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Effect of Pedestrian Characteristics on Choosing Their Crossing Techniques: Case Study on Tabuk City / Saudi Arabia

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ABSTRACT

Traffic research studies usually focus on vehicle traffic analysis. Few studies discussed pedestrian safety. On congested roads, pedestrians become under tension to pass the road safely. The aim of this paper is to identify the public knowledge of pedestrian crossing tools in Tabuk city, Saudi Arabia and to analyze the effect of some pedestrian personal characteristics on their acceptance to use crosswalks or footbridges. The present study proves statistically that illiterate pedestrians are usually not willing to use crosswalks or footbridges in their crossing. Further, females are more likely to use crossing facilities than males. The statistical tests show that pedestrian age and driving experience are not significant characteristics affecting the pedestrian crossing technique. The study recommends to strengthen pedestrian knowledge and awareness of obeying the rules and to launch intensive programs of awareness of traffic regulations.

KEYWORDS: Pedestrian characteristics, Crossing tools, Crosswalks, Footbridges, Statistical tests.

INTRODUCTION

Transportation is known as the movement of people from one location to another. Land, air and water are the main transport modes. In Saudi Arabia, a lot of pedestrian accidents have been recorded in the past several years. An interaction between pedestrians and vehicles usually occurs due to pedestrian illegal crossing. In Tabuk city, many pedestrians cross the roadway randomly, thus increasing the possibility of accident occurrence. There are several tools that pedestrians can use to cross the road safely. These tools could be at grade with roads such as crosswalks or grade-separated like footbridges. The study of Issa (2016) concluded that the main reason of traffic accidents in Saudi Arabia was related to inadequacies of supervision by the law enforcement agents. Another local study found that 76% of the total accidents were related to human errors (Ratrout and Issa, 2015).

This study aims to describe conditions of pedestrians in Tabuk city through identifying public knowledge and acceptance to pedestrian crossing tools. Pedestrian crossing tools include: footbridges, pedestrian crossing countdown signals and pedestrian crossing signals at intersections. The study also aims to evaluate statistically the effect of certain pedestrian personal characteristics on crossing technique choice based on a questionnaire distributed to a sample of pedestrians.

LITERATURE REVIEW

Historically, several pedestrian studies were conducted globally and each study was different from the others according to several factors. These factors include (but are not limited to): crossing volume,

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behavior of pedestrians and vehicle volume. Marisa and Vedagiri (2014) analyzed statistically factors affecting pedestrian crossing behavior under mixed traffic conditions. The study estimated the crossing speed for old and adult pedestrians at 0.95 m/s and 1.12 m/s, respectively. Xin (2013) studied pedestrian walking speed at signalized crosswalks. He found that pedestrian green time, crosswalk length and pedestrian crossing direction affect the speed value.

Guo (2011) investigated the relationship between pedestrian waiting time and pedestrian crossing violation. Results indicated that about 10% of pedestrians were at high risk of violation to cross the street. About 50% of pedestrians would still obey the crossing rules even after waiting for 50 seconds. According to the European code, crosswalks shall be solid white, from 0.15 m to 0.6 m in width and from 1.8 m to 3.0 m in length (MUTCD, 2002). TABC (2009) indicated that more than 50% of pedestrian crashes occurred at signalized intersections in China, with 24.62% of all traffic fatalities occurring to pedestrians. In the U.S.A., percentage of pedestrian fatalities was found to be 12.1% (National Highway Traffic Safety Administration, 2009).

Regarding pedestrian personal characteristics, several studies have examined the differences in pedestrian behaviors based on their gender, age, marital status, education and income. Generally, it was found that male and young pedestrians were more likely to commit violations (Bernhoft and Carstensen, 2008; Holland and Hill, 2007). A field study explored different pedestrian behaviors at signalized intersections in China manually. Results showed that gender, age, arrival time, traffic volume and crosswalk length were the most important factors affecting violation (Zhu-Ping, 2013). In Malaysia, a study analyzed pedestrian walking speed at unsignalized and signalized intersections. They found that age and gender were significant factors influencing pedestrian crossing speed (Goh et al., 2012).

Another study discussed the effects of seasonality, age and gender of pedestrians at sidewalks and signalized crosswalks. It concluded that walking speeds at sidewalks were significantly different from those on crosswalks (Montufar et al., 2007). Srinivas (1994) conducted on-site surveys to obtain information on pedestrian crossing behavior at signalized intersections using a video recording technique.

