

Pedestrians' Vulnerability Considering Parental Status, Age, Sex and Crash Severity

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ABSTRACT

This study attempts to test hypotheses related to child pedestrian casualties as per their parental living conditions as being together, separated, living without mothers or without fathers. These are analyzed according to the children age, sex and injury severity. The necessary data are taken from questionnaires administered by Directorate of Traffic in Bahrain. The questionnaires are filled out on scene by accident investigators for every pedestrian crash spread over a period of eight years. The actual traffic crash records were categorized according to the investigated characteristics considering their expected risk. The former frequencies were categorized according to the necessary investigated characteristics. Furthermore, they were compared to those expected as per their percentage presence in the society. The data were statistically analyzed using Chi-square tests to compare the actual crash frequencies to those expected in each subcategory. The findings revealed that children who are under 15 years of age and living with both parents are less exposed to traffic crashes compared to those living in families without mothers. Living with separated parents also leads to higher exposure to accidents. The effect of the latter on children exposure to crashes is even greater than living without fathers. While the absence of mothers from home increases the vulnerability of young male children who are under 15 years to traffic crashes, the absence of fathers increases the vulnerability of those who are between 16 to 20 years. Vulnerability of female children to crashes showed no significant differences for different living conditions. Many factors contribute in traffic crashes involving young pedestrians. The above findings assist the officials for better utilization of the resources in the field of traffic safety education, engineering solutions, roadway improvements and law enforcement.

Keywords: Children Pedestrians, Vulnerability, Crash Exposure Rate, Parental Status, Sex.

1. INTRODUCTION

Although the traffic accident rates in Bahrain are close to those in some of the developed countries (Figures 1 and 2), the pedestrians' accidents show alarming figures. Currently, the traffic crash fatalities in the country indicate 3.8 pedestrians' fatalities per 100,000 of

the population and 1.3 per 10,000 vehicles.

The accident exposure rate was a subject of interest to many researchers in different parts of the world (Roberts, 1993). Before suggesting any remedies, an analytical study was needed to investigate this phenomenon. The emphasis in this study will not be on the crash itself but the study will try to have a comprehensive view of the personal background of the victims among children involved in these crashes as per their family living conditions. It is generally believed that the background of

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the victims would provide strong clues to the variability in the risk exposure of different groups of pedestrians (Duckett, 1995) and (Roberts et al., 1994). For example, (Galloway and Patel, 1982) showed that the victims' background is related to their exposure to accidents. Fortaine and Gourlet (1997) proved that younger and older pedestrians were more exposed to risk than other age groups. In Saudi Arabia, which is a neighboring country, similar results were observed (Al-Ghamdi, 2002). Stevenson et al. (1992) arrived at a similar conclusion in Perth/Australia. Other researchers (Lalloo and Sheiham, 2003) did not quite have the same opinion even though they admitted that young and male victims were over-presented in the statistics.

Results from a study conducted by Al-Madani and Al-Janahi (2005) showed high risk exposure rates to traffic crashes by young and old, male and female pedestrians having low educational qualifications. Earlier studies showed an over-presentation of pre-school age pedestrians and those above 20 years of age in traffic casualties during the weekends when compared to working days (Al-Madani, 2006). No significant differences between weekend and weekdays were observed for young pedestrians who are between 5 and 10 years of age (Al-Madani, 2006).

2. OBJECTIVE AND HYPOTHESES

Pedestrian traffic casualties are to be analyzed using relevant risk exposure rates for different age groups, sex, and injury severity of pedestrians. The most vulnerable age groups of young pedestrians are also to be identified in terms of parental status of living with both parents (normal family condition), with separated parents, in a family without father or in a family without mother.

The hypotheses are set based on logical reasoning since literature on the topic is scarce.

1. It is hypothesized that children living with both parents at home are less exposed to traffic crashes as pedestrians than children living with separated parents, without fathers or without mothers. This is simply because they receive better attention from the physical presence of both parents.

