EVALUATION OF PEDESTRIAN INFRASTRUCTURE AND PEDESTRIAN BEHAVIOUR IN JORDAN

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INTRODUCTION

Pedestrians in Jordan are exposed to high risk in traffic. The fatality rate is 63 pedestrians per million inhabitants. This fatality rate is high when compared to international statistics. The rate in Europe is 14 pedestrians per million inhabitants, it is the lowest in the world (Berg, 2002). In 2004, a total of 70,266 crashes were reported by police, there were 818 deaths and 16,727 injuries. Pedestrian accidents that compose only 7% of all accidents lead to 40% of all fatalities in Traffic. Forty per cent of all traffic fatalities in Jordan are pedestrians and half of it is among children under the age of 15 years.

Pedestrians, children in particular, accidents and behaviour have been investigated to some extent in Jordan (Shbeeb, 2002). The study indicated that pedestrian facilities are lacking. These crossings are a few in numbers and if they are provided, pedestrians are rarely given priority. Traffic safety awareness may be a contributing factor influencing both pedestrians and driver behaviour and consequently road accident numbers.

Road Traffic accidents in Amman Province in 2004 shows that 28% of all fatalities in traffic are reported in Amman and 28% of all sever injuries are also reported in Amman. The proportion is higher for slight injuries, which reaches 39%. Amman has developed rapidly over the last 60 years in term of area and population. Whilst its area did not exceed (**3Km^2**) and the population (**3,000)** inhabitants in the beginning of the last century, it became approximately (**688 Km^2**) in the year **2005** and two- millions of population. The significant tangible developments require developing and implementing plans and projects that aim at providing services in all disciplines and ensure having a safe and secure society in the city. The municipality is currently working in a plan that addresses pedestrian needs and integrate their movements within its transportation projects (Build pedestrian foot bridges, tunnels and walkways all over the kingdom, marking pedestrian crossways in the streets, establishing special points for the stop of public transportation means that serves the majority of population and considering traffic calming when necessary).

Greater Amman municipality prepared a 5-year plan (**2005-2009**) did not address the spatial distribution of these activities. It is hoped that the eastern part of the city, which represents the low income area and have a low ownership level and walking is a main mode of transport, will receive equal attention as the Western part, which is the home of high income groups in the city. All road user types' needs should be considered on equal basis regardless of their area of residence or work. Pedestrian needs should be taken into consideration when planning and constructing road. Exactly in the same way the driver needs are considered or maybe more. Until now, pedestrians were not received the attention that they should have.

This paper aims at investigating pedestrian safety conditions across Amman city. Two neighborhoods in two different regions in the city were selected. Um-Uthina Al-Hay Al-Sharqi area as a sample of the western side of Amman –High income area and Al-Hashimi Al-Shamali as an example for the eastern areas- Low income area. The differences and similarities in infra structure level and traffic safety in both areas are thoroughly examined together with road user behaviour and attitude.

STUDY AREA

Al-Hashimi Al-Shamali: Low Income Area

It is an area is located within Basman region, and it is one of the seven areas that is formed the old Capital Amman. It has a high population density with (**76,375**) inhabitants resides on an area of (**3**) Km^2. The common style of living is the public folk style as seen through the architecture as the majority of housing are of the category (C and D class of buildings in the city). The housing class, is defined by lots area, building setback. Class C and D are categorised with small lot area and narrow setback. No industrial activity can be seen in the area, and this is due to planning and regulating constraints. Commercial activities in the area limited to small businesses, such as small commercial shops that employ few personnel. The area is served with public transport (busses, service cabs (mostly available), and taxes). Due to the fact that the area is very close to Amman down town, there is a high demand on housing projects in form apartments. There are a number of commercial streets and some commercial banks in the area. The area is a base for a number of mosques, three public parks, cultural and gym centres, and recently a new hospital that is opened to the public.

There are 133 streets in the area that could be characterized as narrow streets. The road conditions have been deteriorated as potholes and patches, on most streets are observed. The streets, in general, are not well lit, poorly furnished as signing and marking are lacking. Sidewalk, although some of them are wide, are in poor conditions. The same applies pedestrian crossways. There is not enough parking stalls, particularly in commercial streets. In total, 971 crashes have been recorded in 2004 that ended up with 12 fatalities and 101 injuries. These accidents involve 71 pedestrian accidents (7% of all reported accidents). Pedestrian accidents account for 44.7% of all fatality, 21.5% of all slight injuries and 33.3% all sever injury.

Um-Uthaina: High Income Area

Um-Uthaina (Al-Hay Al-Sharki) within is located with Zahran Area. Um-Uthaina does not have high population density as its inhabitants do not exceed (**16,440**) reside on an area of (**1,156**) **km^2**. High standards living are prevailing in this area. This is can be seen from the architectural style of the buildings, as most of the houses are of the category (A and B, 1^{st} and 2^{nd} class of buildings in the city, which is defined by large lots area, wider building setback). There are some commercial activities along Shatt al Arab, a number of companies and Trade Houses, in addition to a 5 star Hotel (The Four Seasons) which is considered as an added value to the area. More and above, there is a number of small hotels, and motels. There are also a number of governmental buildings (ministries and schools), bank branches, mosques, restaurants, public parks and some medical clinics.

The 51 streets in the area are wide with wide side walks and some assigned pedestrian's crossways. It is equipped with good lighting system. The streets are furnished with traffic signs, but they are not well maintained. A few humps are installed. There are many intersections, which creates safety problem. Some streets need road maintenance, and lighting system maintenance. Car parking stall are inadequate, particularly in the commercial streets like Shat Al-Arab and Al-Basra Street. The area is not served with public transportation system as the vehicle ownership level is high. In total, 301crashes have been recorded in 2004 that ended up with 14 injuries and fatalities. These accidents involve 5 pedestrian accidents (2% of all reported accidents). Around 25% of all sever injuries reported in the area involved pedestrian accidents.

In Summary, the two selected urban areas have the characteristics that can be summarized in Table 1

Table 1 Study Areas Main Characteristics

Characteristic	Al-Hashimi Al-Shamali: Low Income Area	Um Uthaina Al-Sharqy High Income Area
Population (2003 census)	76375	16440
Land uses	residential, commercial & some gardens	Residential, offices & some commercial areas
Main transportation modes	Walking & public transport	Own cars
No. of streets	133	52
Street Standards	Low	Moderate to high
Pedestrian Facility	Poor	Fair
Major land marks	Prince Hamza Hospital, Al Hashimi Sports Club	Four Season Hotel, Ministry of Environment and Transport
All Crashes	1051	306
Collision	971	301
Pedestrians	71	5
Turnover	9	
Injuries	181	14
Fatalities	12	
No. of schools	11	2
No. of Mosques	5	3
No. of churches	2	0
No. of Gardens	5	1

All streets were evaluated with respect of how attractive they are for pedestrians. A checklist was developed and used for the inspection. Moreover, 10 streets were selected and a thorough detailed study was completed for each street (Table 2).

Table 2: Characteristics of the Selected Streets that were thoroughly Evaluated.

