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Analysis of Pedestrians' Perceptions about the Design Aspects of Crossing Facilities: A Case in Nizwa, Oman

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Abstract: This study aims to identify the key factors in pedestrians' intentions when using crossing facilities. For this purpose, a comprehensive questionnaire was designed and conducted at selected locations in Nizwa city. The main investigated variables are linked to personal characteristics, opinions on the main reasons for accidents, and how hard it is for pedestrians to cross roads at different locations in Nizwa city. Statements were also designed on the safety and health aspects of pedestrian crossings, as well as the physical and design aspects of pedestrian crossing facilities. Suitable locations were selected for the survey to assess the main concerns of pedestrian facilities. A total of 280 usable samples were collected from the selected locations. The analysis results revealed that young pedestrians do not find it difficult to use pedestrian bridges and underpasses when crossing roads. Pedestrians' prioritization of safety when crossing, pedestrians' health conditions, the proper cleaning and lighting of facilities, and the good design of facilities are significant determinants of pedestrians' intentions when using crossing facilities. Crossing facilities need to be maintained properly, for example, through the cleaning and lighting of facilities. Proper awareness among pedestrians and vehicle drivers is required for the safety of pedestrians.

Keywords: pedestrians; crossing facilities; urban planning and design; pedestrian crossing; Oman

1. Introduction

An increase in urban population and traffic demand has caused a severe problem for drivers and pedestrians globally. Many communities around the world have started to urge people to stop using automobiles in order to reduce environmental and social issues. At the same time, communities provide pedestrian facilities to discourage automobile dependency for short-distance trips. Communities are also working to educate people to use pedestrian safety signs to ensure safe, sound, and smooth traffic movement as well as safe road crossing for pedestrians.

Each year, many people lose their lives in road accidents around the world. Many leave early in the morning for schools, offices, and other workplaces to support their families but never return home, and some become permanently disabled.

Several research studies have focused on both road geometry (especially on crossings near intersections in urban areas) [1–3] and on different types of users (by gender, age, work) and travel habits (i.e., motivation for travelling, travelling alone or in groups) [4–6].

Oman is among the countries that are seriously affected by road accidents and pedestrian fatalities. Around 23.8% of road crash-related fatalities are pedestrians [7]. The main cause of these accidents is the behavior of drivers when they pass areas that are designated especially for pedestrians without slowing down their vehicles. At the same time, pedestrians are also responsible for such incidents, as they do not follow guidelines and traffic signs properly. According to the World Health Organization (WHO) report in 2013, Oman has the highest number of deaths in road accidents, and 23% of those are pedestrians [8].

Pedestrians being run over resulted in the death of 212 and injured 678 people in 2013 according to the Royal Oman Police (ROP) traffic department [9]. The fatality rate for pedestrians is higher than for drivers and passengers. The most common accidents involve passenger cars, followed by pedestrians and bicycles [7]. The deaths of pedestrians on Omani roads, where the number of fatalities from traffic accidents continues to rise, are a major concern. Pedestrians often face difficulties when it comes to crossing the roads that are designed for high-speed traffic. Most pedestrian accidents occur either due to a lack of proper crossing facilities on major roads, poor driving by vehicle drivers, or the inattention of pedestrians while crossing the road.

Many pedestrians feel uncomfortable or even hesitant when they use marked and/or constructed crosswalks due to poor driving attitudes. The planning of pedestrian facilities is an important factor in urban transportation infrastructure. To provide a safe and sound environment, one of the main factors to consider is the provision of a safe, well-maintained, and convenient environment for pedestrians, especially at the crossing points of roads. Pedestrian crossing facilities include zebra crossings at intersections, footbridges, and underpasses. There is a need to identify some important factors that are required to be considered while planning and designing appropriate crossing facilities. The provision and use of a specific crossing facility are strongly related to the pedestrians' characteristics, and the physical and operational features of the crossing facilities [10–12]. To improve the performance of existing pedestrian facilities and to plan and design better them for future needs, it is important to know the specific requirements of pedestrians through their perceptions.