2. Opposite to the above; children living with separated parents or living without either of them are vulnerable to pedestrian crashes. In other words, their percentage involvement in crashes is greater than their proportion in the society. The reasons are lack of adequate attention due to the loss of either parents or of being separated. Moreover, living in such an environment leads to serious psychological consequences as mental or mind distraction. The latter have negative effects on their involvement in traffic crashes.

3. METHODOLOGY

Considering absolute accident frequencies for any particular group of pedestrians might give false indications of their risk in being involved in traffic crashes. In order to present a more just vulnerability indicator to traffic crashes for any group of pedestrians, the number of crashes for any considered group should be compared to their proportion in their specified group; e.g. percentage in the pedestrians' society or in the population.

A number of studies, e.g. Lawson and Edwards (1991), considered the whole population of the place where the accidents occurred as the basis for the comparison between the observed number of accidents and that expected. This method assumes that the presence of any group of pedestrians' population is similar to its presence in the whole state population. This assumption might be valid for some sectors of the society but surely not for all of them as for elderly people. The more appropriate method would be to use the pedestrians' population for representation. However, such information is not available for all the required characteristics of the pedestrians. Therefore they are used wherever available.

Chi-square method was used to compare the observed accident frequencies for each category of pedestrians to the expected number of accidents according to their relevant proportion in the pedestrians' population, wherever available, or the country's population instead. The null hypothesis is that the expected injury accidents should match the actual ones. The alternative hypothesis is that the actual number and the expected number of

accidents differ significantly at a level of significance less than at 0.05. The residuals indicate the deviation between the expected and the observed values.

A new measure of deviation between the expected and the observed frequencies was developed in this study. This is called the weighted-residual. It shows the deviation between the residual and expected frequency expressed in percentage. This measure, in fact, gives a better indication of the deviation when compared to the absolute expected frequencies, since the deviations can be judged better in a percentage manner.

$$\text{Weighted residual} = (\text{Residual frequency} / \text{Expected frequency}) * 100$$

A positive weighted residual indicates over-presentation (vulnerability) of the tested group. In other words, the actual number of accidents is greater than the expected one. On the other hand, a negative weighted residual indicates otherwise, i.e. an under-presentation (safer).

4. DATA GATHERING

4.1. Description of the Data: The pedestrians' injury crashes considered in this study cover almost all the pedestrians' crashes which occurred during the period from 1995 to 2003, excluding 1999 and 2001. The necessary data are taken from questionnaires administered by the General Directorate of Traffic in Bahrain (1995). The questionnaires are filled out, along with the crash report, by the accident investigator at the scene. The valid data showed 3312 injury accidents during the covered period. These are categorized as follows: 100 fatalities, 943 serious injuries, 2010 slight injuries and 259 unclassified cases (Table 1). Some of the questionnaires were excluded due to lack of details, lack of information or wrong booking at the scene of the crash. These were excluded from the statistical tests for that particular missing character. Therefore, the total number of tested cases varies from one character to another. The actual number of crashes can be seen in Table (2).

Data related to the socio-demographic characteristics of the population were extracted from the official *Statistical Bulletin of Bahrain*. These are published by the Central Statistical Organization (2001).

4.2. The Questionnaires: The questionnaires included details regarding the pedestrian crash along with socio-demographical details of the victim. The details included, among others, the following: accident severity, personal and demographical details as nationality, age, sex type, educational background and living area; living conditions, as family size and father's number of wives; social background as social status and parent's educational background; day type as working day or holiday; ethnic details, day, date, time, location, roadway environment, and pre-accident environment.

