PEDESTRIAN SAFETY IN KOREA

Dr. Duk-Myung CHANG
Research Director
Korea Traffic Science Institute
Road Traffic Safety Association
#300-11 Yeomgok-Dong, Seocho-Ku,
Seoul, 137-170 Korea
Tel: 82-2-3498-2175
Fax: 82-2-3498-2061

Dr. Karl KIM
Professor
Dept. of Urban and Regional Plan
University of Hawaii at Manoa
Porteus Hall 107; 2424 Maile Way
Honolulu, Hawaii 96822
Tel: (808) 956-7381
Fax: (808) 956-6870

abstract: This study utilized three different techniques to examine the pedestrian accident problem in Seoul. This process included the collection and analysis of crash data, observational data, and attitudinal surveys. The data were analyzed to determine the significant factors that contribute to pedestrian accidents. Counter-measures to reduce pedestrian accidents fall into three categories: education, engineering, and enforcement. Various recommendations for improving safety were made. Evaluations of these measures after their applications, and further improvement on them as necessary, will make increase safety for Korean pedestrians.

1. INTRODUCTION

Pedestrians accidents are predominantly an urban phenomenon. Historically, urban spaces were designed with the pedestrian in mind as walking was the most common mode of transit. The advent of the automobile drastically changed the urban environment. As transportation networks and urban development patterns adapted to motor vehicles, pedestrian circulation was overlooked (Levinson, 1986). The subsequent neglect of pedestrian traffic resulted in unsafe crossings, frequent conflicts between pedestrians and traffic, overcrowded streets, obstructions at street corners and along sidewalks, long lines of people waiting at busy bus stops, inaccessible subway stations, inconvenient connections between office buildings and parking garages, and other problems for the pedestrian.

Due to an increase in pedestrian accidents in the 1970s, a number of programs and plans to reduce pedestrian collisions emerged. In a study of pedestrian fatalities in the United States and Western Europe between 1975-1989, Western Europe showed a 48.5% decrease in pedestrian fatalities and the U.S. showed a 12.8% decrease. While in Europe a decrease in fatalities occurred over the total time period studied, the U.S. had an increase in pedestrian fatalities until 1979 and a decrease from 1979-1983; between 1983-1989, the rate held steady. These numbers hint at a possible trend in pedestrian fatalities. The United States, a country where most pedestrians are also drivers, had a lower pedestrian fatality count than Western Europe in 1975. This trend may result from the fact that pedestrian fatality injuries can not be reduced significantly beyond a certain rate (Choueiri *et al.*, 1993).

As newly industrialized nations shift to greater reliance on the automobile pedestrian research needs to be condected in order to avoid the mistakes of the past. Studies performed in the United States and Europe provide information about the causes of pedestrian accidents and successful countermeasures. Pedestrian accidents are complex, requiring knowledge of driver, pedestrian, vehicle and environmental factors. By pinpointing the causes and suggesting appropriate countermeasures, analysis must be given to each category to determine the factors at work.

1.1 Pedestrian Accident Trends in Korea

On the past two decades, traffic accidents in Korea have risen dramatically. While the population in Korea has grown almost linearly, the numbers of vehicles and people with drivers licenses have increased exponentially by 4790% between 1970 and 1993. In 1993, almost half (117,431) of the total (260,921) traffic accidents in Korea involved a pedestrian with 5,241 resulting in fatalities. In addition, 55,660 people were seriously injured and another 64,240 pedestrians slightly injured (Korea Road Traffic Safety Association, 1993).

According to data from the National Police Agency, the elderly are less likely to be involved in pedestrian accidents. However, the fatality rate for older pedestrians was significantly higher than for almost every other age group. Their proportion of fatalities was greater than their proportion of total injuries. Children less than 16 years of age were involved in less than 5% of the total number of pedestrian accidents in Korea in 1993. Young children, aged less than eight years, accounted for fewer than 1% of the total. However, similar to the elderly, they were over-represented in terms of the number of injuries and fatalities. Data on all traffic accidents in Korea show that the proportion involving men is almost twice as high as the involvement rate of women. A majority of pedestrian accidents that can be classified by pedestrian movement occurred while crossing the street between intersections and at places other than those identified as pedestrian crossings. Although many pedestrian accidents occurred outside designated crossings, the fatality rate for these sometimes illegal movements was higher than if a pedestrian is crossing within a legal crossing zone.

1.2 Kangnam Gu, The Area of Study in Korea

Kangnam Gu, the 12th administrative district among 25 districts in Seoul, was established on 1 October 1975. Within Kangnam Gu, there are 26 dongs or subdistricts. The total area of Kangnam Gu is about 39 km^2. On the north of Kangnam Gu lies the Han River. In the east and west, it is bordered by Songpa Gu and Socho Gu respectively. On the south side of Kangnam Gu lies the city boundary of the greater Seoul. The terrain in Kangnam is generally flat, except in the southwestern part of the region, where there is a range of mountains which stretches into Socho Gu and peaks at Daemosan at an elevation of 290 meters.

According to the 1990 census, there were 490,767 persons residing in Kangnam Gu. Of these, 245,025 of them were male, and 245,742 were female. The overall population density was 12,593 persons per square kilometer which was relatively low compared with other areas in Seoul. There has been a dramatic increase in population over the past two decades, beginning in 1970. Kangnam Gu had a population median age of 27 which was higher than the city average of 26.9. Most of the resident population had attained a high level of education. Over 25% of the population in 17 dongs had either attended college or received some form of higher education. A majority of residents were professionals or managers, office workers, or engaged in wholesale, retail and service industries.

Wholesale and retail centers and various financial institutions are the major features in Kangnam Gu. Some of the commercial land was valued at more than 10 million Won per square meter. In 1993, there were twenty-six elementary schools, twenty-two middle schools and seventeen high schools in Kangnam Gu. In addition, there were two public libraries, four museums, two auditoriums and fifteen cinemas. Many social service facilities such as churches and hospitals are also located within the district. Despite the fact that there were no universities located within the district, there were twenty-five research institutes within Kangnam Gu, giving it the largest concentration of research facilities of all districts within Seoul.