Perception surveys are one of the mediums through which pedestrians' perceived difficulties in using different crossing facilities can be understood. Climatic and environmental factors play a significant role in a pedestrian's walking ability and the potential to use crossing facilities, such as footbridges and underpasses. There is a need to identify pedestrians' perceptions regarding the conditions of existing crossing facilities in Nizwa city. It is also necessary to assess pedestrians' preferences toward crossing facilities by considering various potential influencing factors. The required data were collected with the help of a questionnaire survey.

The collected data were analyzed using factor analysis and Structural Equation Modelling (SEM) methods. This paper is organized in the following manner. The relevant research is presented in Section 2. The characteristics of the pedestrian facilities in the study and the research methods are presented in Section 3. A discussion of the survey and analysis results are provided in Section 4. Conclusions are presented in the last section.

2. Literature Review

The ideal pedestrian environment consists of an infrastructure system in which there is some respect for pedestrians. It includes the provision of footpaths and pedestrian crossing facilities with a proper lighting system and easy accessibility.

Many other factors can also contribute to pedestrians' needs and facilities. Sometimes, for normal pedestrians, it seems to be fine if there are cracks or unevenness on the footpath surface, however it may cause extra effort or work for those who are disabled or cannot walk in the same way as non-disabled people. It is clearly understood that drivers dominate the shared space with pedestrians without any hesitation and few people would reject such a thing. According to Moody (2011), the pedestrians' perception and their attitude toward the shared space were found to be poor, and it was found that females and old age people were negative toward this concept of a shared space with drivers [13]. There could be an argument that the reduction in road accidents is because cyclists may use alternative streets from those old age people. Melia and Moody (2011) elaborated further on the concept of shared spaces and said that the recovery for those who are blind, or who focus away from their footsteps is hard compared to those who have clear eye contact and interactions during road crossing [14].

Pasanen and Salmivaara (1993) conducted three research studies regarding the severity of injury and collision speed [15]. They estimated that 5% of pedestrians would die if they were struck by a vehicle at a speed of 20 mph and this percentage would rise to 40% if the speed was doubled, i.e., 40 mph, and it would be 100% if the speed was greater than 50 mph. The factors that contribute to pedestrian accidents or fatalities include human, environmental, and infrastructural factors [16]. Age and gender have the most significant effect on crossing speed, and fear of falling had a significant effect on the proportion of downward head pitches during the crossing [17]. The most significant factors that contribute to fatal or non-fatal pedestrian crashes are disobeying traffic signs, inattentiveness, and an improper way of crossing roads. Those are some of the causes of accidents and they contribute to 3, 15, and 28% of pedestrian deaths, respectively [18]. Age, sex, group size, pedestrian flow, and pedestrian signals are associated with pedestrian violations and pedestrian speed is dependent on the type of crossing [19].

During the past few years, many studies have been conducted to find out what is needed by pedestrians when they have to cross a road [20–22]. For example, Moore's studies suggest that 80% of people would use an underpass/overpass if it was constructed in London and the usage would be none if the travel time was more than 1.5 times compared to a ground crossing [20]. Additionally, it was suggested that the provision of obstacles-like fences can encourage the use of the pedestrian facilities. Sharples and Fletches (2000) studied the pedestrians' view on road crossing facilities for an overpass [21]. Sisiopiku and Akin (2003) concluded that the main reason for the pedestrian to use pedestrian facilities depends on the factor of safety, comfort, and visibility [22,23]. Rasanen et al. (2007) have studied five different overpasses in the city of Ankara [24]. They found that the use of overpasses depends on the amount of time and factor of safety. Xiong et al. (2008) stated that safety, comfort, and how convenient the facility is are the main factors of pedestrians' choosing a crossing facility [22]. The Binary Logit (BL) model showed that the selective preference of using an overpass was significantly influenced by eight factors, including gender, age, career, education level, license, detour wishes, detour distance, and crossing time [25]. A study conducted in Delhi showed that pedestrians put a high priority on convenience than safety while using crossing facilities and the use of an overpass or bridges decreases with old age [26]. However, another study reported that safety is one of the first important points for most pedestrians, and they prefer an overpass/underpass to crossing the road [27]. The width of the road can be one of the important points that can play a vital role in causing accidents, as a longer pedestrian crossing exposes the pedestrians to more risk. The most significant factor in a pedestrian's decision to use a footbridge is the presence of an escalator, and being in a hurry and fear of heights are significantly related to not using a footbridge [28]. The insufficient security, longer times, poor entrance design, hawker's problem, and discomfort are also some of the main concerns of pedestrians for not using crossing facilities [11,12]. It has been found that those who are young and male pedestrians are more likely to violate traffic rules and do not use pedestrian crossings [29,30]. Slower walking and congestion during crossing roads could be a vital cause of accidents. Diaz (2002) experimented that a younger group of people showed a more positive attitude toward crossing in risky situations compared to old people [31]. According to Qureshi et al. (2015), female pedestrians usually take more time in crossing the roads as they are more cautious and concerned about safety than males [32]. Gender and age are significantly related to people's willingness to walk for longer times and avoid using footbridge/underpass facilities [10]. The perceived behavioral control variable is a strong predictor of a pedestrian's decision to cross roads [33].