TYPES OF PEDESTRIAN CROSSING TOOLS

Several tools are used to protect pedestrians and to help them cross roads safely and comfortably. There are many pedestrian tools, but this research concentrates on the most three necessary tools, which are:

1- Footbridges.
2- Pedestrian crossing countdown signals.
3- Pedestrian crossing signals at intersections.

Footbridges

A footbridge is a bridge designed for pedestrian crossing, especially at roads having two or more lanes per direction with high traffic volume and high speed. It is made of steel, wood or reinforced concrete. There are five common types of footbridge: beam, girder, covered, rigid frame and truss bridges. Truss bridge is the most common type used in Saudi Arabia. It has high strength and low weight ratio compared to other types. It is simple to install or uninstall.

Pedestrian Crossing Countdown Signals

A countdown is a sequence of backward counting to indicate the time remaining before pedestrians can cross the road. Pedestrian signals help pedestrians cross the road with traffic lights. A pedestrian facing a walk signal may cross the road in the direction of the signal. While crossing, pedestrians have the right-of-way over all vehicles. There are two common countdown signals: timer signal and call button signal, as shown in Figure 2.

Pedestrian Crossing Signals at Intersections

Such signals provide safe crossing for pedestrians at intersections, by counting pedestrian frequency and calculating the necessary timing (Figure 3).

Figure (1): Truss footbridges

(a) Timer signal (b) Call button signal

Figure (2): Pedestrian crossing countdown signals

Figure (3): Pedestrian crossing signals at intersections

STUDY ANALYSIS

This study aims to describe conditions of pedestrians in Tabuk city and to identify public acceptance to pedestrian crossing tools based on a questionnaire distributed to a sample of pedestrians. The questionnaire was divided into three parts. The first part is related to certain pedestrian personal demographics (such as: age, gender, educational level and driving experience). The second part introduces certain questions to identify pedestrian knowledge and recognition of road signs. The third part examines public acceptance of using crossing tools. The questionnaire forms were distributed at several intersections in the city.

The following equation was used to estimate the number of interviewed pedestrians (since standard deviation is not known):

$$N = p.q.(\frac{Z\frac{\alpha}{2}}{d})^2$$

where:

p: the proportion of interviewed pedestrians who accepted to use crossing tools.

q: the proportion of interviewed pedestrians who did not accept to use crossing tools.

To have the largest sample size, p is considered to be 0.5. Confidence level is considered to be 90%; so, $Z_{\alpha/2}$ equals 1.645 and permitted error (d) is ±0.1, while the sample size is 68. To avoid any missing data and to be more conservative, this number is increased to about 100 pedestrians.

Table 1 shows the various variables used in the survey along with their respective definitions and parameters.

Table 1. List of variables and their definitions

Variable	Parameter
Gender	0 for males and 1 for females
Age	0 for children, 1 for adults and 2 for old pedestrians
Driving experience	0 for no experience, 1 for up to 5 years experience and 2 for more than 5 years experience
Educational level	0 for illiterate, 1 for low educated and 2 for high educated pedestrians
Using crosswalks	0 for pedestrians using marked crosswalks 1 for those crossing at unmarked crosswalks
Using footbridges	0 for pedestrian using footbridges to cross 1 for those not using footbridges in crossing

OBSERVATIONS

The statistics from the observed data show that the proportion of male pedestrians is higher than that of female pedestrians. Further, the proportions of adult, highly educated and high-driving experience pedestrians are the largest compared to other groups. The study statistics and observations are shown in Table 2.

Table 2. Study observations

Variable	Characteristic	Percentage
Gender	Male	87
	Female	13
Age	Children	18
	Adults	49
	Old people	33
Driving experience	Without	23
	5 years or less	18
	More than 5 years	59
Educational level	Illiterate	5
	Low education	19
	High education	76
Using crosswalks	Using marked crosswalks	66
	Not using marked crosswalks	34
Using footbridges	Using footbridges	80
	Not using footbridges	20

Pedestrians were asked about their involvement in traffic accidents. About 51% indicated that they were exposed to an accident and 55% of them were exposed to an accident *via* feet. In general, 60% of the interviewed pedestrians answered correctly some traffic sign inductions.