1.3 Project Description

This project used three different methods to analyze pedestrian accidents. The first method was through the analysis of police crash reports. The second method was through observations of conflicts between motorists and pedestrians. The third method was through surveying attitudes of both drivers and pedestrians. The combination of the three provides different types of information on pedestrian accidents.

2. CRASH DATA ANALYSIS

The application of a crash data file to transportation planning is one of the most useful instruments of accident analysis. The data file consisted of 1,650 records with over 100 individual variables for accidents occuring in Kangnam Gu during 1995, which were coded and converted to computerized format. This file allowed the analysis of both driver and pedestrian characteristics. Overall, the results of the descriptive statistical analyses provided a clear picture of the pedestrian collisions which have occurred on the streets of Kangnam Gu. Of the 1,650 collisions in Kangnam Gu, 396 were pedestrian related and 1,254 were non-pedestrian collisions (see Figure 1). Among pedestrian collisions drivers were at fault 40.15% of the time, and pedestrians were at fault 35.10% of the time. Fault other than driver or pedestrian totaled 24.75 %.

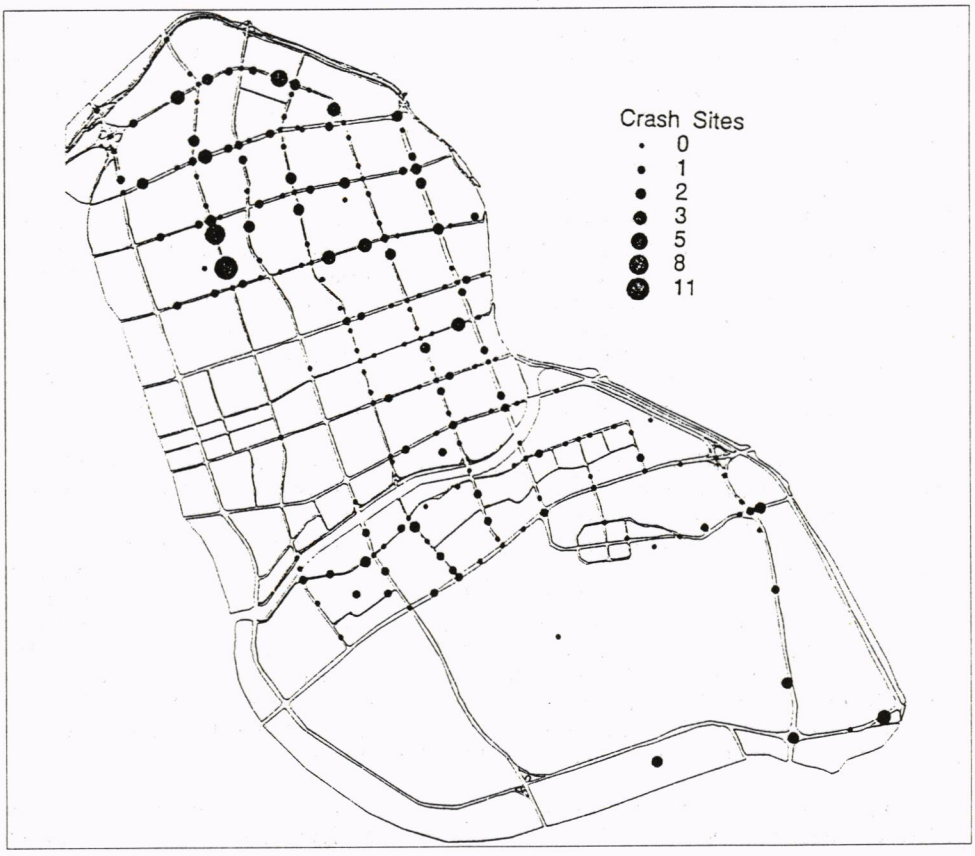

Figure 1. Pedestrian Accident Locations in Kangnam Gu in 1995

Fault was determined through a cross tabulation of the variables type of collision (pedestrian and non-pedestrian) and cause of the accident by pedestrians or by drivers. In addition, an understanding of the amount of fault that could be attributed to pedestrians, drivers, or other factors was gained. The analysis of crash data focused on determining:

- whether pedestrian accidents are a problem in Kangnam Gu;
- the characteristics of the pedestrians and motorists involved in collisions;
- the human and other factors involved in pedestrian collisions;
- any significant differences in age and gender of drivers and pedestrians involved in collisions; and
- who was at fault in the pedestrian collisions.

2.1 Methodology

After the data set was built, various statistical tests including analyses of means, correlation matrices, and cross tabulations were performed. A Chi-square analysis was conducted. The investigation established a series of variables explaining cause and effect of pedestrian collisions in Kangnam Gu.

2.2 Results

Pedestrian accidents in Kangnam Gu accounted for 24% of the total number of traffic accidents. Table 1 contains the overall occurrence of traffic collisions that involved both pedestrians and drivers. Of the total number of pedestrian accidents, 342 (86.4%) were male pedestrians and 54 were females. Of those persons involved in the 396 pedestrian accidents, only 8 were fatal or incapacitating injuries, 158 were nonincapacitating injuries, 156 were possible injuries, and 71 were no injuries, and 3 were missing. Drivers were found to be at fault in 40.2% of the pedestrian collisions in Kangnam Gu, while pedestrians at fault 35.1% of the time. However, 62.4% of the pedestrian collisions in Kangnam Gu were caused by drivers, and 31.6% of them were caused by pedestrians. 6.0% of the pedestrian collisions in Kangnam Gu did not involve driver or pedestrian fault. In these cases, fault was attributed to conditions in the surrounding environment. In 99.2% of the pedestrian collisions, the driver action was the initial cause of the accident, while the pedestrian action accounted for only 0.8% of collisions. 98.4% of the drivers involved in pedestrian collisions had a valid Korean drivers license.