Area	Street Name	Length (m)	Width (m)	Classification	No. of Section	Land use
Low Income Area	**Jaaber Bin Mabthool**	700	10	Collector	8	Residential & Commercial
	Sulayman Al-Halabi	8090	12	Arterial	11	Residential & Commercial
	Al-Ameer Rashid Al-Hassan	2000	20	Arterial	12	Residential & Commercial
	Sa'd Bin Rabee	460	10	Collector	6	Residential
	Sahl Bin Adiy	200	10	Collector	3	Residential
	Al-Hammamat	390	10	Local	3	Residential
	Lubabah Bint Al-Hareth	200	10	Collector	3	Residential
High Income Area	**Sa'd Bin Abi Waqqas**	9320	20	Arterial	8	Offices & commercial
	Shat Al-Arab	604	20,40[1]	Collector	3	Residential & Commercial
	Balqees	565	12	Local	5	Residential

METHODOLOGY

Each street was divided into a number of sections; the section is defined as the link between two intersections/junctions. The study for each section includes collecting the following data:

- Traffic Volume:
- Speed data
- Road Inspections survey

[1] The width of sections 1, 3 is 20m, and the width of section 2 is 40m.

Traffic Volume

Two periods of counting were considered (morning and evening). The counting was made in 15-minute periods. The traffic composition was determined by considering the proportion of passenger cars, buses and trucks. The peak hour factor for each section and each period was also determined. The analysis also covered the calculation of traffic density and the associated level of service (LOS). Data on pedestrian volume for each section and each direction was collected during a two hours of observations (Morning and evening) in 15 minute periods. The numbers of pedestrians on the street are differentiated if the pedestrians were walking along the sidewalk or the street.

Speed

Speed was measured for all sections of all selected streets in both areas. A sample of 30 vehicles of each class (passenger care, bus and trucks) was considered when collecting data for each section. The time required by each type of vehicle to traverse a defined 50 meter section was measured. The speed was calculated by dividing the defined distance by the measured time. The collected data for each section of the selected streets by vehicle type are categorized into the average speed and the 85% speed.

The average speed and the 85^{th} speed are compared with the speed limit for each street. Accordingly, the (LOS) was defined for each street and for each section. The walking speeds as well as the crossing pedestrian speeds were measured.

Road Inspection Survey

The checklist adopted procedure provides better understanding on what type of infra structure is provided in the investigated areas. All streets in both areas were evaluated. The following characteristics were considered:

1. Streets conditions (geometric characteristics, parking conditions, traffic calming: humps, drainage conditions)
2. Sidewalk conditions (sidewalk design, sidewalk conditions, cleaning services, obstruction on sidewalk including tress, lighting conditions, use of sidewalk for other purposes, and Aesthetic)
3. Pedestrian crossing (crossing design, conditions, driver behaviour in the vicinity of crossing)
4. Other pedestrian facilities-Foot Bridge (design and conditions)
5. Public Transport Services (bus stops location and accessibility, and service quality)
6. School (School surrounding environment and student behaviour in the school vicinity)
7. Pedestrian behaviour on the sidewalk and when crossing
8. Disable person needs

Each section of all streets in both areas was visited and checked with respect to each item in the checklist. Number “1” was given if the section under investigation satisfied the tested item and “0” otherwise.

Questionnaire Rating:

The other questionnaire that was prepared includes all the checklist questions but formulated in a rating form. It was distributed among traffic safety and highway experts. In total, 16 experts participated in the rating process. The sample includes experts from Balqa’ Applied University, Ministry of Public Works & Housing, Greater Amman Municipality, Traffic

Department, Jordanian Traffic Institute, and Arabtech Jardanah Consultants. The subjects were asked to rate on a scale from 0 to 5 the impact of each item on the check list on pedestrian safety. The lower scale (0) is used if the tested item has no impact. The average values for each item in the list were used to rate each section on various streets in both areas. The averaged weight given by all experts for the item under investigation is multiplies by **1** if the tested item is observed on the section and by **0** otherwise. The summation of all tested items is supposed to reflect who unattractive the area is from pedestrian perspective. As most of the questions were formulated negatively. The higher the score of the section, the less attractive the section is for the pedestrians.

Since the total sum of the weighted average of all tested item is 460 and in order to simplify the comparison process, the score of each section has been adjusted to have its maximum as 100. The same adjustments were made for each category in the list. Accordingly, ten indices were used to describe the existing infrastructure of each section. Indices from 1 to 9 describe the street, sidewalk, crossing, footbridge, transit system, school and mosque surrounding, pedestrian behaviour and the needs of disable persons and the tenth index describe the overall attractiveness of the tested section.

Correlation analysis describing the relationships between the rates founded and the traffic volume, measured average and 85th speed, pedestrians' volume and number of pedestrians using the street and the sidewalk were completed.

Road survey

The GPS was used to determine the location of each element on the road of the selected streets and its height if needed. The target is to calculate the sidewalk effective width and proposed the appropriate remedial measures.

RESULTS

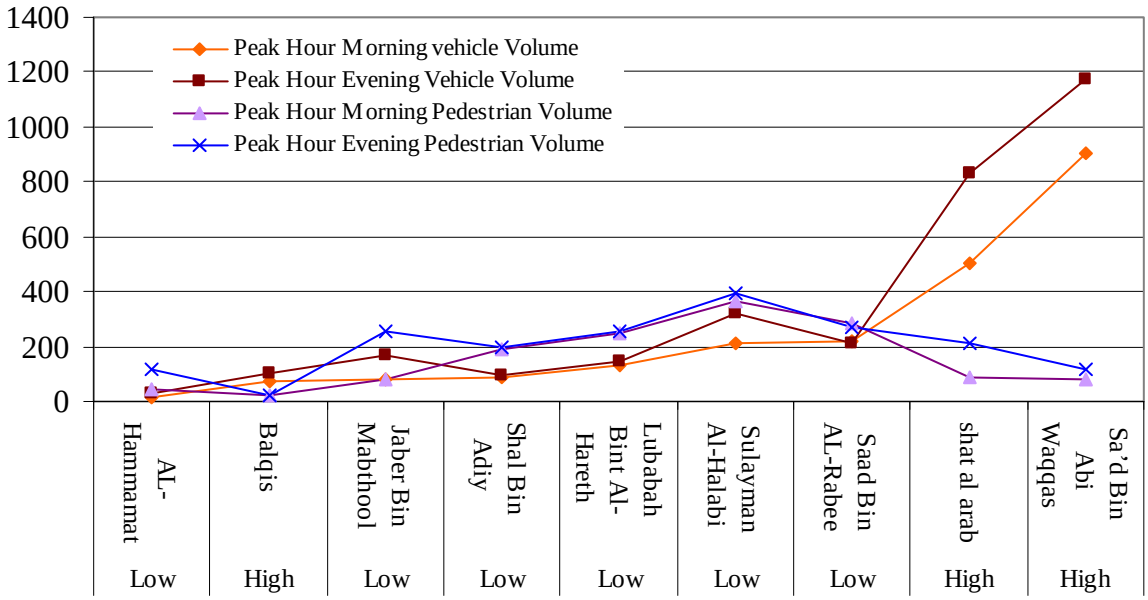
Traffic Volume

Hourly vehicle traffic volume in the peak morning hour in high income is more than that in low income area. Most of the vehicles in traffic stream are the small saloon cars, and small number of trucks and Buses. On the other hand, the hourly pedestrian traffic volume (the pedestrians' movement) is greater in the low income area than the high income area. Figure 1 shows that in the high income area pedestrian movements are higher in the evening and it is done for exercising or shopping while walking in the low income area is done for work, or going to school or shopping. Higher proportions of pedestrian in the low income are walking on streets instead of walking on the sidewalks (Figure 1). The proportion of buses and trucks are smaller during evening and it is lower in the high income area.