The distracted walking factors include anything that takes the pedestrians' attention away from roads. These days, mobile phones are one of the main causes of it, especially for the new generation. It is seriously dangerous and can put the users in a hazardous environment [32,34]. Researchers have shown that a cell phone distracts the pedestrian and it also reduces the attentiveness of the pedestrian while crossing roads [35]. Another main cause of distracted walking is anger that cannot be controlled and cannot be avoided when it happens [36]. Mwakalonge et al. (2015) reported that some organizations/agencies are trying to encourage pedestrians to walk safely and avoid the things that could distract their attention at the roadside [37]. Some of them include wearing headphones, texting, and talking on a cell phone. Distracted pedestrians who require more time to cross, miss safe crossing opportunities, look left and right less, and engage more on a cell phone are more likely to be hit by a vehicle [38]. The reviewed literature provides a good understanding of the significant factors in the usage of pedestrians' crossing facilities. Most of those studies provided a segregated insight on the importance of human characteristics and the physical and design characteristics of crossing facilities. Additionally, most of the studies are concerned with assessing the performance of facilities in medium- and big-size cities. There is a need to evaluate pedestrians' likelihood to use the crossing facilities under the influence of the pedestrian's health and physical characteristics, and the physical and design parameters of the crossing facilities. As mentioned earlier, it is evident from the literature that there is no study conducted in Nizwa, Oman, which evaluates the perceptions of the pedestrians regarding their road crossing behaviors considering their physical health as well as the physical and design parameters of the pedestrian crossing facilities. Therefore, this research study fills a gap in the body of literature by manifesting some of the important determinants from the perspectives of pedestrians in their road crossing behaviors.

3. Materials and Methods

Figure 1 shows a pictorial view of the workflow. The main components of this research study include a literature review, selection of case study city, questionnaire design, sample size selection and questionnaire survey, data analysis and composition, and interpretation of results.

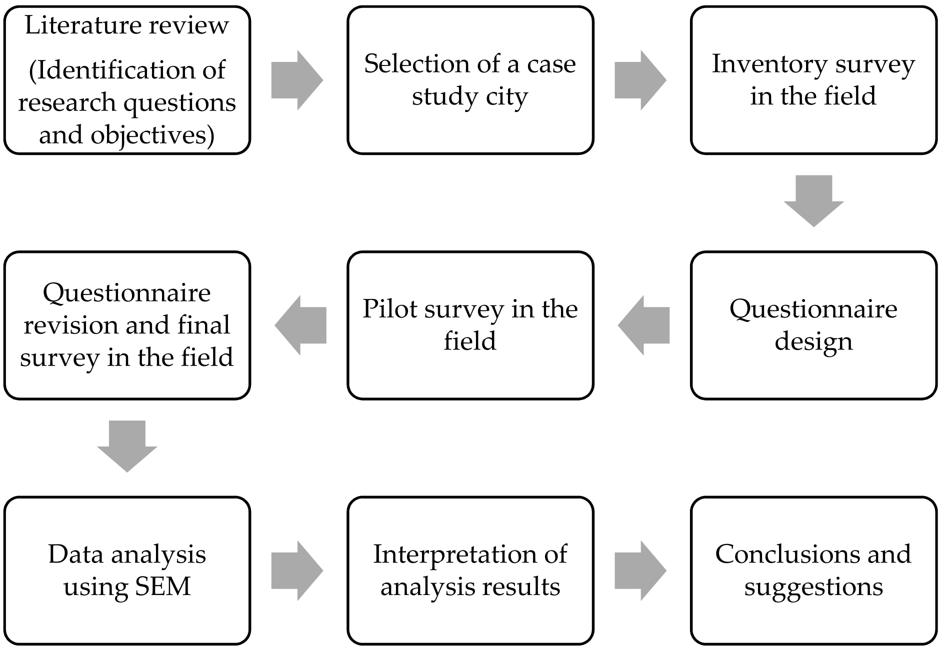

Figure 1. A pictorial view of the research workflow.