Factors, such as roadway geometry and weather conditions, are examples of environmental conditions that cause accidents. A majority of pedestrian accidents (394 or 99.5%) occurred on major roads, and urban areas accounted for 373 of the pedestrian collisions. Of those urban collisions, 301 occurred in a commercial area, 68 in residential areas, and 27 in other places. Pedestrian collisions that occurred at signalized locations numbered 246. Fridays have the greatest frequency of pedestrian accidents in Kangnam Gu, with a total of 71 (17.9%) pedestrian collisions. Passenger cars accounted for 277 (70.0%) pedestrian collisions. Male drivers were responsible for 210 pedestrian accidents, which represented 53% of the total collisions recorded in the data set. Female drivers accounted for 9.3% of the pedestrian accidents. The remainder of the pedestrian accidents were caused by pedestrians: 111 of these were male and 14 were female.

The causes of pedestrian collisions were divided into three categories: driver, pedestrian, and environment. Table 2 outlines the significant causes of accidents involving a pedestrian based on these categories. The leading driver variable for pedestrian accidents was ignore signal, which accounted for 62 (15.7%) of the

driver causes in the 396 pedestrian accidents. This was followed by sudden stop which caused 39 accidents. Speeding totaled 20 collisions, followed by illegal turn at 14 pedestrian collisions. The variable drunk accounted for 11 observations representing 2.8% of the total pedestrian collisions.

Table 1. Pedestrian Accident Characteristics in Kangnam Gu in 1995

Characteristics		Pedestrian		Driver		DF	χ^2 Value	Prob. Value
		Freq.	%	Freq.	%			
Age	0-9	7	1.77	21	1.67	8	3.156	0.924
	10-19	7	1.77	26	2.07			
	20-29	114	28.79	395	31.50			
	30-39	139	35.10	394	31.42			
	40-49	82	20.71	272	21.69			
	50-59	42	10.61	125	9.97			
	60-69	5	1.26	19	1.52			
	70-79	0	0.00	1	0.08			
	80+	0	0.00	1	0.08			
Sex	Male	342	86.36	1091	87.00	1	0.107	0.743
	Female	54	13.64	163	13.00			
Injury Severity	No	71	17.93	238	18.98	4	4.211	0.378
	Possible	156	39.39	545	43.46			
	Nonincapacitating	158	39.90	444	35.41			
	Incapcitating/Fatal	8	2.02	16	1.28			
	Missing	3	0.76	11	0.88			
Presence of Signal	Signal Present	246	62.A2	894	71.29	1	11.852	0.001
	No Signal	150	37.88	360	28.71			
Accident Location	Urban	373	94.19	1145	91.31	1	3.401	0.065
	Rural	23	5.81	109	8.69			
Roadway Classification	Minor	2	0.51	3	0.24	1	0.704	0.401
	Major	394	99.49	1251	99.76			
Fault of First Harmful	Driver	247	62.37	1071	85.41	2	293.05	0.001
	Pedestrian	125	31.57	33	2.63			
	Missing	24	6.06	150	11.96			
Time of Day	Day	167	42.17	500	39.87	1	0.661	0.416
	Night	229	57.83	754	60.13			
Day of Week	Monday	47	11.87	155	12.36	7	8.332	0.304
	Tuesday	61	15.40	197	15.71			
	Wednesday	66	16.67	183	14.59			
	Thursday	44	11.11	172	13.72			
	Friday	71	17.93	191	15.23			
	Saturday	64	16.16	173	13.8			
	Sunday	36	9.09	147	11.72			
	Missing	7	1.77	36	2.87			
Roadway Alignment	Straight	353	89.14	1044	83.25	1	8.037	0.005
	Curved	43	10.86	210	16.75			
Weather	Clear	304	76.77	985	78.55	1	0.559	0.455
	Not-clear	92	23.23	269	21.45			
Roadway Surface	Wet	69	17.42	193	15.39	1	0.932	0.334
	Other	327	82.58	10.61	84.61			
License	Has valid license	379	98.44	1207	98.37	1	0.009	0.923
	No valid license	6	1.56	20	1.63			

Table 2. Attributing Cause in Pedestrian Collisions in Kangnam Gu

Attributing Causes	Variable	Frequency (N)	Percentage (%)
Gender	**Male Driver**	**210**	**53.03%**
	Female Driver	37	9.34%
	Male pedestrian	**111**	**28.03%**
	Female Pedestrian	14	3.53%
	missing/no response	24	6.07%
Total Collisions (N)		**396**	**100%**
Driver Attributed Causes	**ignore traffic signal**	**62**	**15.66%**
	sudden stop	**39**	**9.85%**
	speeding	**20**	**5.04%**
	illegal turn	14	3.54%
	drunk	11	2.77%
	avoid accident	10	2.53%
	fail track	2	0.51
	pass control	1	0.25
Subtotal Collisions (n)		**159**	**40.15%**
Pedestrian Attributed Causes	**illegal corssing**	**55**	**13.89%**
	ignore the car	**21**	**5.30%**
	ignore walk signal	**14**	**3.54**
	pedestrian monitor	**12**	**3.03%**
	walk in roadway	9	2.27%
	incorrigible	9	2.27%
	other pedestrian	8	2.02%
	leave bus	5	1.26%
	pedestrian speed	3	0.76%
	pedestrian inattention	2	0.51%
	play in street	1	0.25%
Subtotal Collisions (n)		**139**	**35.10%**
Environmentally Attributed Causes	**light conditions**	**14**	**3.54%**
	downhill	2	0.51%
	slippery	2	0.51%
	sight to corner	2	0.51%
	pothole or leading	2	0.51%
	inconsistent roadway	1	0.25%
	visual obstructions	1	0.25%
	sight distance	1	0.25%
Subtotal Collisions (n)		**25**	**6.31%**
Other Factors	**Subtotal (n)**	**73**	**18.43%**

As seen in Table 2, the primary pedestrian cause of collisions was illegal crossing which accounted for 13.9% pedestrian collisions. This was followed by pedestrians ignoring the car with 21 observations at 5.3%. The third most common pedestrian cause was ignore the walk signal totaling to 14 pedestrian collisions at 3.5%. Female pedestrians demonstrated less risk taking behavior than male pedestrians.