Speed

Streets in the high income area are wide and facilitate speeds. The observations showed that the speed is higher in this area compared to the low income area (Figure 2). The analysis shows that the operating speed for passenger car (48.6 km/h) in the high income area is higher than that in low income area (251 km/h). The statistical analysis showed that there is a significant difference in average speed due to area ($t=5.645$, $p=0.0001$). It also suggests that the average operating speed for buses in high income area (41.1 km/h) is greater than the low income area (22.8 km/h). However, the statistical analysis failed to prove that there is significant difference between the two means due to area (($t=-2.75$, $p=0.1$). Further, the operating speed for truck is also higher in the high income area (35.8 km /h) than the low income area (21.8km/h). There is also no significant difference in the average between the two areas ($t=-2.99$, $p=0.082$).

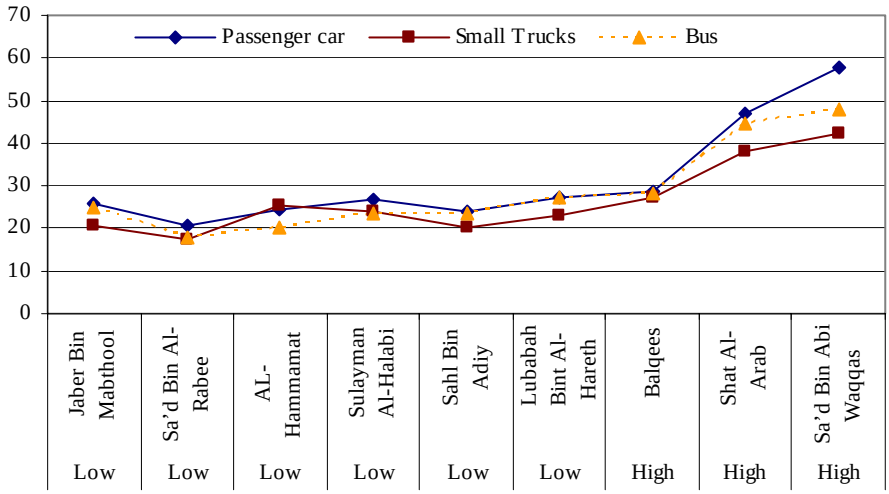
The Level of Service (LOS) according to highway capacity manual for urban streets is based on average through-vehicle travel speed for the segment, section, or entire urban street under consideration (Figure 2).



Bus & Truck% Morning	33	46	32	27	34	31	19	22	14
Bus & Truck% Evening	29	45	24	26	37	24	15	15	2
% of pedestrian on Sidewalk	58	45	59	85	91	60	66	40	42

Figure 1: Traffic Volume by Street, area and period of observation

The average speed of trucks in both areas is 26.5 km/h and it is slightly less than the speed of buses (28.6km/h). There is no significant difference between the two types of trucks ((t=0.46, p=0.65).



LOS	C	D	C	D	C	C	C	A	A

Figure 2: The average traffic Speed and LOS by Area and Vehicle Type

The 85th speed is significantly higher than the average speed in the high income area (t=-5.57, p=0.0001), which is not the case for the low income area (t=-0.37, p=0.716). The highest 85th speed in the high income area is 72.5 km/h (Figure 3), which is much higher than the speed limit on this road (50 km/h). The 85th speed is significantly different from the speed limit in the low income area (t=-7.7, p=0.0001). This is not the case for the high income area (t=1.01, p=0.333)

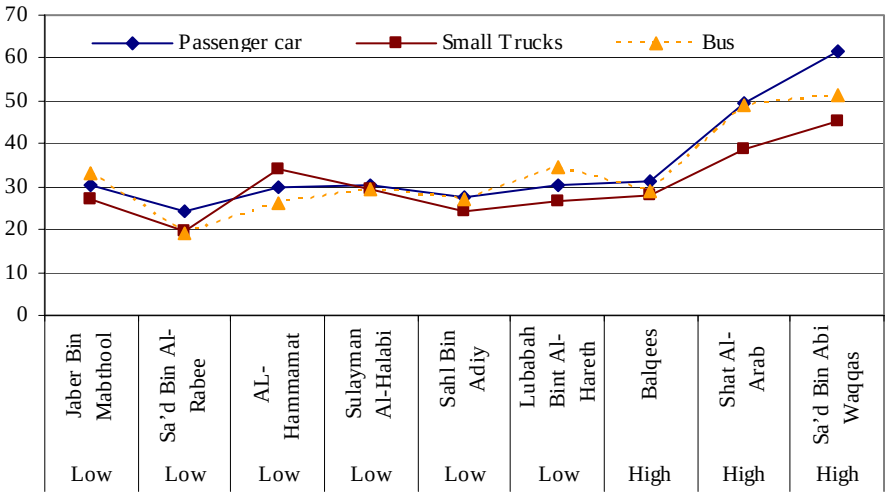


Figure 3: The 85th traffic Speed by Area and Vehicle Type

Pedestrian Speed

The analysis showed that female walking speed is less than male speed (t=4.23, p=0.0001) and is also less than male crossing speed (t=4.4, p=0.0001). The speed at low income group area is lower than that of high income group area. There is significant difference in walking speed between the two areas (t=-03.77, p=0.001). The same is applicable for crossing speed (t=-11.22, p=0.001). Pedestrian speed in the low income group area is higher when they are on walking on the sidewalk than when they cross the street (Table 3).

Table 7: Pedestrian Speed by Gender, and Style

Area	Gender	Style	Average	85th Percentile	Standard Deviation
Low Income Group Area	Female	Walking	1.17	1.23	0.10
		Crossing	1.12	1.26	0.20
	Male	Walking	1.44	1.62	0.30
		Crossing	1.25	1.48	0.34
High Income Group Area	Female	Walking	1.40	1.59	0.28
		Crossing	1.92	2.30	0.55
	Male	Walking	1.80	2.02	0.37
		Crossing	2.36	2.70	0.53

Road Inspection

The analysis involves the calculation of the indices that have been developed based on the field survey that was completed by using the check list and by area (Table 4). The lower the index is the more attractive the area for pedestrians. The results indicated that the infrastructure in high income area is more attractive to pedestrian as indicated by all indices except the index that refers to the foot bridge conditions. Table 4 shows that there is significant difference between the indices that refers to street, sidewalk, schools, parking, pedestrian behaviour and the pedestrian special need due to area of income. It also shows that both areas do not provide for pedestrian with special needs. Street conditions and sidewalk conditions are not providing walkable environment as indicated by their indices.

