Relationship Between Child Pedestrian Accidents and City Planning in Zarqa, Jordan

ADLI H. AL-BALBISSI, MOHAMED T. ABOUL-ELA, AND SABAH SAMMOUR

The relationship between child pedestrian accidents and city planning was studied in Zarqa, Jordan. Variables considered included road pattern, road density, population density, size of green areas, and number of schools in the area. Data were collected for child pedestrian accidents from police records. Analysis of these data revealed several conclusions among which is that children 5 to 9 years of age account for 33 percent of the total number of pedestrian casualties and 49 percent of child pedestrian casualties. This group constitutes about 17 percent of the total population of Jordan. The city was divided into 16 study zones and statistical analysis was performed using multiple regression techniques. Significant relationships were obtained between child pedestrian accidents and several land use variables. Developed models can be used to give an estimate of the reduction in child accidents because of changes in road pattern and other variables. From these models, a 25 percent reduction in the number of four-leg (cross) intersections could reduce accidents by approximately 24 percent.

Accidents in residential areas have long been recognized as a problem of major concern for the general public and road safety authorities. Profound and direct impacts on the community occur because the close-to-home occurrence of these accidents frequently involves children.

Road accidents within the young age group is of great importance in Jordan because children under 15 years constitute about 50 percent of the total population. In response to the high exposure of this age group to traffic accidents, an investigation was conducted to ascertain the relationship between child road accidents and city planning aspects that may explain the high incidence of casualties in this age group. In Jordan, 1981 statistics showed that children under 15 years account for 61 percent of total pedestrian casualties (*1*).

Whitelegg (*2*) states that an urban system carries an intrinsic level of risk and can be assessed in statistical terms. He indicated that the close association between geometric design and layout and accident probabilities is an important element in the exploration of spatial selectivity and accident causation.

Appleyard (*3*) reports findings related to spatial selectivity and child casualties. In California, more accidents involving children (55 percent) occurred between intersections than at intersections (32 percent). Backett and Johnson (*4*) found that child casualties were more likely to occur in neighborhoods with few back yards, few playgrounds, and low parental supervision. This finding is closely related to those of Blackman (*5*), who found that death rates were higher for pedestrians in poor areas because reduced car ownership resulted in more walking. In addition, poorer levels of recreational facilities lead to more on-street activity in these areas.

A United Kingdom study of 9,000 streets in local authority residential estates (*6*) found that accident rates were low in cul-de-sacs and high in estates designed in accordance with traditional practice. Children represented 76 percent of the casualties and 49 percent of the fatalities. The mean pedestrian accident rate in simple cul-de-sacs was less than one-sixth of the overall mean.

Whitelegg (*2*) reports findings of a study in Gothenburg, Sweden, where most accidents involving children occurred in residential areas, but accident rates differed by district. Older areas had six times the accident risk of newer areas in which pedestrian and vehicle routes are separated.

One study that investigated the relationship between pedestrian accidents (not just children) and city planning was that of Crompton (*7*). Pedestrian casualties were studied in 474 1-km squares distributed in regions of England and Wales. All squares with less than 20 percent of the area developed and all predominantly nonresidential squares were omitted. Multiple regression analyses were carried out with pedestrian casualty rates per square kilometer of development as the dependent variable and with three different sets of independent variables: activity set (including numbers of pedestrians, vehicles, and parked vehicles), census data (including population, number of households, etc.), and land use set (including road length, number of shops, number of junctions, etc.). Crompton (*7*) concluded that land use variables influence pedestrian casualty rates to a considerable extent.

STUDY OBJECTIVES

An attempt will be made to define and quantify the problem of child traffic safety in selected Jordanian cities. The relationship between city planning criteria and child road accidents was investigated with the aim of classifying factors that make the highest contribution to the problem of child accidents. The following is a list of the main objectives of this research:

- Quantify the problem of child traffic safety in Jordanian cities using the city of Zarqa as a study case,
- Analyze the spatial distribution of child road accidents in Zarqa,
- Establish the relationship between child accidents and several city planning criteria, and

Department of Civil Engineering, Jordan University of Science and Technology, Irbid, Jordan.