The most frequent environmental cause for pedestrian accidents in Kangnam Gu was light conditions. This accounted for 3.5% of the pedestrian accidents in the crash data file. In all, environmental factors were responsible for 6.3% of the pedestrian collisions. Each of the male driver cohorts reported frequencies of light conditions being a factor of pedestrian collisions.

3. PEDESTRIAN/VEHICLE CONFLICT ANALYSIS

Pedestrian/vehicle conflict analysis involves the use of data on near misses as a surrogate measure of actual pedestrian collisions. A pedestrian/vehicle conflict occurs when a driver and/or pedestrian has to take some action, such as a change in direction, speed, or both, in order to avoid a collision (Institute of Transportation Engineers, 1994). Conflict data determine the nature of pedestrian accidents.

Pedestrian/vehicle conflict studies involve the collection of data such as characteristics of pedestrians and drivers, pedestrian and vehicle volumes, pedestrian and driver behaviors, land use activities, vehicle types, traffic violations, and other relevant conditions. This data are used to indicate the presence, magnitude, and type of activity at a particular site. The research instruments used in this study, were designed to include both descriptive and inferential statistical analyses and to address the following research objectives:

- Determine whether involvement in vehicle/pedestrian conflicts can be associated with certain pedestrian and driver characteristics (i.e. age, gender, activity type).
- Determine whether different pedestrian or driver groups tend to be involved in certain types of conflicts more than others.
- Determine the variation of these conflicts over time and space.
- Determine the relationship between traffic volumes (both vehicles and pedestrians) and the number of pedestrian/vehicle conflicts.
- Is there a significant pattern in this relationship, or does it seem to be a random occurrence in terms of the factors observed?

3.1 Conflict Analysis Methodology

The data collected through the observational analyses were analyzed in order to determine the frequency of occurrence, as well as the mean values of all variables. This data was further examined to determine the similarities and differences between those involved in relatively minor conflicts, and those involved in more severe events. The data were compared between the different sites based on their classification as a high accident location or not, and based on the different types of activity generators present at each site. Data relating to the following list of variable types were compiled on pedestrian/vehicle conflicts:

- Level of conflict (slight conflict to actual collision).
- Characteristics of pedestrians involved, including age, gender, type of activity, and crossing movement.
- Characteristics of drivers involved, including gender, seat belt use, and vehicle movements.
- Type of vehicles involved in conflicts.
- Which party took evasive action (pedestrian, driver or both).

The goal of the site selection process was to select a diversity of street and roadway conditions for pedestrians in Kangnam Gu, and to identify locations that would be representative of sites throughout Seoul. Seven sites were observed over a period of one week. The map in Figure 2 shows where the sites that were observed are located. Site that were selected must have an average pedestrian

volume of 10 or more pedestrians per signal cycle and minimum vehicle volume of 50 vehicles per hour to ensure the accuracy of the short volume counts.

Figure 2. Map of Seven Observation Sites in Kangnam Gu

3.2 Conflict and Land Use Specific Findings

The results of the observational analyses can be seen in the Tables 3 and 4. Table 3 compares pedestrians and drivers involved in conflicts to those that were not involved in conflicts. A comparison between those involved in minor conflicts (slight evasions), and those involved in major conflicts (near-misses and pedestrian/vehicle collisions) is also included. The percentages presented in this table are based on the number of observations collected, and are not based on the volumes of pedestrians or vehicles present at each site.

Table 4 shows each variable as it relates to the different sites classified as a high or low accident location and to the sites classified by their primary activity generator or land use (i.e. retail, commercial, school, and park). The percentages presented in this table are based on the total of observations collected for each variable, some of which were collected as part of the conflict information, and some as the pedestrian and driver characteristics samples.

Table 3. Conflict Involvement and Severity

VARIABLE		Conflict / No Conflict		Coflict Severity	
		NoConflict	Conflict	Minor	Major
Driver Gender	Male	82.89%	**85.50%**	85.75%	83.66%
	Female	17.11%	14.50%	14.25%	16.34%
Seat Belt Use	Not Using	55.11%	44.73%	45.07%	42.22%
	Using	44.89%	**55.27%**	54.93%	57.78%
Vehicle Movement	Left-Turn	N/A	N/A	20.82%	34.21%
	Right-Turn	N/A	N/A	34.82%	23.03%
	Straight	N/A	N/A	**38.27%**	**36.18%**
	Other	N/A	N/A	6.09%	6.58%
Traffic Signal	Yes	N/A	N/A	**61.29%**	**78.01%**
	No	N/A	N/A	38.71%	21.99%
Vehicle Stop	Yes	N/A	N/A	63.24%	53.95%
	No	N/A	N/A	36.76%	**46.05%**
Vehicle Stop For	Pedestrian	N/A	N/A	84.02%	**90.12%**
	Signal (sign)	N/A	N/A	15.98%	9.88%
Vehicle Type	Cars	61.16%	65.15%	**66.13%**	58.28%
	Trucks	10.16%	6.64%	5.88%	**11.92%**
	Vans	6.70%	5.89%	5.88%	5.96%
	Taxis	13.39%	13.78%	**13.85%**	13.25%
	Buses	5.36%	4.56%	4.65%	3.97%
	Motocycles	3.24%	3.98%	3.61%	**6.62%**
Pedestrian Gender	Male	48.89%	**53.17%**	52.84%	55.90%
	Female	51.11%	46.83%	47.16%	44.10%
Pedestrian Age	Children	36.08%	**13.08%**	12.62%	16.77%
	Teens	9.54%	**14.03%**	14.38%	11.18%
	Adults	44.05%	**63.56%**	63.50%	63.98%
	Seniors	10.33%	**9.33%**	9.49%	8.07%
Pedestrian Activity	Walking	58.49%	**61.15%**	62.65%	48.73%
	Running	7.18%	11.63%	10.66%	19.62%
	Standing	33.03%	24.15%	23.54%	29.11%
	Other	1.31%	3.08%	3.14%	2.53%
Crossing Movement	Legal	52.38%	**63.77%**	63.02%	**69.92%**
	Illegal	47.62%	36.23%	36.98%	30.08%
Who Evaded	Pedestrian	N/A	N/A	36.30%	38.96%
	Driver	N/A	N/A	**47.19%**	26.62%
Site	Hakdongno & Yongdo	15.23%	15.91%	13.97%	**31.68%**
	Hakdong School	13.74%	**4.21%**	3.97%	6.21%
	Nasan Dept. Store	12.14%	20.60%	**21.68%**	11.80%
	New Hilltop Hotel	13.68%	17.54%	16.72%	**24.22%**
	Sunnung Park	14.28%	14.28%	14.81%	9.94%
	Nonhyun School	16.18%	**7.41%**	7.94%	3.11%
	Galleria Dept. Store	14.75%	20.05%	**20.92%**	13.04%