3.1. *Pedestrian Crossing Facilities in Nizwa City*

Nizwa is an ancient city in Oman that is located in the Ad-Dakhiliyah region. Nizwa city was selected as a case study seeking its historical importance in Oman. This city was also selected because it was easy and convenient to find the target population. There are many commercial centers where it was easy to find a large number of pedestrians. Pedestrian crossing facilities such as footbridges and underpasses are also available at some locations on the major urban highways in this city. The geographic location of Nizwa city is presented in Figure 2. Only the area of Nizwa municipality is shown in the figure because the crossing facilities are not available in the surrounding municipalities. The available pedestrian footbridges and underpasses are also shown in Figure 2. At present, there are 3 footbridges and 5 underpasses in Nizwa municipality. The preliminary field survey revealed that crossing facilities (underpass/overpass) are not available at major commercial locations (e.g., near Nizwa mall, and Nizwa Grand mall). At these places, pedestrians are crossing the road directly through traffic, which is extremely risky and can result in deadly accidents. A typical pedestrian footbridge and underpass facility is shown in Figure 3. Figure 3 also shows the pedestrians who are crossing the roads at mid-links where crossing facilities do not exist.

Figure 2. A map showing the location of Nizwa with pedestrian crossing facilities.

(**a**) Pedestrians crossing a road (a location without crossing facilities)

Figure 3. *Cont.*

(**b**) A typical pedestrian crossing bridge

(**c**) A typical pedestrian underpass

Figure 3. Pedestrian crossing and crossing facilities at different locations (source: authors).

3.2. Questionnaire Design

A comprehensive questionnaire was designed to achieve the research objectives of this study. The questionnaire consisted of four parts. The first part of the questionnaire consisted of some personal information on the respondents such as gender, age, profession, and opinion on pedestrian crossing facilities issues. In part 2, questions were included on pedestrians' accident experience or having a close call, road crossing frequency, and opinion on the main reasons for pedestrian accidents. These opinions were asked on five-point Likert scale for their level of agreement (i.e., strongly disagree—1, disagree—2, neutral—3, agree—4, and strongly agree—5). The main selected reasons included a lack of pedestrian facilities, fewer road signs, aggressive driving behavior, lack of awareness, lack of respect for pedestrians' spaces by drivers, and pedestrians disobeying to the traffic signs. In part 3, many statements were designed and evaluated on a five-point Likert scale for the level of agreement (i.e., strongly disagree—1, disagree—2, neutral—3, agree—4, and strongly agree—5). The main motive behind the design of these statements was to evaluate the opinion of the pedestrians regarding their behaviors in relation to road crossing facilities.

The statements were about the pedestrian's attitudes and intentions while crossing the road, preferences in the use of pedestrian underpasses and footbridges for crossing, interaction with other pedestrians while walking, timesaving, and convenience. Physical conditions and design aspects were also considered in designing these statements.

It was assumed that the individual's priorities regarding safety parameters, comfort, and convenience in using a crossing facility, and the design and physical elements of facilities may have a significant influence on the pedestrian's intentions to use the footbridges and underpasses. Lighting, climatic conditions, and cleanness factors were considered to define the comfort condition of the facilities. It was also hypothesized that the weather pattern of an area and the pedestrian's health conditions also have a significant influence on people's walking intentions. In part 4 of the questionnaire, pedestrians were asked to report how hard is for them to cross roads at different locations in Nizwa city. These locations included the roads in front of Nizwa Grand Mall, the road in front of Lulu and Mukhtar gift center, the road in front of Badr-al-Sama and National gift center, and the road in front of Oman-tel office.