Table 4: Pedestrian attractiveness indices by class of income

Category Index	Income Area	N	Minimum	Maximum	Mean	Std. Deviation	t-value	Sig.
Street	Low	184	12.8	49.5	29.8	8.0	**3.71**	**0.0003**
	High	111	10.5	39.2	25.9	7.0		
Sidewalk	Low	183	15.1	40.2	27.7	6.1	**3.17**	**0.0020**
	High	112	9.2	42.9	24.9	8.0		
Crossings	Low	184	9.1	35.8	15.4	6.8	0.58	0.5634
	High	112	4.9	29.2	12.9	4.7		
Foot Bridge	Low	187	0.0	24.1	15.9	6.6	0.17	0.8657
	High	114	0.0	18.5	18.2	2.4		
Transit	Low	187	5.6	32.7	17.1	4.1	1.11	0.2725
	High	113	5.6	32.2	15.4	3.8		
Schools	Low	184	0.0	31.5	1.7	5.1	**2.37**	**0.0201**
	High	112	0.0	15.0	0.4	2.0		
Mousqe	Low	187	11.9	40.5	12.5	3.8	1.26	0.209
	High	114	0.0	11.9	11.4	2.4		
Parking	Low	187	0.0	83.9	34.1	17.3	**15.79**	**0.0000**
	High	114	0.0	48.4	1.8	7.7		
Pedestrian behaviour	Low	187	0.0	78.9	20.9	22.6	**4.84**	**0.0000**
	High	114	0.0	41.6	3.6	8.7		
Special needs	Low	187	24.6	100	64.9	13.1	**8.33**	**0.0000**
	High	113	0.0	73.7	43.5	16.5		
Overall	Low	183	13.3	36.7	24.4	5.0	**5.70**	**0.0000**
	High	109	11.2	28.6	19.8	4.5		

The pedestrian attractiveness overall index is highly correlated to street, sidewalk and to less extent to pedestrian behaviour and pedestrian crossing. It is also significantly related to the conditions for pedestrian with special needs and transit system conditions (Table 5).

Table 5: The correlation between pedestrian attractiveness overall index and other indices

	Street	Sidewalk	Pedestrian Behaviour	Parking Conditions	crossing	special needs	Transit system	Schools	Foot Bridge	Mousque
Correlation	**0.882**	**0.877**	**0.696**	**0.663**	**0.501**	0.433	0.367	0.201	0.086	0.083
Sig	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0466	0.0398	0.4153

WALKING ENVIRONMENT COMPARISONS

The following presents a comparison between both areas based on main categories that have been found related to the overall attractiveness indices.

Steet Conditions: The analysis of street conditions included in the survey aims at defining the main aspects that have negative impacts on pedestrian safety. Figure 4 shows that the streets in the high income group area are better than those of low-income group area. The main weakness aspects with regard to pedestrians are the absence of medians, and if they are provided are narrow. The pavements in both areas are deteriorating and low skid resistance is a problem in the high income area.

Traffic Calming-humps: more humps are found in low income group area. However, when found in high income group area they are in better shape, maintained and signed (Figure 5).

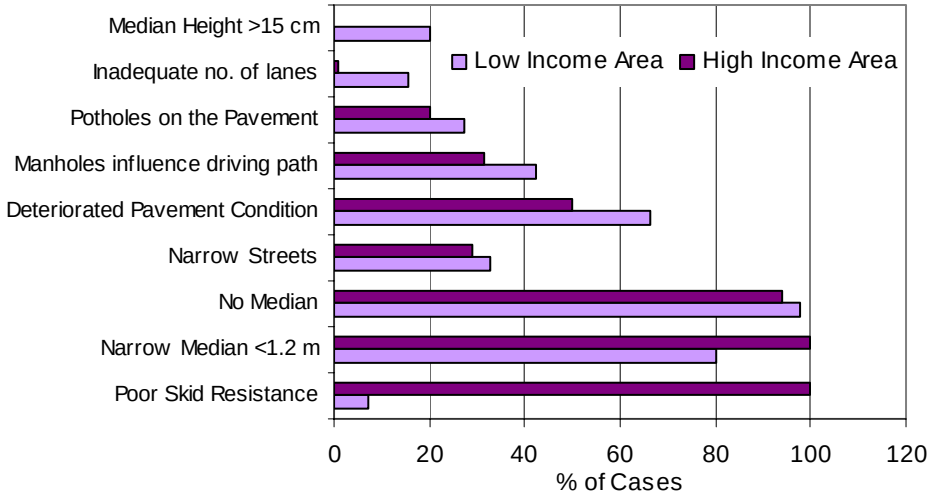


Figure 4: Street Characteristics by Income Group Area

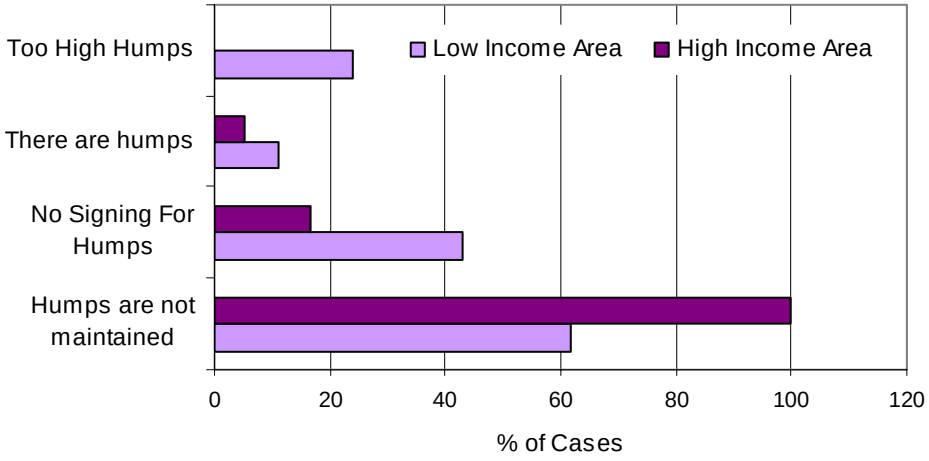


Figure 5: Traffic Calming Conditions by Income Group Area

Sidewalk design: Sidewalks in high income group area are more provided than in low income group area. They lack continuity in both areas, but it is more obvious in low-income group area. Narrow sidewalks are more reported in low income group area. In general, sidewalk can be described as wide. In fact, their width is not constant and that is even more in low income group area. The sidewalks in both areas are higher than what they should be (Figure 6).

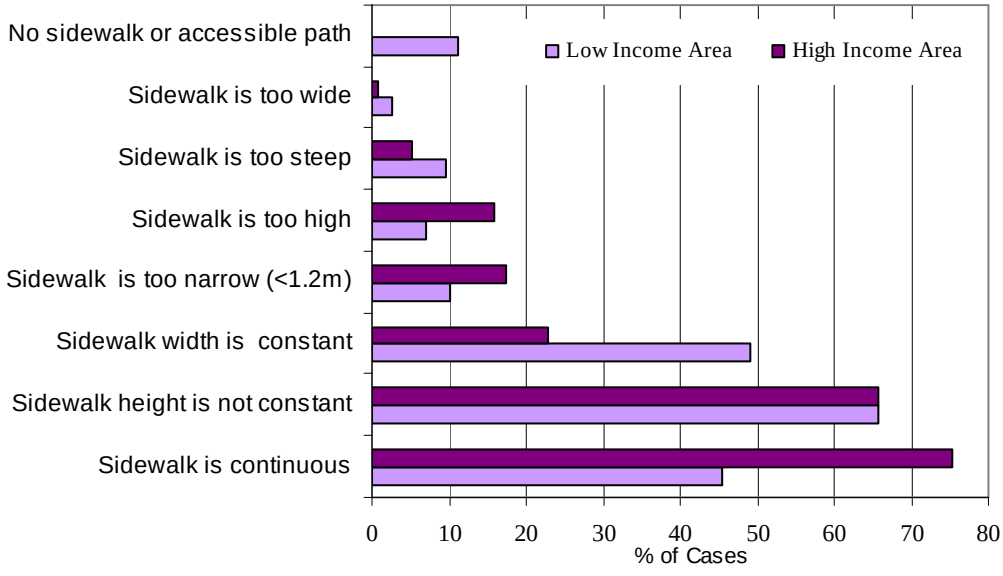


Figure 6: Sidewalk Design by Income Group Area

Sidewalk conditions: they are often tiled, maybe to less extent in low income group area. They are often described as cracked in low income group area. They have different size and colour. Sidewalks lack continuity and quite often the curb stones are not marked (Figure 7).