Table 4. Variables by High or Low Accident Location and Land Use

VARIABLE		Accident Rate		Activity Generator			
		High	Low	Comm.	School	Retail	Park
Driver Gender	Male	88.87%	76.63%	**89.54%**	85.41%	77.46%	**88.89%**
	Female	11.13%	23.37%	10.46%	14.59%	22.54%	11.11%
Seat Belt Use	Not Using	44.87%	**55.60%**	39.94%	56.67%	51.85%	55.21%
	Using	**55.13%**	44.40%	**60.06%**	43.33%	48.15%	44.79%
Vehicle Movement	Left-Turn	22.83%	21.77%	30.50%	10.69%	20.63%	16.48%
	Right-Turn	32.68%	34.48%	30.50%	10.69%	39.69%	39.01%
	Straight	37.27%	39.31%	31.42%	77.10%	33.40%	39.01%
	Other	7.22%	4.44%	7.57%	1.53%	6.29%	5.49%
Traffic Signal	Yes	67.49%	56.58%	77.64%	0.00%	72.41%	38.12%
	No	32.51%	43.42%	22.36%	**100.00%**	27.59%	61.88%
Vehicle Stop	Yes	34.99%	42.71%	34.71%	57.25%	28.43%	59.12%
	No	**65.01%**	**57.29%**	65.29%	42.75%	71.57%	40.88%
Vehicle Stop For	Pedestrian Signal (sign)	81.15%	90.77%	88.00%	**96.43%**	79.78%	87.10%
		18.85%	9.23%	12.00%	3.57%	20.22%	12.90%
Vehicle Type	Cars	57.77%	**72.83%**	56.20%	67.03%	62.85%	77.41%
	Trucks	8.92%	6.79%	10.28%	7.89%	5.85%	9.04%
	Vans	7.32%	4.40%	6.76%	7.53%	6.23%	3.92%
	Taxis	**15.55%**	10.57%	18.59%	3.58%	14.76%	9.04%
	Buses	5.72%	3.52%	5.07%	0.00%	8.52%	0.00%
	Motocycles	**4.73%**	1.89%	3.10%	**13.98%**	1.78%	0.60%
Pedestrian Gender	Male	54.96%	47.94%	53.57%	48.92%	47.44%	64.17%
	Female	45.04%	52.06%	46.43%	51.08%	52.56%	35.83%
Pedestrian Age	Children	15.44%	**27.72%**	8.04%	**63.28%**	8.04%	9.80%
	Teens	13.87%	10.76%	12.87%	3.91%	**19.24%**	9.48%
	Adults	**62.46%**	**49.54%**	**71.05%**	28.13%	62.06%	60.13%
	Seniors	8.23%	11.98%	8.04%	4.69%	10.67%	**20.59%**
Pedestrian Activity	Walking	54.56%	**67.41%**	43.89%	**90.49%**	46.90%	78.22%
	Running	**12.26%**	7.33%	**13.55%**	7.38%	10.96%	4.95%
	Standing	**31.45%**	21.49%	40.94%	0.97%	**40.42%**	7.26%
	Other	1.73%	3.77%	1.62%	1.17%	1.72%	9.57%
Crossing Movement	Legal	71.62%	41.25%	**69.53%**	25.00%	**60.24%**	7.8%
	Illegal	28.38%	58.75%	30.47%	**75.00%***	39.76%	**92.2%****
Who Evaded	Pedestrian	34.25%	**40.04%**	31.11%	**37.40%**	36.40%	49.18%
	Driver	**47.90%**	39.64%	**50.92%**	32.82%	**46.18%**	33.88%
	Both	17.85%	20.32%	17.97%	29.77%	17.42%	16.94%

* There were few or no crosswalks at the chosen school locations making most crossing movements illegal by definition.

** The geometry of the intersection and the placement of the crosswalk produced a high number of illegal crossings.

A Chi-square analysis was performed on each variable under each condition (conflict/no conflict, minor/major conflict, high/low accident location, and activity generator type) to determine if the differences between conditions were statistically significant. These results are displayed in Table 5.