5. RESULTS AND DISCUSSION

5.1 Parental Living Condition by Injury Severity

Pedestrians living with families without the physical presence of the mothers are highly vulnerable to traffic crashes of various severity injuries when compared to those living with conventional families in which both parents are really living with them in the same family (Table 3). As can be seen from Table (3), the percentage of weighted residuals shows a significant over-presentation of the pedestrians living in families without mothers when compared to the percentage of their presence in the society. Over-presentations of as high as 900% are observed in case of fatal and severe injury crashes and of as high as 275% in case of slight injury crashes. On the other hand, families without fathers showed higher pedestrian vulnerability to traffic crashes, but at a much lower scale than those living without mothers. Over-presentations of 34 and 28% were observed for severe and slight injury accidents, respectively. As a result, one may say that the presence of the mothers at home plays an important role in reducing the risk of their children being involved in traffic crashes as pedestrians, regardless of their age.

5.2 Parental Living Condition by Age of Young Pedestrian Casualties

Young pedestrians who are below 15 years of age and living with families without mothers are more vulnerable to traffic crashes than those living with both parents

together (Table 4). However, no significant difference was observed between the actual number of pedestrian casualties and that expected for children who are over 15 years of age for the different parental living conditions (Table 4). In fact, the observed number of young pedestrian crashes showed at least a 100% over-presentation when compared to their proportion of presence in the society. The effect of losing a mother, from a vulnerability point of view, is the highest in the age group of 10 to 15 years. Percentage of weighted residual to the expected number of crashes is as high as 614. It is quite important to mention that children, especially those in the age group of 10 to 15 years, who are living with families in which the parents are separated, are more vulnerable to accidents when compared to those living with families without fathers.

When pedestrian casualties are further subdivided into slight and severe injury crashes; the analysis revealed that children pedestrians of five years of age or less and those between 10 and 15 years of age who are living with families without their mothers are highly exposed to traffic crashes of both types of severities (Tables 5 and 6). Their involvement in crashes showed an over-presentation of both types of injuries compared to their presence in the society. The above result was still true for those between 10 and 15 years of age but for slight injury crashes only. No significant difference was observed for those above 15 years of age for severe injury crashes.

In summary, beside the psychological effect of young children living with families without the physical presence of the mothers at home, they are more exposed to traffic crashes than the children who are living with both parents together, without fathers, or even with separated parents.

5.3 Parental Living Condition Considering Age and Sex Type of Young Pedestrian Casualties

It is quite interesting to mention that no significant differences in the number of young pedestrian traffic crashes were observed between female children of different parental living conditions (Table 7). This was true for all the tested age groups of female children. In

other words, the influence of different living conditions, in terms of risk exposure to pedestrian traffic crashes, is minimal on female children in this part of the world. However, significant differences were observed for the male ones (Table 8). In fact, male pedestrians in the age groups 0 to 5, 5 to 10 and 10 to 15 years who are living with families without mothers are significantly more exposed to traffic crashes than those who are living with their parents when compared to their percentage of presence in the society. Young children between 15 and 20 years of age (Teenagers) who are living with separated parents or with families without fathers face higher risk of being involved in pedestrian crashes compared to those living with normal families, i.e. both parents together, or with families without mothers.

The above discussion clearly reveals the role of both parents' presence at home on reducing the male children involvement in pedestrian traffic crashes. While, the absence of mothers from home has a significant negative effect on the safety of young male pedestrians who are less than 15 years of age, the absence of fathers has a significant negative effect on the safety of those who are between 16 and 20 years of age.

It is quite strange to find out that the results also revealed that young male children who are under 15 years of age are safer, as pedestrians, than others when they are living with a family without father (Table 8). This can be seen from the negative percentage weighted residuals in Table (8). The possible explanation could be that the mothers may give more attention to their children when they are solely responsible for their children. However, those who are above 15 tend to revolt or do not obey the rules set by the mothers at home. On the other hand, female children are less affected, compared to male ones, by traffic crashes when they are living in families without fathers or mothers. This is because they are more at home than outside. Furthermore, when they are outside they are usually accompanied by an adult.

5. CONCLUSION

Children living with families of different parental status, as with both parents, with separated parents,

without mothers or without fathers, are exposed to traffic crashes as pedestrians at different explosive levels. The vulnerability of such children to traffic crashes varies from one type of living condition to another.