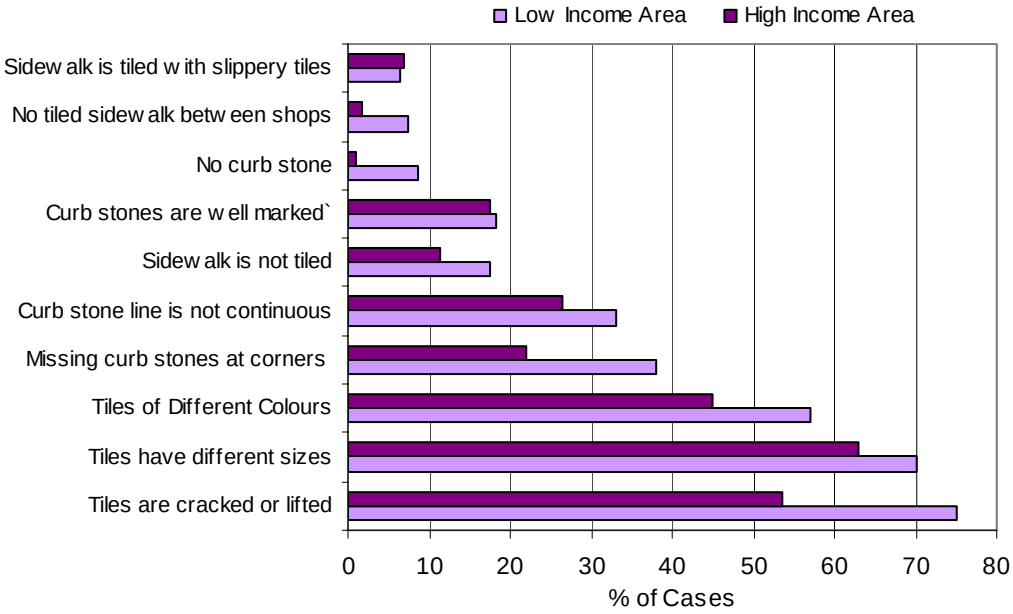


Figure 7: Sidewalk Conditions by Income Group Area

Use of side walk for other purpose: Sidewalks are often occupied with parked vehicle, construction materials in high income group area and also by merchandise in low income group area (Figure 8)

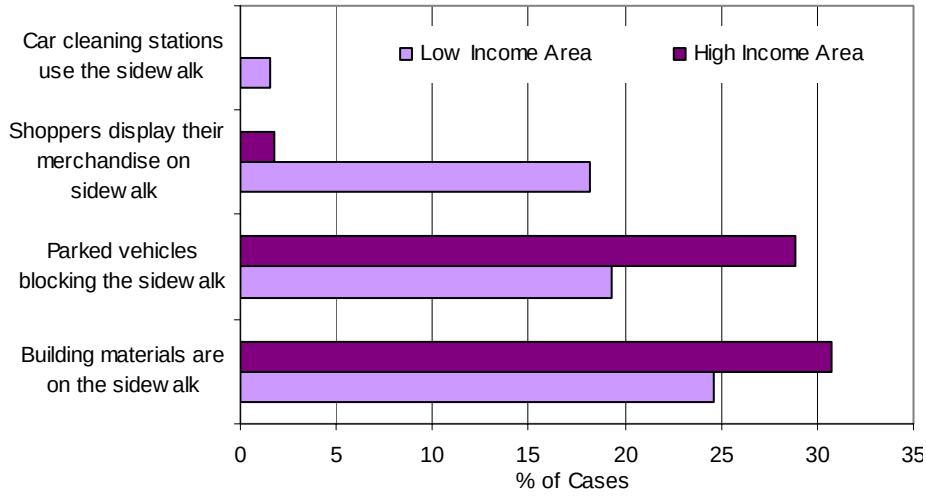


Figure 8: Use of side walk for other purpose by Income Group Area

Obstacles on Sidewalk: In low income group area the sidewalks are obstructed by holes and light and telephone poles to less extent by trees. While in high income group area, the trees and light/telephone poles obscure the view and to less extent the holes in the pavement (Figure 9)

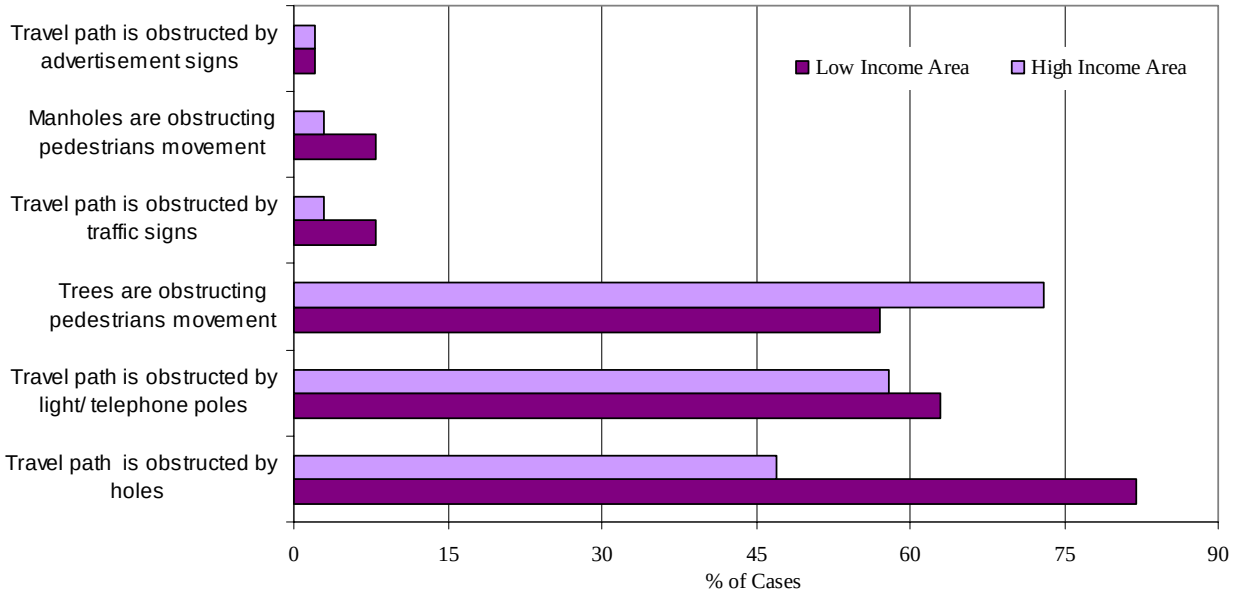


Figure 9: Obstacles on Sidewalk by Income Group Area

Trees: they are normally considered as a mean to beautify the streets. However, when they are badly located they turned to be a problem for pedestrians. They often obscure pedestrian path and force him or her to step down from the sidewalk and walk on street and be directly exposed to traffic. In this study, they are not as common in low income area as in high income area. Once exits, they are short in both areas, but the situation is worsen in low-income group area. Trees are often closely spaced and not well trimmed (Figure 10).