STATISTICAL ANALYSIS

Contingency tables and Chi-square (χ^2) statistical test are generally adopted to display relations between parameters. They were used to analyze the effect of the four personal characteristics of pedestrians (gender, age, driving experience and educational level) on using crosswalks or footbridges in crossing. A confidence level of 90% is adopted (α=0.1). The difference clearly appears in the two personal characteristics: gender and educational level. Age and driving experience do not represent significant statistical differences. Samples are shown in the following tables and figures.

Table 3. Relation between age of pedestrians and their willing to use crosswalks

Age	χ^2 test	Pedestrians using crosswalks	Pedestrians not using crosswalks
Children	Observed value	10	8
	Expected value	11.88	6.12
	Contribution to χ^2	0.29	0.58
Adults	Observed value	33	16
	Expected value	32.34	16.66
	Contribution to χ^2	0.013	0.026
Old people	Observed value	23	10
	Expected value	21.78	11.22
	Contribution to χ^2	0.068	0.133

χ^2 = 1.11, Degree of freedom (DF) = 2, P-value >0.1.

Table 3 shows that there is no difference between age of pedestrians and their willing to use crosswalks in their crossing, since the P-value is more than 0.1. Even though there is some difference that appeared in children among the interviewed pedestrians, where the observed value of those not using crosswalks is higher than expected. Figure 4 displays the relation between age of pedestrians and their willing to use crosswalks.

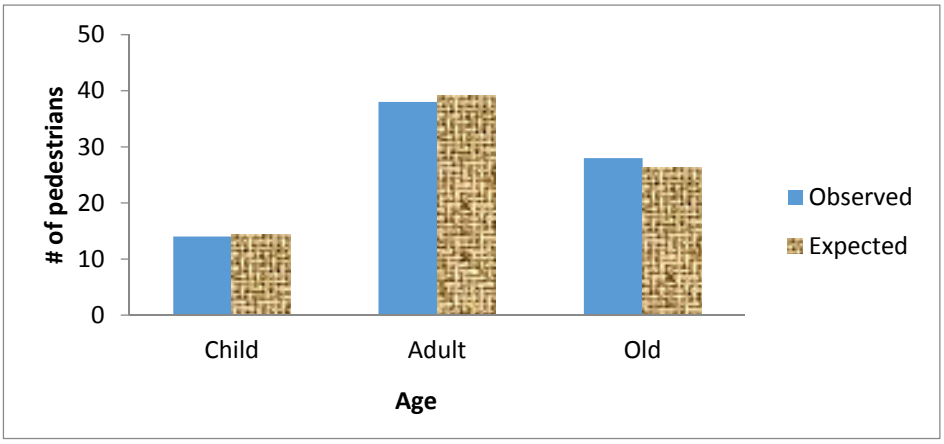

Figure (4): Relation between age of pedestrians and their willing to use crosswalks

The results illustrated in Fig. 4 indicate that young pedestrians are usually not willing to use crosswalks in their crossing. This appeared in the observed value (10) which is lower than the expected value (around 12).

Table 4. Relation between educational level of pedestrians and their willing to use crosswalks

Educational level	χ^2 test	Pedestrians using crosswalks	Pedestrians not using crosswalks
Illiterate	Observed value	0	5
	Expected value	3.4	1.6
	Contribution to χ^2	3.40	7.22
Low education	Observed value	11	8
	Expected value	12.7	6.3
	Contribution to χ^2	0.23	0.46
High education	Observed value	56	20
	Expected value	50.9	25.1
	Contribution to χ^2	0.51	1.04

$\chi^2 = 12.86$, DF=2, P-value <0.01.

The P-value in Table 4 is less than 0.1. This indicates that there is a statistical difference between pedestrian educational level and their willing to use crosswalks. The values in Table 4 are displayed in Figure 5.

