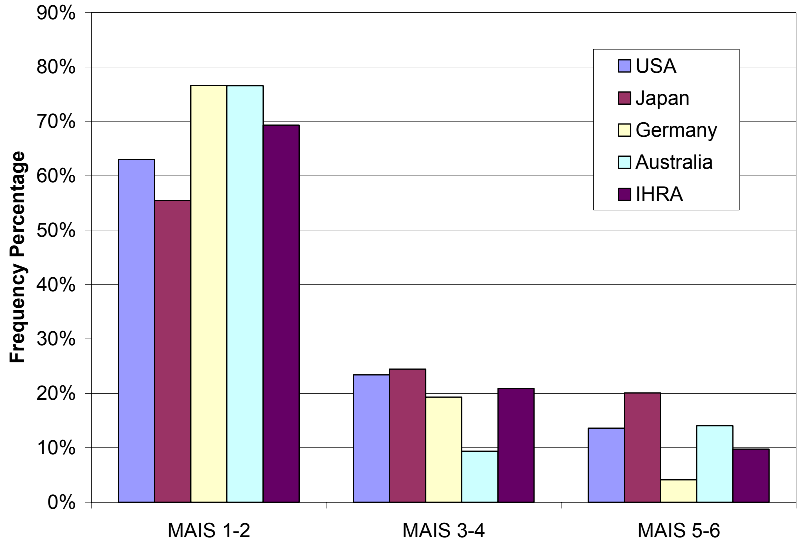

Figure 3.7 MAIS Injury by Country

The cumulative MAIS injury distributions are further broken down by age, body region, and injury severity in Figures 3.8 – 3.10. Age classifications are grouped as children (age 15 years and younger) and adults (age 16 years and older). All body regions are included for both children and adults in Figure 3.8, with distributions shown for MAIS 2-6 and MAIS 3-6 injuries. The injury distribution distinction between children and adults is evident in this figure. Children (ages 15 and under) are injured at slightly lower impact velocities than adults in most cases.

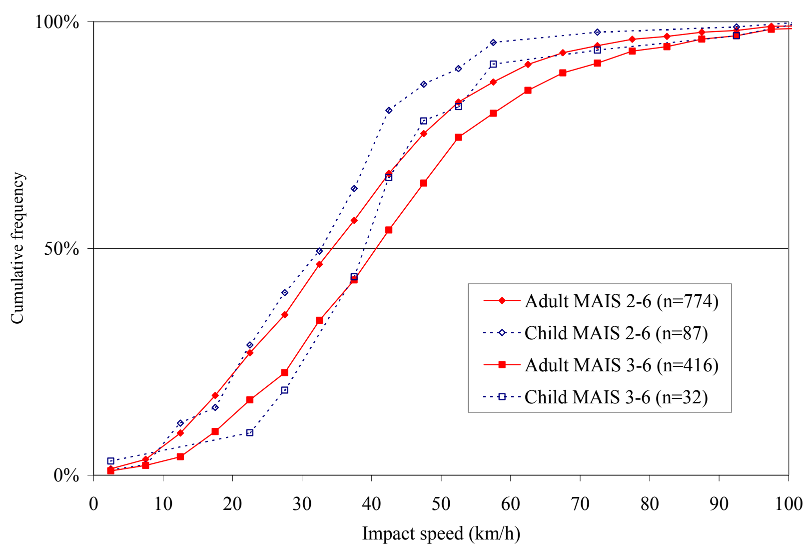

Figure 3.8 Impact Velocities by MAIS Level – All Body Regions

Head injury distributions are shown in Figure 3.9. For adults, the MAIS 3-6 and MAIS 4-6 injury distributions are almost identical, while the MAIS 2-6 distribution occurs at lower velocities. For children, there is similar separation between the MAIS 2-6, 3-6, and 4-6 injury curves, and the distributions are roughly the same shape. Once again, this figure exhibits the relationship between injury severity and impact velocity.