• Suggest guidelines for improving traffic safety in existing residential areas as well as new areas.

The city of Zarqa was chosen because of its relatively large population. Data, which included population density, road patterns, and location of schools and recreational facilities, were also available on town planning criteria in different zones. Also, in Zarqa, the difference between old and new areas can be noticed clearly.

STUDY AREA AND DATA COLLECTION

Zarqa is the second largest city in Jordan, with a 1988 population of nearly 350,000. The city is located 30 km northeast of Jordan's capital, Amman. Figure 1 shows the road network in the city. The grid system of road pattern is dominant in Zarqa's central areas, whereas in modern areas in the northern part of the city, curvilinear patterns with loops and cul-de-sacs are the main feature of the network.

In order to analyze the spatial distribution of child pedestrian accidents, the city was divided into 16 study zones corresponding to administrative municipal divisions as well as zones used in the 1979 census. These zones are shown in Figure 2.

Information on child pedestrian accidents was obtained from files in police headquarters in Amman for 1988. Data were limited to 1988 because of a new system of accident recording implemented in 1987. In this system, information on age, sex, and pedestrian action was available as well as the approximate location of the accidents. Child pedestrian accidents were allocated to the zones shown in Figure 2.

One year of data was considered sufficient because the analysis focused on the spatial distribution of child road accidents. An analysis of the trend of child road accidents was not under consideration. Such a trend will have little or no influence on the spatial distribution of child road accidents.

Information on road density and pattern was obtained from city maps. The area of roads in each zone was calculated as well as the number of four-leg (cross) intersections and their percentage.

Data on population density for each zone were obtained from the Department of Statistics. Data about elementary schools, parks, and playgrounds were obtained from the city government. These data are presented in Table 1.

CHILD PEDESTRIAN CASUALTIES

Figure 3 shows the distribution by age group of pedestrian accidents in Zarqa. From Figure 3, the group of children 5 to 9 years old has the highest incidence of road accidents. As

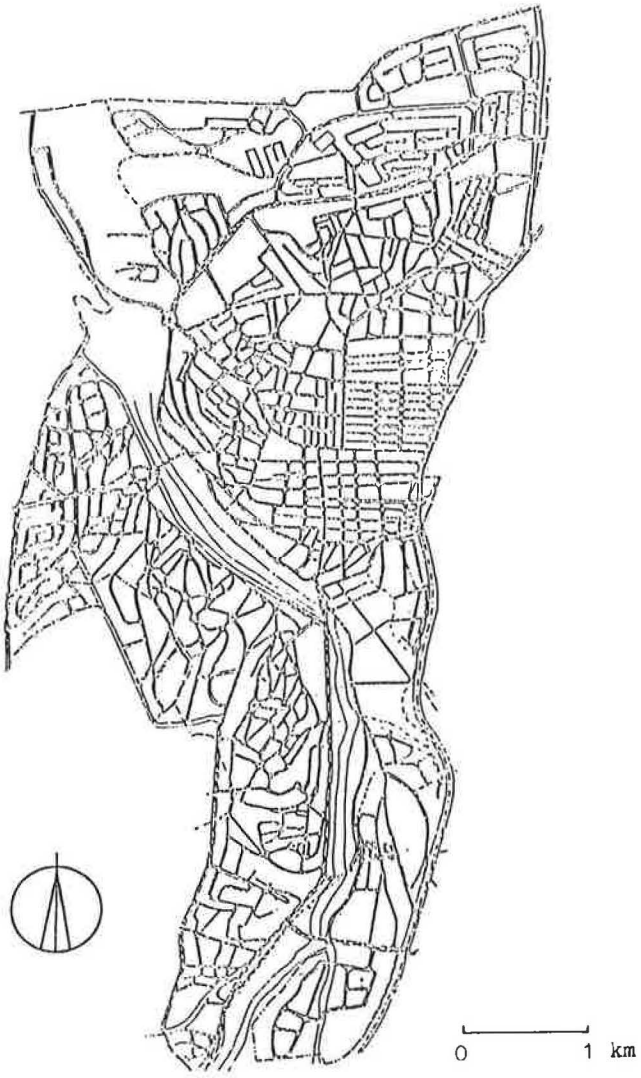

FIGURE 1 Zarqa road network.