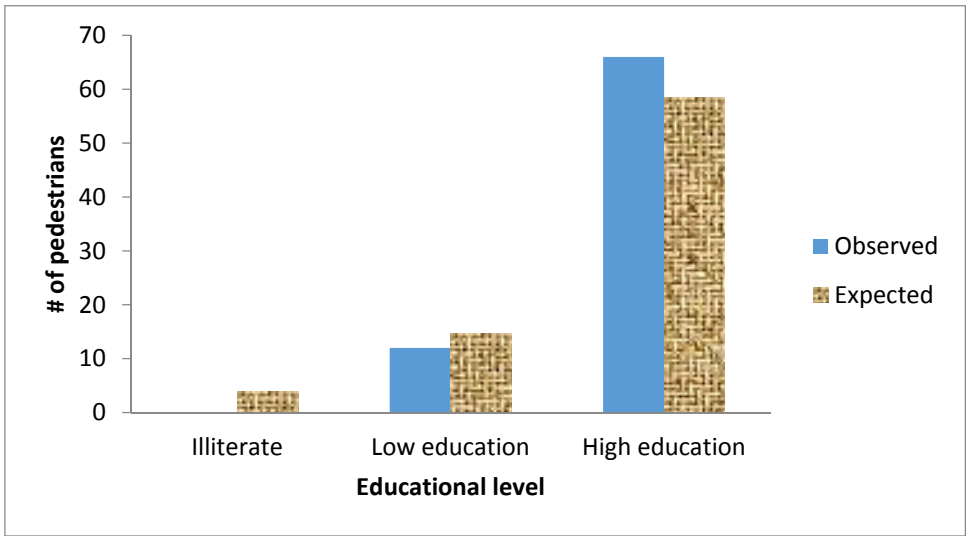

Figure (5): Relation between educational level of pedestrians and their willing to use crosswalks

The difference clearly appears in illiterate pedestrians, where the crossing expected value (3.4) is higher than what is observed (0). On the other hand, the observed value of highly educated pedestrians using crosswalks (56) is higher than the expected value (51). This indicates that as educational level goes higher, the pedestrian use of crosswalks increases.

Table 5. Relation between age of pedestrians and their willing to use footbridges

Age	χ^2 test	Pedestrians using footbridges	Pedestrians not using footbridges
Children	Observed value	14	4
	Expected value	14.4	3.6
	Contribution to χ^2	0.011	0.044
Adults	Observed value	38	11
	Expected value	39.2	9.8
	Contribution to χ^2	0.037	0.147
Old people	Observed value	28	5
	Expected value	26.4	6.6
	Contribution to χ^2	0.097	0.388

χ^2=0.724, DF=2, P-value >0.1.

Results depicted in Table 5 on footbridge crossing support those of Table 3 for crosswalks. The P-value is more than 0.1. Again, the difference appeared in old pedestrians, where the observed value of those not using footbridges is lower than what is expected. Figure 6 below displays the relation between age of pedestrians and their willing to use footbridges in crossing.

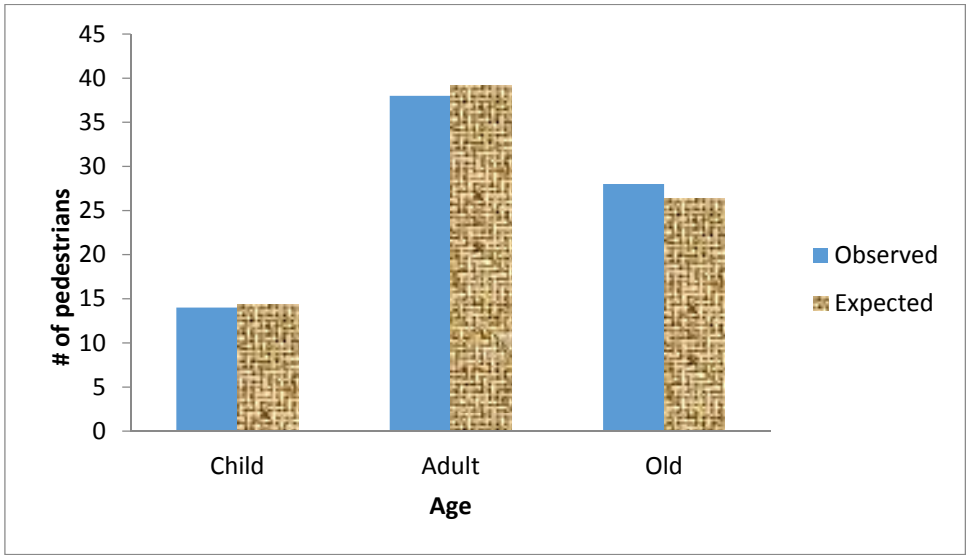

Figure (6): Relation between age of pedestrians and their willing to use footbridges

The results from Figure 6 indicate that old pedestrians are usually willing to use footbridges in their crossing. This appears in the observed value (28) which is higher than the expected value (around 26).