3.3. Survey Instrument and Sample Size

This survey was conducted at different selected locations in Nizwa city. These locations were selected considering the availability of pedestrian facilities and pedestrian volume. The suitability of conducting the survey was also considered in selecting these locations. The survey involved pedestrians who cross these roads regularly and have been affected every day due to a lack of facilities. Some locations without crossing facilities were selected because at some of these critical locations, a lot of pedestrians cross the roads, which is unsafe to do. It was hypothesized that the perceptions of such pedestrians were important in understanding their needs regarding the design, safety, comfort, and physical aspects of crossing facilities. The perceptions of both users and non-users help in obtaining an understanding of the inquiry in question. Initially, a pilot survey was conducted to check the suitability and correctness of the designed questionnaire items. This pilot survey also helped to know the target respondents' understanding of the questionnaire statements.

The questionnaire items were revised to incorporate the feedback of the pilot survey. The target sample size was decided considering the available pedestrian population, easiness in conducting the survey, and schedule limitations. Another consideration was the requirements of the sample size for use in the Structural Equation Modeling (SEM) analysis. The minimum required sample size was 200 to minimize bias in the results [39,40]. Other researchers have suggested that a ratio of 10 observations per indicator [41], and the minimum sample size should be at least ten times the number of free parameters [42] for conducting SEM analysis. Considering these recommendations and constraints, it was hypothesized that a sample size of 200 is suitable to develop a structural model. All the respondents were approached randomly and interviewed individually. The respondents were instructed on the contents of the designed survey. Most of the respondents had low literacy levels, as the majority belong to different developing countries and the labor classes. The number of collected samples was 280.

3.4. Data Analysis Methods

The collected data were analyzed using the multivariate statistical analysis method. Factor analysis is a pre-requisite of the Structural Equation Modelling (SEM) process. Some researchers in transportation research have used SEM to analyze pedestrians' behavior related to crossing facilities [43,44]. This method was deployed for its consistency with the nature of collected data and the available sample size. Initially, Exploratory Factor Analysis (EFA) was conducted on pedestrians' perceptions of various elements of crossing facilities. The EFA helps in extracting the appropriate and interpretable factors with specific observed variables or indicators. The extracted factors were named according to the nature of their associated observed variables. A structural model was constructed using extracted factors. The SEM technique has several advantages over conventional regression analysis. This approach helps researchers to diagnose the direct and indirect influence between different variables. It also enables the researchers to include more observed variables in the structural model. The reliability of the developed structural model was checked against their recommended values using the indices of the selected goodness of fit parameters. These parameters included the ratio of the chi-square test to the degree of freedom (2–5), Root Mean Square Residual (RMSR) and Root Mean Square Error Adjusted (RMSEA), which should be under 0.08, and Comparative Fit Index (CFI), Group Fit Index (GFI) and Adjusted Group Fit Index (AGFI), which are required to be more than 0.9 [45–48].

4. Results

4.1. Distribution of Personal Characteristics

The total number of collected samples was 280. Table 1 shows the distribution of the personal characteristics of the respondents. Most of the respondents are in the age group of 21–40 years. According to the sample size distribution, 97% of the respondents are males. Only a few females were found for responses while crossing the roads at selected locations and all of them were expats. This is true as females occasionally cross roads and go out for traveling. The majority of respondents are married and use crosswalks at different locations. More than 50% of the pedestrians are workers. The people who use their private cars rarely cross roads. Almost 70% of the respondents said that the crosswalks are a major concern in Nizwa city. Most of the respondents cross a road more than 2–3 times a week.

Figure 4 shows the main reasons for pedestrian accidents. It shows that 146 out of 280 agreed that accidents happen due to a lack of pedestrian facilities and around 112 said it was due to fewer road signs, and 110 agreed on aggressive driving behavior.

Table 1. Description of respondent's socio-demographics.