Children who are under 15 years of age and living with families without mothers are more exposed to traffic crashes, as pedestrians, than those living with both parents. This is true for severity crashes. However, this was not true for older children. The negative effect of losing mothers is found to be the highest on children who are between 10 and 15 years. Children living with families in which the parents are separated are more vulnerable to traffic crashes than those living with

families without fathers.

The findings clearly revealed the important role played by the presence of both parents at home in reducing their male children's involvement in pedestrian traffic crashes. Furthermore, while the absence of mothers from home plays a significant negative effect on the safety of young male pedestrians who are below 15 years, the absence of fathers plays a significant negative effect on the safety of children who are between 16 and 20 years. Female children pedestrians living with both parents, with separated ones, without fathers or without mothers are all equally affected by traffic crashes.

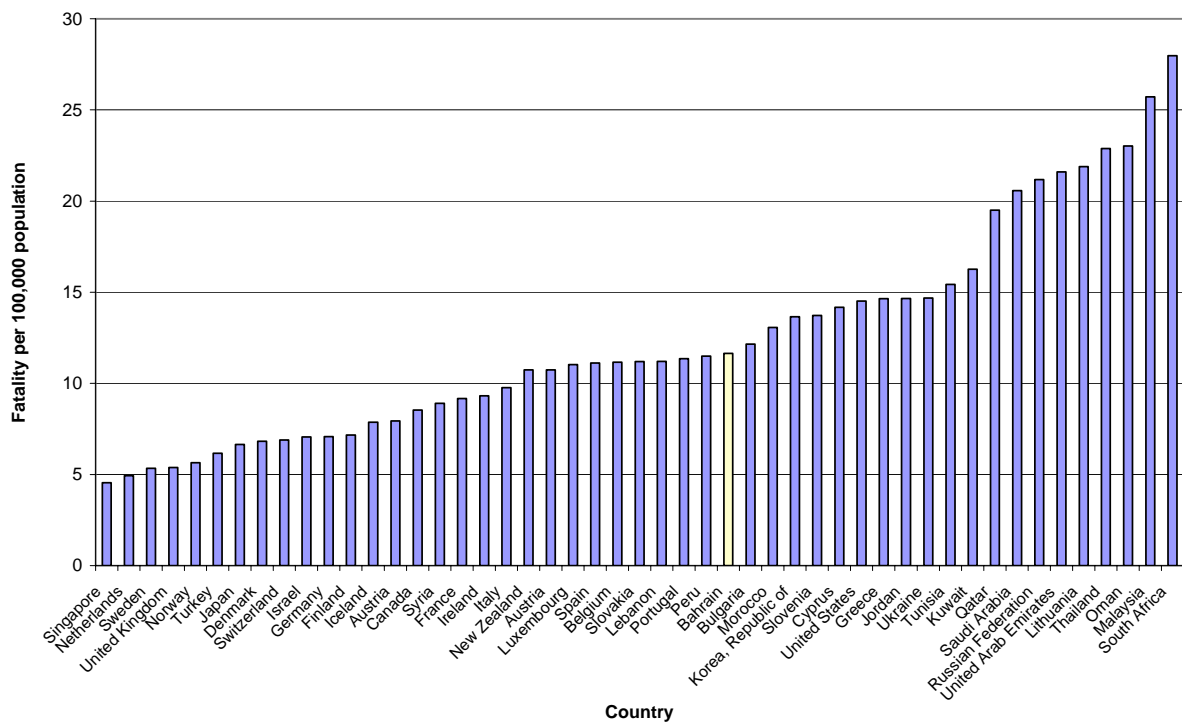


Fig. (1): Traffic crash fatalities per 100,000 of the population for selected countries (2004-2006).

Fig. (2): Traffic fatalities per 10,000 vehicles for selected countries (2004-2006).