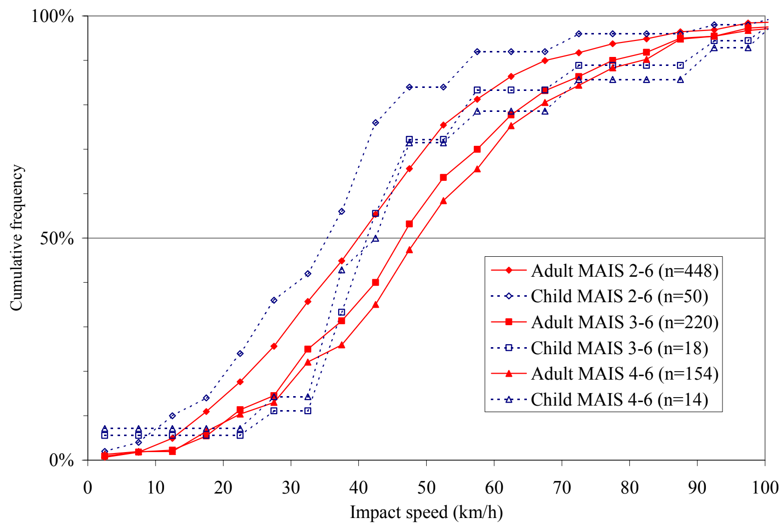

Figure 3.9 Impact Velocities by MAIS Level – Head Injuries

Injury distributions for children and adult leg injuries are shown in Figure 3.10. This figure shows that for leg injuries, injury severity is affected less by impact velocity than for head injuries. Once again, children suffer leg injuries at lower velocities than do adults.

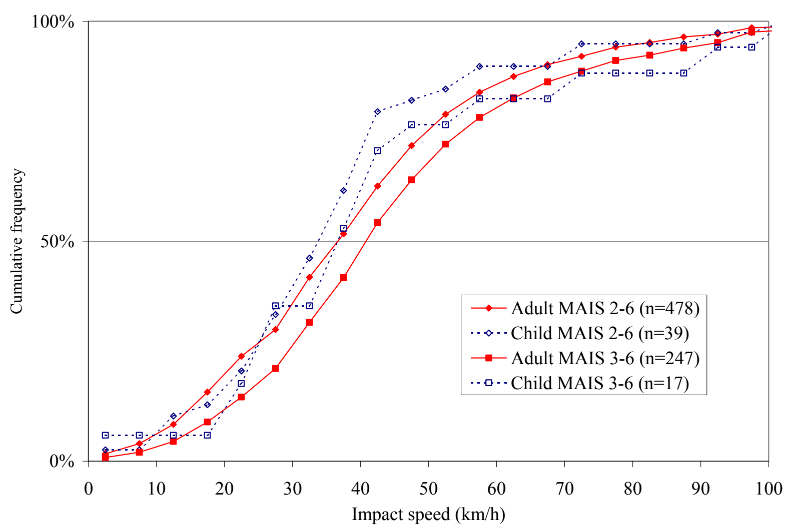

Figure 3.10 Impact Velocities by MAIS Level – Leg Injuries

The major conclusions from this analysis are:

1. The head and legs each account for almost one-third of the 9,463 injuries in the IHRA dataset.
2. For children, the top surface of the bonnet is the leading cause of head injury, while for adults the windscreen glass is the leading source of head injury.
3. Children (ages 15 and under) account for nearly one-third of all injuries in the dataset, even though they constitute only 18% of the population in the four countries.
4. Older individuals are more likely to suffer severe injuries in pedestrian crashes.
5. Children (ages 15 and under) are injured at lower impact velocities than are adults.

This compilation of pedestrian accident data from Australia, Germany, Japan, and U.S.A. provides a unique and important dataset. Issues such as the need for weighting the information included in this dataset and the problems associated with weighting are discussed in Chapter 8. In this chapter, MAIS for each case was used instead of all injuries in Figures 3.3 – 3.10 to eliminate the possibility of cases with more injuries skewing the data. The cumulative injury distribution data will provide a basis for establishing component pedestrian protection test procedures, priorities, and potential benefits assessments.

References:

[i] Isenberg, R.A., Walz, M., Chidester, C., Kaufman, R.; "Pedestrian Crash Data Study-An Interim Evaluation," Fifteenth International Technical Conference on the Enhanced Safety of Vehicles, Paper No. 96-S9-O-06, 1996.

[ii] Isenberg, R.A., Chidester, C., Mavros, S.; "Update on the Pedestrian Crash Data Study," Sixteenth International Technical Conference on the Enhanced Safety of Vehicles, Paper No. 98-S6-O-05, 1998.

[iii] United States Bureau of the Census, International Population Database (2001).