Characteristics	Distribution (%)
Gender	Male (97%), Female (3%)
Age (years)	Under 20 (2), 21–30 (41), 31–40 (33), 41–50 (23), above 50 (1)
Marital status	Single (48), married (52)
Profession	Student (16), Business (12), worker (54), other (180)
Issues of crosswalks	A major issue (70), a moderate issue (26), a minor issue (4), not an issue (0)
Frequency to use crosswalks per week	More than 5 times (22), 4–5 times (32), 2–3 times (42), Just today (4)
Accident experience	Yes, hit (2), Yes, a close call (12), Hit and close call (2), no (84)
How often do you cross the road?	Never (62), occasionally (37), regularly (1)

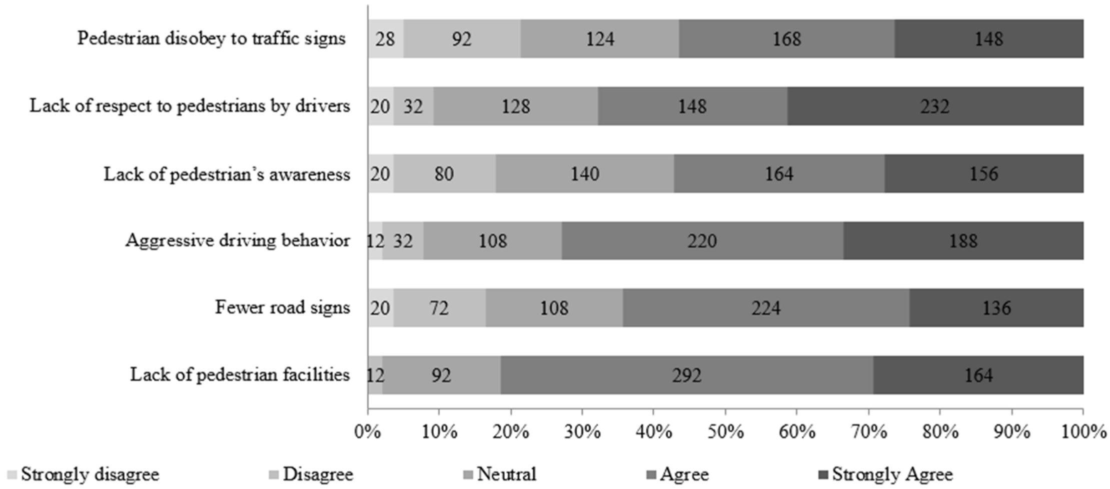

Figure 4. Opinion on the main reasons for pedestrian accidents.

Figure 5 shows how hard it is to cross the road at each selected location according to the user's point of view. The main roads in front of Nizwa Grand Mall and ROP police and the crossing location between Lulu and Mukhtar gift center were found to be critical or hard for pedestrians to cross.

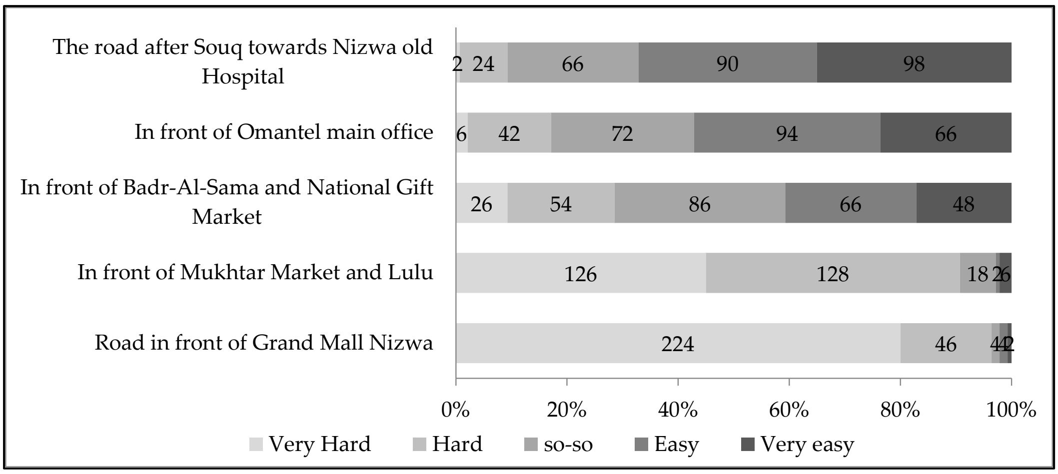

Figure 5. Difficulties in crossing at different locations.