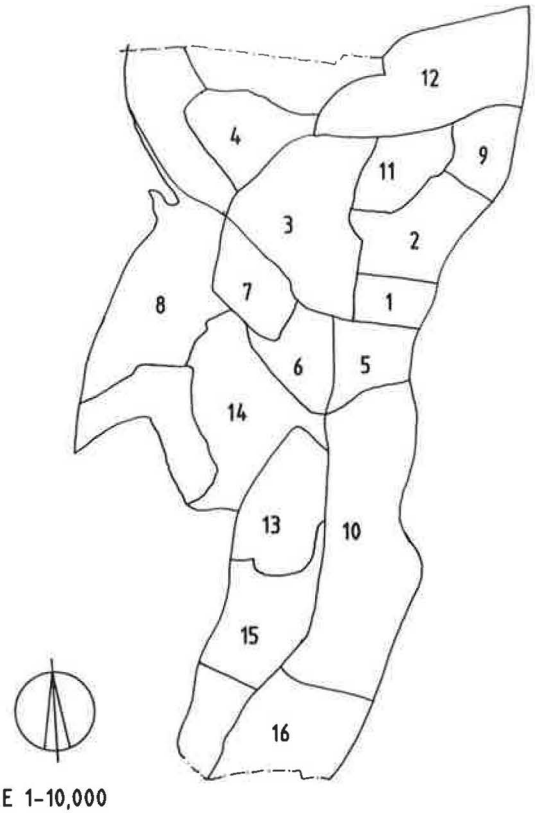

FIGURE 2 Zarqa study zones.

TABLE 1 DATA FOR TOWN PLANNING CRITERIA IN ZARQA

Zone	Area of Zone (km²)	Area of Streets (km²)	Road Density (%)	Population (1988)		No. of Intersections		No. of Elementary Schools	Green Area (donums)
				Per Zone	Density (persons/donum)	Four Legs	Total		
1	0.456	0.158	34.85	19.036	41.746	22	41	58	0.000
2	1.228	0.384	31.15	18.662	15.197	34	72	19	8.466
3	2.037	0.490	24.06	70.117	34.422	51	105	30	0.000
4	0.875	0.119	13.53	1.509	01.724	7	32	2	5.163
5	0.684	0.170	24.84	26.049	38.003	43	55	28	0.000
6	0.641	0.150	23.30	22.480	35.070	27	42	16	9.531
7	0.759	0.203	26.71	21.923	28.971	14	47	10	0.000
8	1.345	0.417	31.01	2.091	01.555	26	74	11	9.281
9	0.743	0.249	33.47	29.862	40.101	10	38	7	0.000
10	2.592	0.400	15.74	43.409	15.324	18	70	27	0.000
11	0.634	0.128	18.39	10.645	15.339	15	40	6	0.000
12	2.195	0.669	30.47	893.000	00.407	13	91	7	41.475
13	1.221	0.289	23.66	11.810	09.672	19	47	7	0.000
14	1.114	0.274	24.55	22.480	20.180	19	56	22	0.000
15	1.193	0.237	19.84	10.056	08.425	14	62	6	0.000
16	0.892	0.177	19.77	5.198	05.227	2	12	5	0.000

Note: 1 donum = 1000 m².