Table 5. Chi-square Tests for Independence Among Variables

Variable	Testing by Conflict / No Conflict			Testing By Minor / Major Conflict		
	DF	χ^2 Value	Prob. Value	DF	χ^2 Value	Prob. Value
Driver Gender	1	2.711	0.100	1	0.475	0.491
Seat Belt Use	1	20.639	0.001	1	0.391	0.532
Vehicle Movement		N/A	N/A	3	16.439	0.001
Signal Present		N/A	N/A	1	14.936	0.001
Vehicle Stop		N/A	N/A	1	4.899	0.027
Vehicle Stop For		N/A	N/A	1	2.074	0.150
Vehicle Type	5	11.126	1.049	5	11.690	0.039
Pedestrian Gender	1	3.552	0.059	1	0.540	0.462
Pedestrian Age	3	169.199	0.001	3	3.244	0.356
Pedestrian Activity	3	31.42	0.001	3	16.180	0.001
Pedestrian Cross Move	1	18.023	0.001	1	2.447	0.118
Who Evades		N/A	N/A	2	36.193	0.001
Site (Individual)	6	182.023	0.001	6	52.704	0.001
Site (Hi/Low)	1	5.803	0.016	1	6.676	0.010
Site (Land Use)	3	172.65	0.001	3	41.577	0.001

VARIABLE	Testing by High / Low Accident Site			Testing By Acitivity Generator Type		
	DF	χ^2 Value	Prob. Value	DF	χ^2 Value	Prob. Value
Driver Gender	1	57.122	0.001	3	49.659	0.001
Seat Belt Use	1	21.368	0.001	3	35.410	0.001
Vehicle Movement	3	4.571	0.206	9	120.002	0.001
Signal Present	1	14.358	0.001	3	261.487	0.001
Vehicle Stop	1	7.582	0.006	3	76.657	0.001
Vehicle Stop For	1	12.386	0.001	3	15.261	0.002
Vehicle Type	5	51.987	0.001	15	218.448	0.001
Pedestrian Gender	1	10.709	0.001	3	26.992	0.001
Pedestrian Age	3	68.852	0.001	9	790.577	0.001
Pedestrian Activity	3	57.622	0.001	9	503.744	0.001
Pedestrian Cross Move	1	153.817	0.001	3	432.142	0.001
Who Evades	2	8.337	0.015	6	33.882	0.001
Conflict / No Conflict	1	5.803	0.016	3	172.650	0.001

3.3 Significant Findings

This section contains a discussion of the significant findings from Tables 3-5. High accident locations account for 1.6 times as many conflicts as low accident locations, and 2.5 times as many major conflicts. Male drivers were more frequently involved in conflicts of all types. However, Chi-square analysis from Table 5 shows that the differences in all cases except between activity generators were not enough to be significant. This implies that in terms of driver gender, there was not enough difference between males and females to explain their involvement in conflicts.

Seat belt use for drivers involved in with pedestrians was 1.2 times higher than the usage rate of drivers not involved in conflicts. The predominant vehicle movement for conflicts was straight ahead (Table 3), although at retail sites, right turn conflicts were the largest percentage (Table 4). Over 77% of conflicts at school sites involved vehicles moving straight ahead, strongly indicating a need for crosswalks and warning signs or signals near school locations. Children are forced by parked cars and a lack of sidewalks around the schools. This puts children in immediate contact with motor vehicles approaching from both directions.

Vehicles were less likely to stop in more severe conflicts and at the low accident locations. This suggests faster vehicle speeds and/or occluded pedestrians at these sites, perhaps calling for warning signs, speed limitations, or restricted street parking. Passenger cars, taxis, and motorcycles were over-represented in conflicts when compared to their distribution in the sampled population. Chi-square tests show that vehicle type is a significant variable in all tested cases.

Male pedestrians were over-represented in all types of conflicts compared to their presence in the sampled population, and at high accident sites, and sites with commercial or park activities. Females were over-represented at the lower accident sites as a whole, and at sites with school or retail land uses. Children and seniors were under-represented in conflicts when compared to their overall presence as pedestrians, while adults and teens were over-represented in conflicts. A higher percentage of pedestrians involved in conflicts were walking or running than in the general crossing population. This can be partially explained by the lack of sidewalks at the school sites, and construction on the sidewalks at the Nasan Department Store site, which forced pedestrians into the streets.

63.8% of pedestrians involved in a conflict with a motor vehicle were making a legal crossing movement, while the sample of pedestrians not involved in a conflict showed only 52.7% of pedestrians making a legal crossing movement. Illegal crossings were much more prevalent at low accident locations, not including school sites (as missing crosswalks at these locations made most crossings technically illegal). This suggests that motor vehicle drivers are not respecting the right of way provided by the crosswalk, and that the lower traffic volumes and speeds at low accident locations give pedestrians the perception that they can cross illegally easier than at the larger, higher volume and higher speed areas. Pedestrians were more likely to take evasive action in the more serious conflicts while drivers were more likely to evade in the less serious conflicts. This suggests that a larger portion of minor conflicts are the result of inattention on the part of the pedestrian, while more serious conflicts may be the result of driver inattention.

While driver gender was not a significant, pedestrian characteristics such as gender, age, activity and crossing movement, all proved to be significant factors. The data showed that males, teens, and adults were the groups most likely to be in conflicts with vehicles. However, a high percentage of pedestrians were crossing the street legally when involved in a conflict, suggesting that drivers are the principal causes of conflicts. Drivers who are wearing their seat belts are more likely to be

involved in a conflict with a pedestrian, than the counterparts who do not wear seat belts (Table 3). Measures designed to regulate the actions and behavior of drivers would be effective in reducing the number of conflicts. In addition, educational programs aimed at teens and adults might remind them that the danger of a pedestrian accident does not stop when they are no longer a child.

For the most part, as volumes increase, so did the number of conflicts. In addition, violations, both of pedestrians and vehicles, became more meaningful at the higher volumes, at the commercial and retail sites, which together had almost 56% of the pedestrian volume, and also had approximately 80% of the more severe conflicts.

Comparing high and low accident locations showed that in general, the high accident locations had slightly lower average pedestrian volumes (453/hr) than the low accident sites (618/hr), but much higher vehicles volumes (1949/hr at high accident locations as compared to 374/hr at low accident locations). The low accident locations averaged 58 conflicts while the high accident locations averaged 65 conflicts. This suggests that the stronger variable in determining the number of conflicts is vehicle volume as opposed to pedestrian volume.