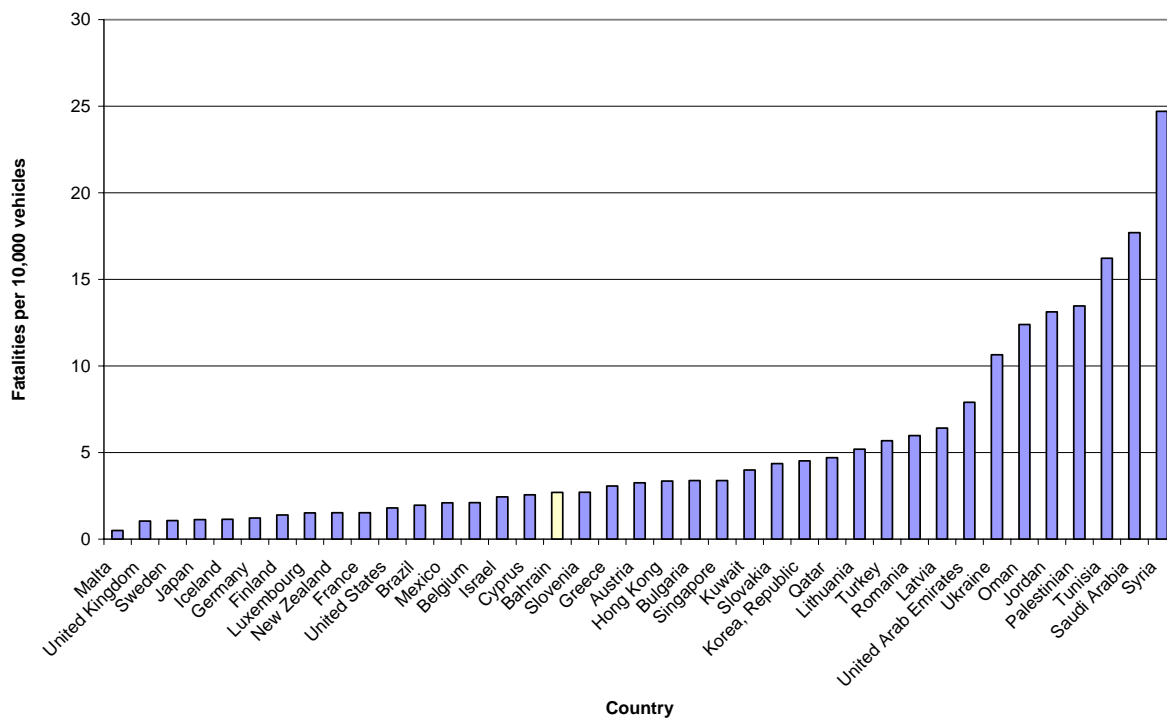


Table (1): Surveyed number of pedestrians' casualties.

Year		1995	1996	1997	1998	2000	2002	2003	Total
Number of injuries	Fatal	16	13	12	23	10	15	11	100
	Severe	141	151	116	168	123	128	116	943
	Slight	291	331	285	305	280	270	248	2010
	Unclassified	37	23	29	67	29	34	40	259
	Total	485	518	442	563	442	447	415	3312

Table (2): Actual number of pedestrians' casualties.

Year		1995	1996	1997	1998	2000	2002	2003	Total
Number of injuries	Fatal	22	23	24	27	17	28	25	166
	Severe	153	169	155	175	138	154	153	1097
	Slight	349	362	368	367	346	354	351	2497
	Total	524	554	547	569	501	536	529	3760

Table (3): Pedestrians' vulnerability results for various severity levels and parental living conditions (all ages).