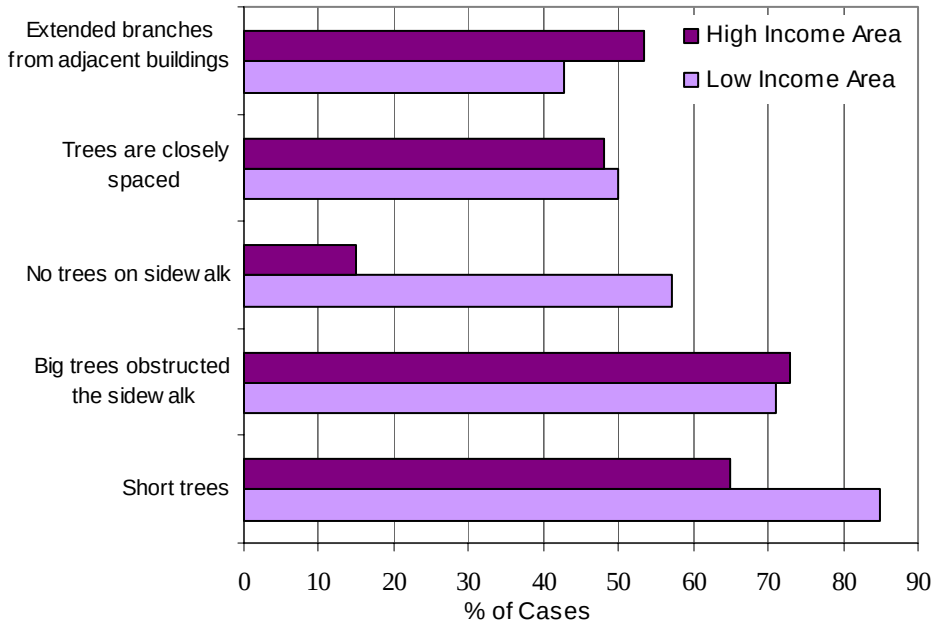


Figure 10: Trees Conditions by Income Group Area

Aesthetic and services: neither the aesthetic aspect nor the service are well taken care in both areas. Some, but few, vending machines are provided. Flower boxes are not provided and if provided they are not well maintained or they obscure the pedestrian pathway (Figure 11).

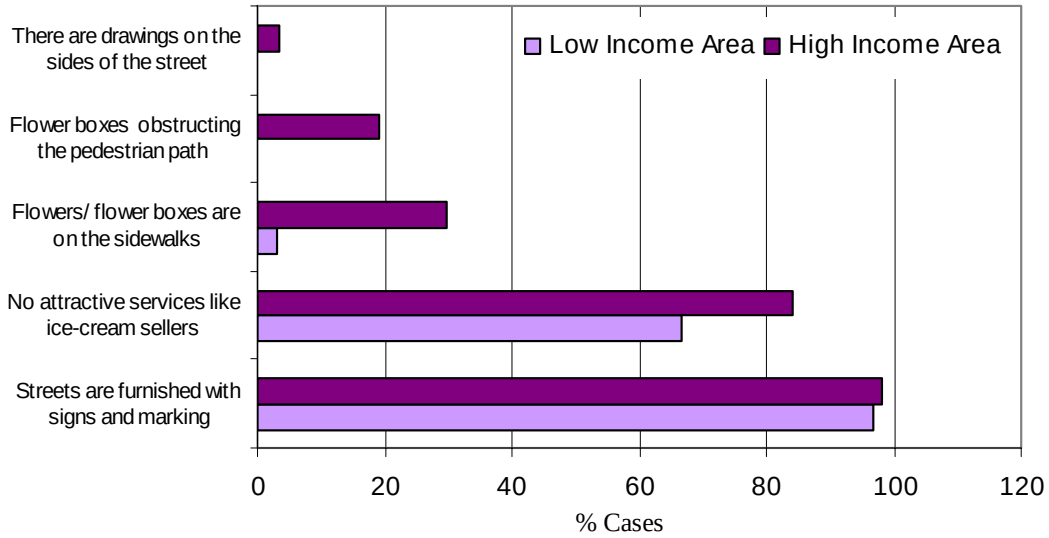


Figure 11: Aesthetic and service by Income Group Area

Pedestrian Crossing: they are not marked and if provided they are not easy to use as they lack the continuity into the sidewalk. Few signals are equipped with special signal for pedestrians (Figure 12).

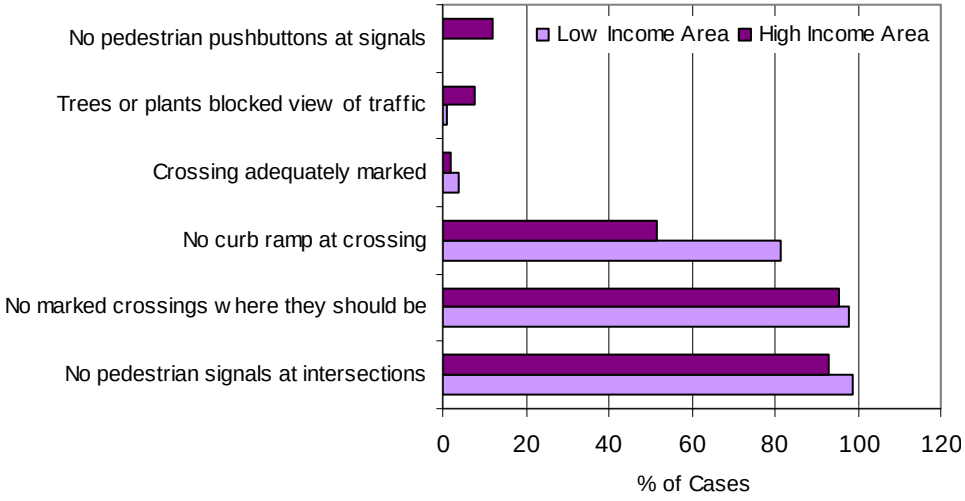


Figure 12: Pedestrian Crossing by Income Group Area

Drier Behaviour in the Vicinity of the Crossing: speed is more problematic in high income group area. High traffic volume hinders the pedestrian from crossing in low income group area. Crossings are not always visible from long distance, parked vehicle obscure pedestrian crossing and more often in low income group area. Drivers yield more in high income group area (Figure 13).

Pedestrian behaviour: Children walk unaccompanied with an adult in low income group area. They quite often they do not respect traffic safety rules. They litter and do not show disciple in using the street (Figure 14).