The highest percentage of conflicts occurred at retail locations (40.7%), the majority of the more severe conflicts occurred at commercial locations. Schools showed the smallest percentage of conflicts with values that were much lower than would be expected considering the volumes present (29.9% of non conflict observations, while only 11.6% of conflicts). Measures to reduce pedestrian/vehicle conflicts should be directed at commercial and retail locations. In addition, further examination on the effects of different time measures such as time of day, day of the week, month (season) of the year is needed.

4. ATTITUDINAL SURVEY

Although observational studies and analysis of crash data files give the researcher a statistical picture of pedestrian accidents, a vital component of a study on pedestrian accidents should include the attitudes of both driver and pedestrian. The objectives of implementing the surveys were as follows:

- Determine general opinions about the causes of pedestrian accidents
- Determine which countermeasures used to reduce pedestrian accidents
- Determine demographic characteristics of the samples surveyed.
- Recommend countermeasures, based on the results of the survey

4.1 Methodology

Pedestrian Safety Survey -- Schools were chosen, and surveys were given out to teachers who stressed the importance of the surveys and requested that students take the surveys to their parents. Parents were instructed to answer the questions to the best of their ability. Specific instructions on how to fill out the survey were included on the survey form. 937 Parents of children at one elementary school, one junior high school, and three high schools were surveyed.

Pedestrian Safety Actions Survey and Pedestrian Safety Policies Survey -- The Galleria Department Store was selected as the site for distribution of the two shorter surveys. The site was attractive because of the width of the sidewalks surrounding the department store which allowed for the setting up of a table without obstructing pedestrian traffic and the high pedestrian volume in the area. Although two different surveys were administered simultaneously, each pedestrian

only completed one survey. The number of surveys collected for approximately five hours were 352 Pedestrian Safety Policies Survey and 345 Pedestrian Safety Actions Survey.

4.2 Results

The findings for the surveys are first displayed as overall frequencies, then they were analyzed by demographic groups according to causes and countermeasures using a 95% confidence interval. Although pedestrian accidents have many causes, on all three surveys and in all analyses performed by aggregate groups, drivers were believed to be at fault over pedestrians by high margins. This was supported by the fact that the causes respondents ranked highest were predominately driver causes (four of the top five), as seen in Table 6. In addition to driver factors being important, this table also shows that four pedestrian factors are included in the top ten causes. The highest rated pedestrian and driver causes were all illegal behaviors (i.e. drunk driving, speeding, crossing on a "don't walk" signal, and jaywalking). According to these results, environmental factors were not as important to respondents, with the highest environmental factor being ranked as number 10. The three highest environmental causes focus on signs and signals.

Those who believe drivers are at fault gave the same ranking to the causes as the overall sample. It was interesting to see that a higher proportion of those who believe pedestrians to be at fault also believed drunk driving to be a major factor in pedestrian accidents. Although there were only slight differences in responses between those who believe pedestrians are at fault and those who believe drivers are at fault, it stands out that the pedestrian at fault group rated the pedestrian factors slightly higher than the driver at fault group. Also, a higher proportion of women marked very important on the causes than men.

As the figures on causes portray, drivers and driver behavior were perceived to be the causes of pedestrian accidents. However, the countermeasures respondents marked as efficient were clearly focused on pedestrians. For instance, education programs and crossing guards near schools were the two countermeasures with the highest percentages of respondents marking them as efficient. Table 7 displays and compares the rankings of countermeasures by respondents on both the Safety Survey and the Actions Survey. The results of the Policies Survey, in which the respondents were asked to rank the three "E's", showed that engineering was the highest rated category, contradicting the results of the Policies Survey and the Safety Survey where education was ranked first.

For purposes of analysis of countermeasures by demographic groups, the Safety Survey was chosen because it was more comprehensive and contained more demographic questions than the shorter surveys. Although there were differences in the ranking of countermeasures, the most approved of countermeasures were geared towards pedestrians, especially children (education for children and more crossing guards near schools) and environmental/engineering. A few interesting results stood out in the comparisons by demographic group. The rankings for males were the same as for the sample population on the first nine countermeasures. Females, on the other hand, ranked installation of warning signs higher and increased penalties for violations lower than the males. Also interesting was the fact those who believe pedestrians are at fault ranked a driver countermeasure (prohibit roadside parking) higher than a pedestrian factor (crossing guards near schools).

The surveys were designed to focus on the attitudes of respondents towards causes of pedestrian accidents and responses to reduce them. The surveys were very important tools in this study of pedestrian accidents because they provided attitudinal data that was impossible to collect from literature and/or observational

studies. With the information gathered from the surveys, solutions to the problem of pedestrian accidents can be found. Some of the major findings from the surveys were as follows:

Table 6. Ranking of Causes

Rank	Causes of Pedestrian Accident	%	Factor
1	Driving under the influence of alcohol	77.6	Driver
2	Driver speeding in high pedestrian areas	67.4	Driver
3	Driver violates traffic signals	66.9	Driver
4	Pedestrian crosses the street when a "Don't Walk" signal is showing	63.5	Pedestrian
5	Driver does not yield for pedestrians in crosswalk	62.9	Driver
6	Pedestrian jaywalks	61.2	Pedestrian
7	Pedestrian darts out into traffic	59.0	Pedestrian
8	Pedestrian is intoxicated	56.0	Pedestrian
9	Driver has bad driving habits/reckless behavior	55.2	Driver
10	Signs or signals are not easily visible	47.1	Environment
11	Pedestrian is working or playing in the roadway	43.5	Pedestrian
12	Pedestrian is a child too young to understand safe pedestrian behavior	43.1	Pedestrian
13	Signs or signals are confusing or not understood	42.4	Environment
14	Poorly placed stop signs	41.4	Environment
15	Crosswalk and/or roadway markings are unclear or not present	39.4	Environment
16	The sidewalk is too narrow or not present	38.1	Environment
17	Pedestrian crosses the street from between parked cars	37.0	Pedestrian
18	The street is poorly lit	36.7	Environment
19	Pedestrian crossing signals do not provide enough time to cross safely	36.3	Environment
20	Vehicle has a mechanical failure	36.2	Vehicle
21	Pedestrian tries to cross when there is not enough time before light changes	32.9	Pedestrian
22	Vehicle is poorly designed	31.7	Vehicle
23	There are obstructions on the sidewalk	31.1	Environment
24	Pedestrian has a physical impairment	30.1	Pedestrian
25	Pedestrian is elderly	29.1	Pedestrian
26	Driver has poor driving skills	28.4	Driver
27	Driver is inexperienced	27.9	Driver
28	There are obstacles/construction on roadway	26.3	Environment
29	Driving of vehicles for business	25.9	Driver
30	Roadway is too wide	12.4	Environment