There are no crossing facilities at these two locations and pedestrians need to cross directly through traffic, which makes it unsafe for them. For other selected locations, the pedestrians feel it is easy to cross the roads because these roads have either a pedestrian footbridge or an underpass. It means that pedestrians feel safe while using a pedestrian bridge and an underpass for crossing.

4.2. Average Responses and Factor Analysis Results

Exploratory factor analysis (EFA) was conducted on the respondents' responses for the statements designed considering the various service, physical, safety, and design aspects of pedestrian crossing facilities. This factor analysis resulted in five factors with an Eigenvalue greater than 1.0, as presented in Table 2.

Table 2. Factor loadings for observed variables of extracted factors.

Observed Variables	Mean	Factors				
		HC	IUCF	PS	WDF	CL
My health/physical condition does not allow me to use the pedestrian footbridge for crossing. (HC-1)	1.843	0.956				
My health/physical condition does not allow me to use the underpass. (HC-2)	1.793	0.863				
I prefer to use the pedestrian footbridge/underpass for crossing a road wherever it is available. (IUCF-I)	4.100		0.761			
I prefer to use a footbridge/underpass for crossing a road as it is safe. (IUCF-2)	4.257		0.680			
I usually wait for a green signal at the intersection for crossing the road. (IUCF-3)	4.243		0.525			
I always wait for a clear road while crossing as it is safe. (PS-1)	4.510			0.867		
I believe that the use of a footbridge/underpass is safer than crossing the road directly. (PS-2)	4.486			0.642		
I do enjoy walking where pedestrian facilities are well-maintained. (WDF-1)	4.171				0.745	
Hot weather affects my ability to walk longer. (WDF-2)	4.407				0.547	
The good design of crossing facilities makes crossing easier. (WDF-3)	4.121				0.542	
I do not like to use the underpass/footbridge due to their poor physical condition. (e.g., dirty) (CL-1)	4.050					0.588
It is difficult to use the underpass at night as there is no or poor lighting. (CL-2)	4.186					0.550
Cronbach's Alpha		0.911	0.701	0.717	0.630	0.524

Note: HC: Health condition, PS: Priorities of Safety, WDF: Well Designed Facilities, CL: Cleaning and lighting, IUCF: Intention to use Crossing Facilities.

This extraction was performed using the Maximum Likelihood (ML) and Equamax rotation methods with Kaiser Normalization. The rotation of factors provides factors that are more logical and interpretable. A factor loading of 0.5 was used as a cut-off-point value for the extraction of factors. The observed variables in each factor with higher factor loading have more influence in explaining the corresponding factor. The extracted factors were named regarding the nature of the observed variables from the perspectives of the pedestrians. These factors are (1) Health Condition (HC), (2) Priorities of Safety (PS), (3) Well Designed Facilities (WDF), (4) Cleanliness and Lighting (CL), and (5) Intention to Use Crossing Facilities (IUCF). The average responses for the observed variables of each factor are also presented in Table 2. Cronbach's alpha values were also estimated for the extracted factors and a higher value of Cronbach's alpha shows the extracted factor has more reliability and internal consistency among respondents in evaluating the observed variables of each factor. The estimated values of Cronbach's alpha are more than 0.5 for all the factors, which shows the moderate level of reliability of the extracted factors [49,50].

The HC factor shows that most of the respondents feel that their health condition does not have an influence on their intention to use pedestrian footbridges and underpasses, as the average values are under 2.0. As most of the respondents belong to the young group and labor class, they do not find it difficult to use a pedestrian footbridge and an underpass. However, this potential would be different for old-aged pedestrians as age has a significant correlation with a pedestrian's ability to use a footbridge and an underpass [10,26].

The results of the 'intention to use crossing facilities' factor depict that pedestrians prefer to use crossing facilities wherever they are available. They also prefer to use the pedestrian footbridges and underpasses because they consider them safe, and they do not need to wait for a green signal in this case. The factor loadings and average responses for the 'priorities of safety' factor show that pedestrians put more weight on their safety while crossing the roads. The results of 'well-designed facilities' imply that if the crossing facilities are designed and maintained properly, it would encourage pedestrians to use them. This may include sheltered facilities and regular maintenance activities. Similarly, the cleanliness and lighting factor shows that the poor physical conditions and absence of proper lighting discourages the pedestrians from using them. These physical and aesthetic aspects of facilities need to be improved.