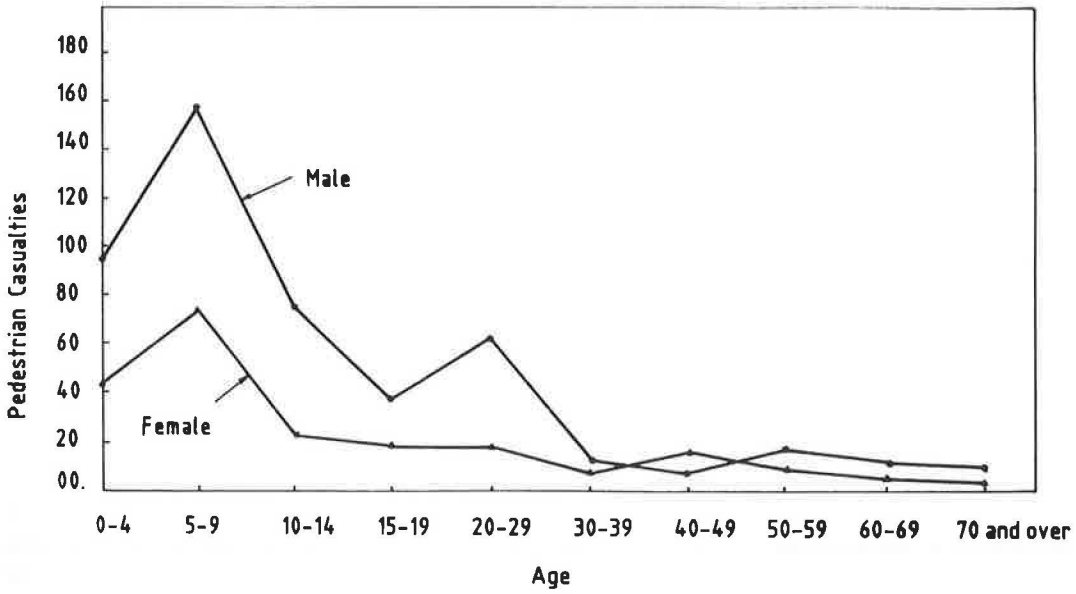

FIGURE 3 Pedestrian casualties in Zarqa.

might be expected, boys outnumbered girls in road accidents with the ratio of girls to boys roughly 1 to 3. The 5 to 9 year age group accounts for 49 percent of child pedestrian casualties but constitutes about 34 percent of the child population.

Nearly 58 percent of child pedestrian accidents occurred between intersections (midblock). About 79 percent of pedestrian accidents involving children occur while crossing the street, 8 percent occur while crossing in front of parked cars, and 9 percent while playing or standing in the street. Detailed numbers of these casualties by age group are shown in Table 2.

MULTIVARIATE MODELS OF CHILD PEDESTRIAN CASUALTIES

Multiple regression analyses were carried out with child pedestrian casualties as the dependent variable and with several independent variables representing city planning criteria in each of the 16 zones. The two best models are as follows:

Model 1 ($n = 16$, $R^2 = 0.82$, $F = 19.02$):

$$1/\ln(CP) = 0.97 - 0.05 \ln(PD) + 0.26/\ln(SR) - 0.18 \ln(CI) \quad (1)$$

TABLE 2 PEDESTRIAN BEHAVIOR AT THE TIME OF THEIR INVOLVEMENT IN AN ACCIDENT IN ZARQA

Age Group (years)	No. of Pedestrians by Behavior				
	Crossing Street	Crossing in Front of Parked Cars	Riding a Bike	Playing or Standing on Street	Not Specified
1– 2	18	4	0	5	0
3– 4	97	11	1	1	0
5– 6	106	14	0	9	3
7– 8	55	2	0	7	2
9–10	46	5	0	9	2
11–12	30	2	2	8	3
13–14	22	1	3	4	1
Total	370	39	6	43	11
Percent	78.9	8.3	1.3	9.2	2.4

The t values corresponding to the four coefficients were 6.4, −2.03, 1.87, and −4.6. In Equation 1,

CP = total number of child pedestrian casualties per zone,
PD = population density (persons per 1,000 m²),
SR = ratio of street area per zone to total street area in the city (percent), and
CI = number of four-leg (cross) intersections per zone.