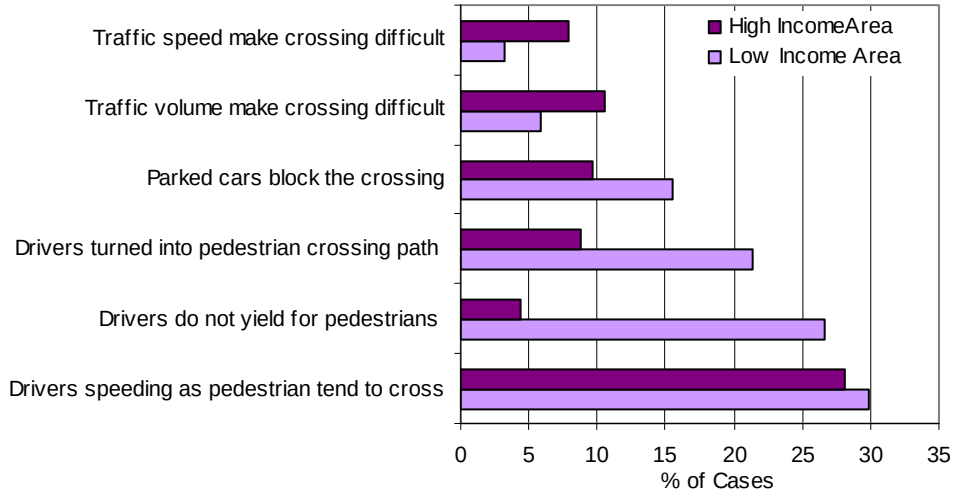


Figure 13: Driver Behaviour in the vicinity of the crossing by Income Group Area

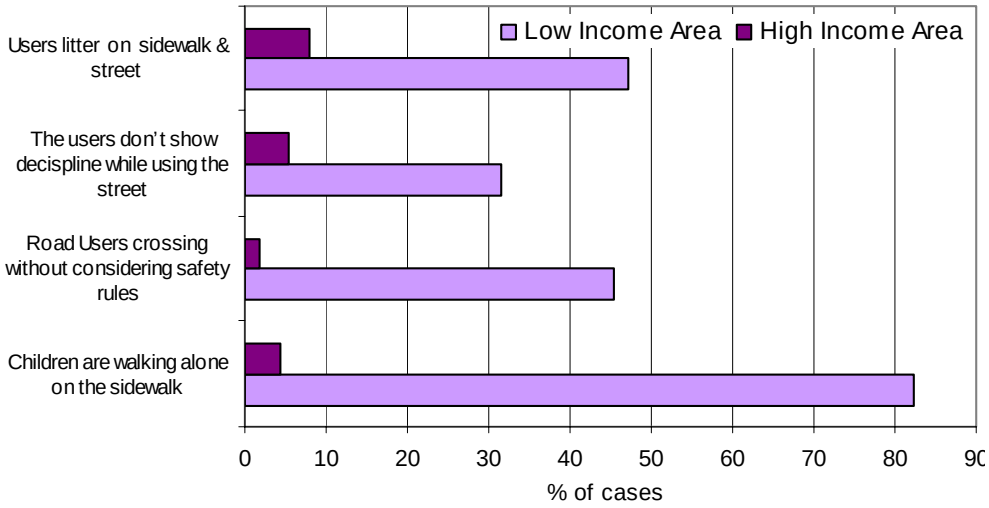


Figure 14: Pedestrian Behaviour by Income Group Area

Sidewalk Use

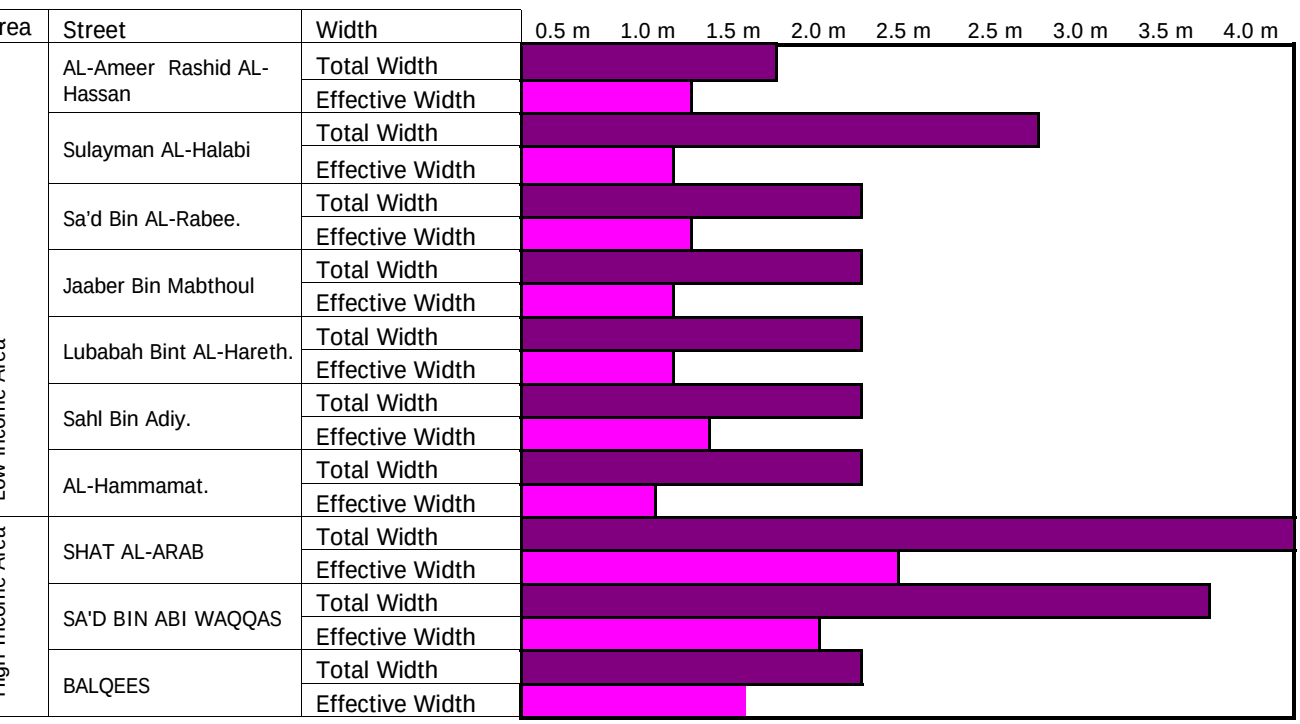
To look more into the influence of the factors that have been examined on the use of the sidewalk, a field survey was completed to determine the effective width that is usable for pedestrians and to look into the use of the sidewalk. The location of each tree, light pole, trash bin and any other obstacle that may obscure the path of the pedestrians were determined by using the GPS and the net usable width of sidewalk was determined. The effective width is reduced to less than 1 m on some of the arterial streets that are serving considerable pedestrian volume (Table 6). The reduction in the usable width of sidewalk is higher in low income area.

The relation between the effective sidewalk width and the proportion of pedestrians using the sidewalk is shown in Figure 15. It shows a trend where the proportion of pedestrians using the sidewalk increases as the effective percentage of sidewalk decreases. However, Insignificant correlation is reported (r=-0.07).

To examine further what makes a considerable proportion of pedestrian to walk on the street instead of the pavement (sidewalk). This proportion is related to the prevailing performance indicator as determined by LOS (Figure 16).