- Although respondents understood the causes of pedestrian accidents to be driver related, the countermeasures they highly supported address pedestrians (education of children and more crossing guards) and the environment. This discrepancy suggests the possibility that acceptability (as determined by the responses to the survey) does not match perceived needs.

Table 7. Comparison of Countermeasures

Rank	Countermeasures	Target of Countermeasure	3 "E"	%
1	Education programs for children	Pedestrian	Edu.	73.2
2	More crossing guards near schools	Pedestrian	Enf.	60.3
3	Prohibit roadside parking	Environment/Driver	Enf.	58.1
4	Install warning (safety) signs	Environment	Eng.	56.4
5	Barriers to prevent crossing	Environment	Eng.	49.1
6	Increased penalties for violations	Driver/Pedestrian	Enf.	44.9
7	Remove roadway obstructions	Environment	Eng.	43.2
8	Adding or adjusting traffic signals	Environment	Eng.	42.3
9	Remove sidewalk obstructions	Environment	Eng.	39.9
10	Education programs for elderly	Pedestrian	Edu.	38.0
11	More enforcement of existing laws	Driver/Pedestrian	Enf.	37.4
12	Redesign roadways to slow vehicle speeds	Environment	Eng.	37.4
13	Installing overpasses or underpasses	Environment	Eng.	37.2
14	Creating areas where cars are not allowed	Environment	Eng.	36.6
15	Install pedestrian refuge islands in medians	Environment	Eng.	36.3
16	Education programs for adults	Driver/Pedestrian	Edu.	33.0
17	Improve roadway lighting	Environment	Eng.	32.9
18	Enact more restrictive laws	Driver/Pedestrian	Enf.	31.9
19	Widen sidewalks	Environment	Eng.	21.3
20	Driving tests for elderly drivers	Driver	Edu.	17.2
21	Adding more crosswalks	Environment	Eng.	16.1

- The two highest ranked countermeasures which address the respondents perceived causes for pedestrian accidents were ranked fifth and sixth overall (barriers to prevent crossing and increased penalties for violations).

- Both the top pedestrian causes and the top driver causes were related to illegal behavior. The top driver causes for pedestrian accidents included speeding, alcohol use, and violations of traffic signals. The top pedestrian causes for pedestrian accidents involved illegal crossings (pedestrian darts out into traffic and jaywalks). Both enforcement and education countermeasures may address these causes.

- The top environmental causes chosen by respondents dealt with signs and signals (signs or signals are not easily visible; poorly placed stop signs; signs or signals are confusing or not understood) and can be addressed through engineering countermeasures.

- Although engineering as a category of countermeasures was ranked first in the Policies Survey, specific countermeasures in the Actions Survey and the Safety Survey ranked highest by the respondents did not reflect this ranking. Instead, education was ranked higher on the Actions Survey and the Safety Survey.

5. CONCLUSIONS AND RECOMMENDATIONS

Countermeasures to reduce pedestrian accidents fall into three categories: education, engineering, and enforcement. Based on the findings from the analysis of crash data, observational studies, and attitudinal surveys; the following recommendations were developed:

- Initiate or continue traffic education programs for children.
- Initiate education programs for adults.
- Construct sidewalks near schools.
- Make signs more visible and/or less confusing or more widespread.
- Shorten vehicle signal cycle time.
- Install pedestrian preemption buttons at traffic signals.
- Eliminate the yellow light after the red signal.
- Construct taxi stops (similar to bus stops).
- Create pedestrian malls/auto free zones or over/underpasses.
- Prohibit roadside parking, especially near schools.
- Maintain crossing guards at schools.
- Restrict vehicles from driving on the sidewalks.
- Require motorcycles and mopeds to comply with the traffic regulations
- Stricter enforcement of driver and pedestrian violations.
- Eliminate U-turns on crosswalks.

The recommendations given include new measures as well as improvements on existing safety measures. These recommendations are backed by the findings of three separate studies: analysis of crash data, analysis of conflict/observational data and analysis of attitudinal/survey data. In addition, successful practices from other countries, as found in the literature review, were also considered. Evaluations of these measures after their applications, and further improvement on them as necessary, will make the roads much safer for Korean pedestrians in the future.

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<Appendix A> DEFINITION OF TERMS

- Cause: An action, event, or circumstance that results in an outcome (pedestrian accident).
- Crossing: The physical act of a pedestrian walking or running from one side of a street to the other
- Fault: The responsibility for failure to act, or a wrongful act, which in turn leads to a pedestrian accident
- Illegal crossing: A pedestrian crossing against the traffic signal, outside of the crosswalk, from between parked cars (except when in a crosswalk), or walking along the roadway (rather than on the sidewalk).
- Initial action of the conflict: The driver or pedestrians action that is attributed as the cause for the underlying pedestrian accident.
- Jaywalking: To cross a street at other than a regular crossing or to cross in a dangerous manner, such as against the traffic light.
- Minor conflict: When a slight evasive action is taken to avoid a collision by a pedestrian or driver of a motor vehicle. (An example of this is: a motor vehicle slowing to allow a pedestrian to finish crossing.)
- Major conflict: When a pedestrian or driver is forced to take extreme action to avoid a collision. (An example of this is: a vehicle making an unexpected stop or a pedestrian jumping back onto the curb to avoid a collision.)