Model 2 ($n = 16$, $R^2 = 0.75$, $F = 12.37$):

$$1/[\ln (CP)] = 0.55 + 0.16 \ln (GPS + 1) + 1.43 \ln [(1/CI) + 1] - 0.14 \ln (SR + 1) \quad (2)$$

The t values corresponding to the four coefficients were 3.7, 2.9, 4.2, and −1.8. In Equation 2, GPS = ratio of green areas (parks and playgrounds in thousands of square meters) to the number of elementary schools in each zone (i.e., green area per school).

The two models are statistically significant at a 10 percent level of significance. Both models indicate the effect of four-leg (cross) intersections and street area. Model 2 shows the effect of green areas represented by the area in thousands of square meters divided by the number of elementary schools in each zone. The significance of this factor suggests that in order to achieve a reduction in child accidents, school playgrounds should be open and available to children during the days when school is not in session.

Different models and variables were considered. The models shown were statistically the most significant. Streets in residential areas were not classified according to traffic volumes because data related to their average daily traffic (ADT) were not available. However, population density (which was included in the model) is believed to reflect traffic demand in a specific area.

The first model was used to estimate the expected reduction in child casualties caused by changes in the existing road pattern. A 25 percent decrease in the number of cross intersections may lead to a 24 percent reduction in child pedestrian accidents. This reduction may be achieved by diagonal or full closure of cross intersections. These methods gave good results when they were implemented in several locations in Europe (*8*) and Australia (*9*).

Information related to the destination of the child was not available, that is, whether the child was on the way to school or to the playground. However, such information would not have changed the major findings because few playgrounds exist outside those found at schools.

CONCLUSION

The results presented provide some evidence to support the hypothesis that a strong relationship exists between city planning and road safety for children. In the city of Zarqa, a significant relationship was found between the number of child pedestrian casualties and population density, road density, green areas per elementary school, and road pattern expressed as the number of four-leg (cross) intersections.

The models presented can be used to predict the expected reduction in child pedestrian casualties from immediate and short-term measures, such as converting four-way intersections to other types of intersections with fewer conflict points.

ACKNOWLEDGMENT

The authors would like to acknowledge the assistance of Adnan Basma in processing the data.

REFERENCES

1. Jordan Statistics Department. *1981 Statistical Yearbook*. Department of Statistics Press, Amman, Jordan, 1982.
2. J. Whitelegg. A Geography of Road Accidents. *Transactions of the Institute of British Geographers*, Vol. 12, 1987, pp. 161–176.
3. D. Appleyard. *Livable Streets*. University of California Press, Berkeley, 1981.
4. E. Backett and A. Johnslon. Social Patterns of Road Accidents

to Children: Some Characteristics of Vulnerable Families. *British Medical Journal*, Feb. 14, 1959, pp. 409–413.
5. A. Blackman. *The Role of City Planning and Child Pedestrian Safety*. Center for Planning and Development Research, University of California, Berkeley, 1966.
6. G. Bennet and J. Marland. *Road Accidents in Traditionally Designed Local Authority Estates*. Supplementary Report 394, Transport and Road Research Laboratory, Crowthorne, United Kingdom, 1978.
7. D. H. Crompton. Pedestrian Exposure to Risk in Housing Areas. In *Transportation Research Record 959*, TRB, National Research Council, Washington, D.C. 1984, pp. 25–35.
8. *Traffic Safety in Residential Areas*. Organization for Economic Cooperation and Development, Paris, France, 1979.
9. W. Hagan and S. Amamoo. Residential Street Management in South Australia. *ITE Journal*, Vol. 58, No. 3, March 1988, pp. 35–41.

Publication of this paper sponsored by Committee on Pedestrians.