Table 6: Effective Sidewalk Width Vs. Total Width by Income Group Area

Area	Street	Width
Low income Area	AL-Ameer Rashid AL-Hassan	Total Width
		Effective Width
	Sulayman AL-Halabi	Total Width
		Effective Width
	Sa'd Bin AL-Rabee.	Total Width
		Effective Width
	Jaaber Bin Mabthoul	Total Width
		Effective Width
	Lubabah Bint AL-Hareth.	Total Width
		Effective Width
	Sahl Bin Adiy.	Total Width
		Effective Width
	AL-Hammamat.	Total Width
		Effective Width
High Income Area	SHAT AL-ARAB	Total Width
		Effective Width
	SA'D BIN ABI WAQQAS	Total Width
		Effective Width
	BALQEES	Total Width
		Effective Width



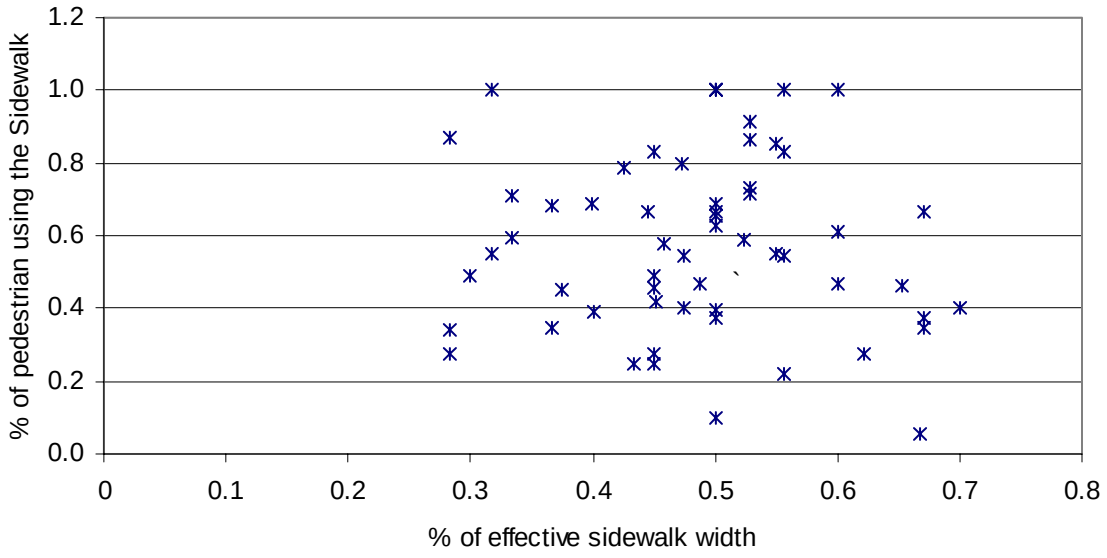


Figure 15: The Relation between Effective Sidewalk Width and the proportion of pedestrians using the sidewalk

Figure 16 shows the better the LOS is, the more pedestrians walk on the streets. High LOS means low density and low flow level and high speed. It seems that the less vehicles on streets are, the more the pedestrians on the street are. The pedestrians may feel that the streets are safe as few cars present.

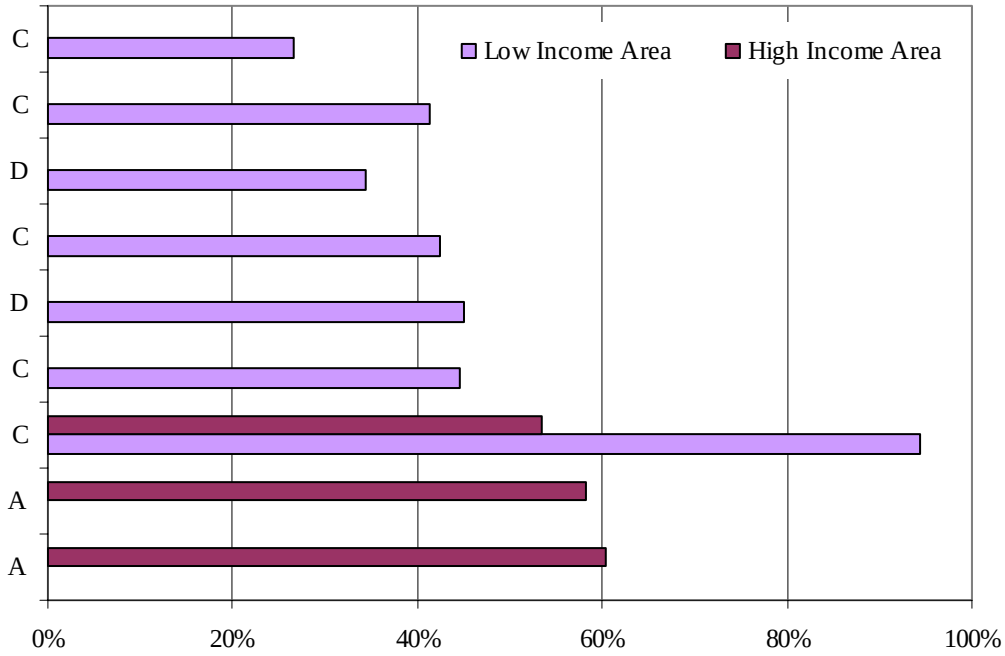


Figure 16: The relation between LOS and proportion of Pedestrians using the Sidewalk.

Further, the Pearson Correlation Analysis was completed to correlate the proportion of pedestrians using the sidewalk and the following variables:

- pedestrian attractiveness overall index
- Speed (average vehicle speed, 85th Speed, and Speed Limit)
- Vehicle Traffic Volume
- Pedestrian Traffic volume
- Pedestrian crashes
- Effective width
- Pedestrian walking and crossing Speed

The following are the variables the correlate significantly with the proportion of pedestrians using the sidewalks (PPUS).

- Pedestrian attractiveness overall index is inversely related to PPUS
- The street width is positively related to PPSU
- The vehicle traffic volume is inversely related to PPSU
- The effective sidewalk is also positively related to PPUS
- No significant relation was reported between speed and PPUS.
- The walking speed and crossing speed is positively related to PPUS
- Pedestrian crashes are related to PPSU

DISCUSSION OF RESULTS

The results showed that the high-income area walking environment measured in term of pedestrian attractiveness index is better than that of the low income area. However, it should be noted that more work is needed to upgrade the sidewalk, crossing and traffic calming devices conditions in both areas. The number of pedestrian accidents is related to pedestrian attractiveness index. The higher the index is, the more pedestrian crashes are. The attractiveness index is related to the streets, sidewalk and crossing conditions. The results showed that pedestrian accidents are positively related to the proportion of pedestrians walking on streets instead of the sidewalk. Walking in the streets makes the pedestrian exposure to traffic longer, thus increase the risk of their involvement in crashes. The study indicates that the proportion of pedestrians using the sidewalk is positively related to traffic volume. As traffic volume increase, speed decreases and encourages more pedestrians to use the sidewalk. Wider streets also invite more pedestrians to walk on the streets rather than on the sidewalks. Therefore, the main conclusions that can be drawn from this study are to widen sidewalk and narrowing the streets. The road network in both areas needs to be upgraded to facilitate pedestrian movements. The emphasis shown be given to sidewalks and pedestrian crossings.

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