Injury Severity	Parental living status	Expected percentage	Observed accidents	Expected accident	Residual	Weighted residual %	X ² (Significance level)
Fatal	Parent together	94.13	37	37.7	-0.7	-2	7.1 (0.068)
	Parent separated	2.31	1	0.9	0.1	11	
	Without father	3.28	1	1.3	-0.3	-23	
	Without mother	0.28	1	0.1	0.9	900	
Severe	Parent together	94.13	433	449.0	16.0	-4	104.4 (0.000)
	Parent separated	2.31	10	11.0	-1.0	-9	
	Without father	3.28	21	15.7	5.3	34	
	Without mother	0.28	13	1.3	11.7	900	
Slight	Parent together	94.13	1058	1076.8	-18.8	-2	27.4 (0.000)
	Parent separated	2.31	26	26.4	-0.4	-2	
	Without father	3.28	48	37.6	10.4	28	
	Without mother	0.28	12	3.2	8.8	275	

Table (4): Vulnerability measures for different parental living conditions by age considering young pedestrians' casualties.

Age	Parental living status	Expected percentage	Observed accidents	Expected accident	Residual	Weighted residual %	X ² (Significance Level)
0-5	Parent together	94.13	380	379.3	-0.7	-0.2	34.589 (0.000)
	Parent separated	2.31	9	9.3	0.3	3.2	
	Without father	3.28	7	13.2	-6.2	-47.0	
	Without mother	0.28	7	1.1	5.9	533.8	
5-10	Parent together	94.13	618	620.3	-2.3	-0.4	5.49 (0.139)
	Parent separated	2.31	20	15.2	4.8	31.4	
	Without father	3.28	17	21.6	-4.6	-21.4	
	Without mother	0.28	4	1.9	2.1	113.4	
10-15	Parent together	94.13	255	251.3	3.7	1.5	29.440 (0.000)
	Parent separated	2.31	1	6.2	-5.2	-83.9	
	Without father	3.28	6	8.8	-2.8	-31.2	
	Without mother	0.28	5	0.7	4.3	614.3	
15-20	Parent together	94.13	170	174.1	-4.1	-2.4	2.205 (0.332)
	Parent separated	2.31	6	4.3	1.7	39.5	
	Without father	3.28	9	6.1	2.9	48.1	
	Without mother	0.28	0	0.5	-0.5	-100	

Table (5): Vulnerability measures for children pedestrians involved in slight injury crashes considering different parental status.

Age	Parental status	Expected percentage	Observed accidents	Expected accident	Residual	Weighted residual %	X ² (Significance level)
0-5	Parent together	94.13	241	241.9	-0.9	-0.4	18.002 (0.000)
	Parent separated	2.31	8	5.9	2.1	35.6	
	Without father	3.28	4	8.4	-4.4	-52.4	
	Without mother	0.28	4	0.7	3.3	471.4	
5-10	Parent together	94.13	390	386.9	3.1	0.8	2.95 (0.399)
	Parent separated	2.31	12	9.5	2.5	26.3	
	Without father	3.28	8	13.5	-5.5	-40.7	
	Without mother	0.28	1	1.2	-0.2	-16.7	
10-15	Parent together	94.13	165	163.8	1.2	0.7	28.1 (0.000)
	Parent separated	2.31	1	4.0	-3.0	-75.0	
	Without father	3.28	4	5.7	-1.7	-29.8	
	Without mother	0.28	4	0.5	3.5	700	
15-20	Parent together	94.13	118	121.4	-3.4	-2.8	3.443 (0.179)
	Parent separated	2.31	3	2.98	0.02	0.7	
	Without father	3.28	8	4.2	3.8	91.3	
	Without mother	0.28	0	0.36	-0.36	-100	

Table (6): Pedestrians' vulnerability measures considering severely injured children considering different parental status.