Table 6. Relation between educational level of pedestrians and their willing to use footbridges

Educational level	χ^2 test	Pedestrians using footbridges	Pedestrians not using footbridges
Illiterate	Observed value	0	5
	Expected value	3.85	1.15
	Contribution to χ^2	3.85	12.89
Low education	Observed value	12	7
	Expected value	14.63	4.37
	Contribution to χ^2	0.47	1.58
High education	Observed value	66	10
	Expected value	58.52	17.48
	Contribution to χ^2	0.72	2.40

χ^2=21.91, DF= 2, P-value <0.01.

A statistical difference appeared clearly between the educational level of pedestrians and their willing to use footbridges (P-value less than 0.1). Figure 7 displays the relation between the educational level of pedestrians and their willing to use footbridges.

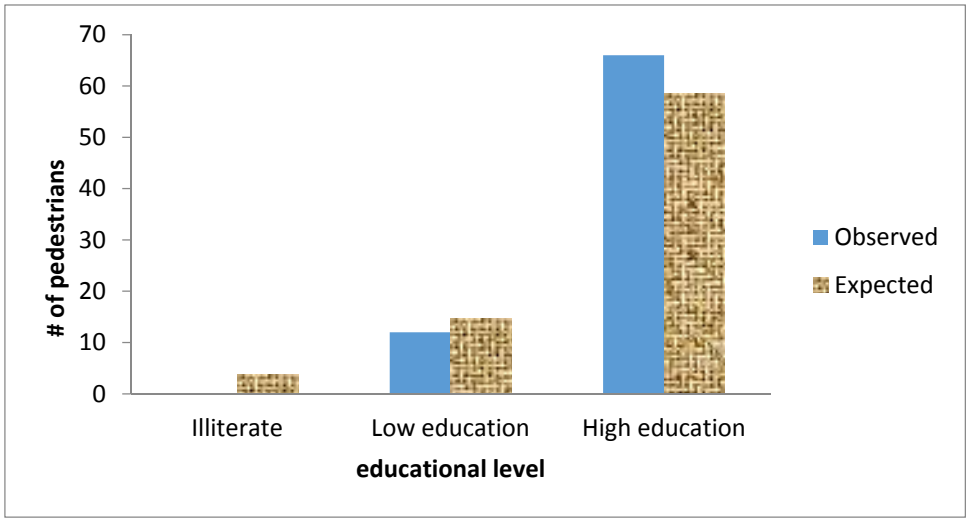

Figure (7): Relation between educational level of pedestrians and their willing to use footbridges

The difference clearly appears in illiterate pedestrians, where the observed value of those not willing to use footbridges (5) is higher than what is expected (around 1). On the contrary, the observed value of highly educated pedestrians using footbridges (66) is higher than the expected value (around 58). Again, this indicates that as educational level goes higher, the use of footbridges by pedestrians increases.

CONCLUSIONS AND RECOMMENDATIONS

In this paper, crossing behavior of a sample of pedestrians was analyzed at signalized intersections in Tabuk. Based on the analysis utilized in the study, the following conclusions were reached.

- The statistical tests conducted showed the significance of some pedestrian personal

characteristics (namely, gender and educational level) that affect the pedestrian crossing.

- On the other hand, these tests depicted that pedestrian age and driving experience are not significant characteristics in terms of affecting the pedestrian crossing.
- The analysis indicated that as pedestrian educational level goes higher, their use of crosswalks increases.
- It appeared that illiterate pedestrians are usually not willing to use footbridges in their road crossing.
- The tests indicated that females are more likely to use crossing facilities than males.
- Analysis of pedestrian age showed that young pedestrians are usually not willing to use crosswalks or footbridges in their crossing.

The following recommendations can be suggested.

- It is recommended to strengthen pedestrians' knowledge and awareness of obeying the rules.
- Significant variables are those to which pedestrians, school teachers, police and legislators need to pay particular attention.
- It is also recommended to launch intensive programs of awareness of traffic regulations.

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