Age	Parental status	Expected percentage	Observed accidents	Expected accident	Residual	Weighted residual %	X ² (Significance level)
0-5	Parent together	94.13	105	103.5	1.5	1.4	24.964 (0.000)
	Parent separated	2.31	1	2.5	-1.5	-60.0	
	Without father	3.28	3	3.6	-0.6	-16.7	
	Without mother	0.28	3	0.3	2.7	900.0	
5-10	Parent together	94.13	167	168.5	-1.5	-0.9	7.9 (0.048)
	Parent separated	2.31	7	4.1	2.9	70.7	
	Without father	3.28	3	5.9	-2.9	-49.2	
	Without mother	0.28	2	0.5	1.5	300.0	
10-15	Parent together	94.13	63	62.1	0.9	1.4	3.502 (0.174)
	Parent separated	2.31	0	1.5	-1.5	-100.0	
	Without father	3.28	2	2.2	-0.2	9.1	
	Without mother	0.28	1	0.2	+0.8	400	
15-20	Parent together	94.13	36	33.9	2.1	6.2	No test performed due to empty cells.
	Parent separated	2.31	0	0.8	-0.8	-100	
	Without father	3.28	0	1.2	-1.2	-100	
	Without mother	0.28	0	0.1	-0.1	-100	

Table (7): Vulnerability measures for female pedestrians' considering different ages and parental living conditions.

Age	Parental status	Expected percentage	Observed accidents	Expected accident	Residual	Weighted residual %	X ² (Significance level)
0-5	Parent together	94.13	118	114.8	3.2	2.8	1.192 (0.551)
	Parent separated	2.31	3	2.8	0.2	7.1	
	Without father	3.28	0	4.0	-4.0	-100	
	Without mother	0.28	1	0.34	0.66	1.94	
5-10	Parent together	94.13	190	189.2	0.8	0.4	3.497 (0.321)
	Parent separated	2.31	7	4.6	2.4	52.2	
	Without father	3.28	3	6.6	-3.6	-54.5	
	Without mother	0.28	1	0.6	0.4	66.7	
10-15	Parent together	94.13	61	63.1	-2.1	-3.3	5.258 (0.154)
	Parent separated	2.31	1	1.5	-0.5	-33.3	
	Without father	3.28	4	2.2	1.8	81.8	
	Without mother	0.28	1	0.2	0.8	400.0	
15-20	Parent together	94.13	54	52.7	1.3	2.5	0.331 (0.565)
	Parent separated	2.31	2	1.3	0.7	53.8	
	Without father	3.28	0	1.8	-1.8	-100	
	Without mother	0.28	0	0.2	-0.2	-100	
+20	Parent together	94.13	47	77.2	-30.2	-39.1	1443.5 (0.000)
	Parent separated	2.31	2	1.9	0.1	5.3	
	Without father	3.28	26	2.7	12.3	455.6	
	Without mother	0.28	18	0.2	17.8	8900.0	

Table (8): Vulnerability measures for male pedestrians considering different ages and parental living conditions.

Age	Parental status	Expected percentage	Observed accidents	Expected accident	Residual	Weighted residual %	X ² (Significance level)
0-5	Parent together	94.13	246	246.8	0.2	0.08	26.165 (0.000)
	Parent separated	2.31	4	6.1	-2.1	-34.4	
	Without father	3.28	6	8.4	-2.4	-28.6	
	Without mother	0.28	5	0.7	4.3	28.6	
5-10	Parent together	94.13	398	401.3	-3.3	-0.8	3.967 (0.265)
	Parent separated	2.31	13	9.8	3.2	32.6	
	Without father	3.28	13	13.6	-1.6	-11.8	
	Without mother	0.28	3	1.2	1.8	150.0	
10-15	Parent together	94.13	180	174.1	5.9	+3.4	14.229 (0.001)
	Parent separated	2.31	0	4.3	-4.3	-100	
	Without father	3.28	2	6.1	-4.1	-67.2	
	Without mother	0.28	3	0.5	2.5	+500	
15-20	Parent together	94.13	102	108.3	-6.3	-5.8	8.262 (0.016)
	Parent separated	2.31	4	2.7	1.3	48.1	
	Without father	3.28	9	3.8	5.2	136.8	
	Without mother	0.28	0	0.3	-0.3	-100	
+20	Parent together	94.13	143	210.9	-67.9	-32.2	3664.0 (0.000)
	Parent separated	2.31	4	5.2	-1.2	-23.1	
	Without father	3.28	29	7.3	21.7	297.3	
	Without mother	0.28	48	0.6	47.4	7900	

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