4.3. Structural Model of Pedestrian Facilities

A structural model was developed using the SEM technique. Figure 6 shows a developed structural model of the pedestrians' intentions to use the crossing facilities. The arrows between the factors show structural equations or relationships and the arrows from factors to observed variables show measurement equations. This structural model was developed using SPSS Amos software. The Amos software package uses a confirmatory approach to test multiple hypotheses at the same time. All the measurement equations were significant at a 5% level of significance. This significance confirms the association of observed variables with their corresponding factor or latent variables. All the standardized estimates of measurement equations are more than 0.5, which predicts a good internal consistency among the respondents in the evaluation of the observed variables.

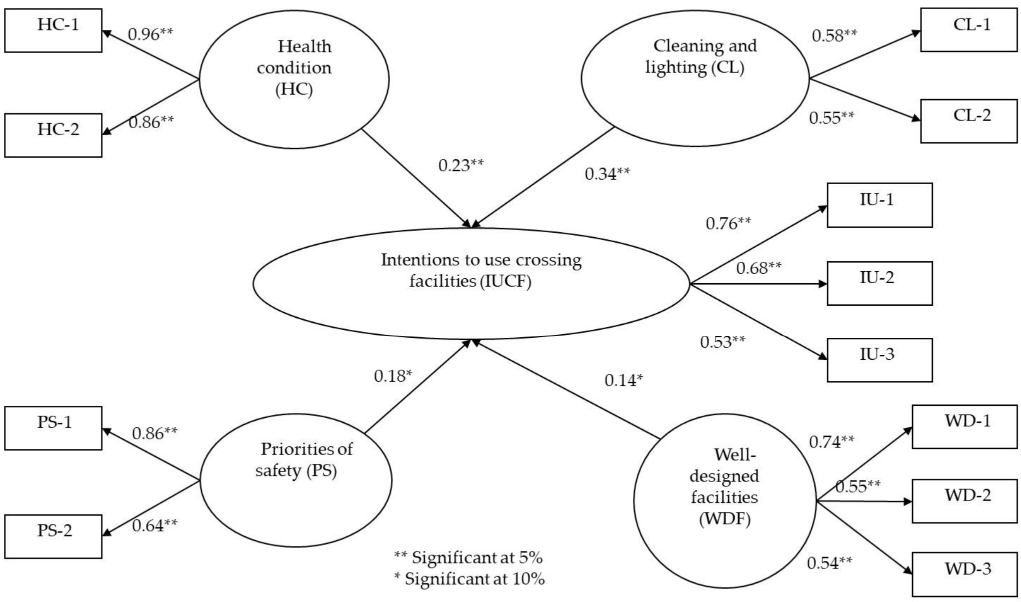

Figure 6. Structural model of pedestrian 's intentions to use crossing facilities.

The structural estimate between health HC and IUCF is positive and significant at a 5% level of significance. It shows that the pedestrians who do not believe their physical condition influences their use of crossing facilities would have a greater preference for using such facilities. This is true considering the age distribution of the collected samples, as most of the respondents belong to the young age group and it would not be difficult for them to walk through a pedestrian footbridge or/and underpass. However, the aged people might be reluctant to use such grade-separated pedestrian crossings. The structural relationship between IUCF and PS is positive and significant at a 10% level of significance, which depicts that people who give more priority to safety would prefer to use crossing facilities. The other studies also reported that pedestrians who give high importance to safety prefer to use crossing facilities. Crossing through proper channels or paths makes pedestrians safer. Therefore, it is vital to make sure that all the provided facilities such as footbridges and underpasses are safe for pedestrian crossings.

The structural estimate of CL with IUCF is positive and significant at a 5% level of significance. It shows that better physical conditions and proper lighting of crossing facilities would encourage people to use these facilities; therefore, cleaning and lighting will help to improve the aesthetic and security of the footbridges and underpasses. At present, it has been observed that many of the pedestrian underpasses do not have proper lighting, and it is dangerous for pedestrians to use them at night. Additionally, the underpasses become blocked by water whenever there is rain.

Proper drainage, cleaning, and lighting are important to encourage pedestrians to use crossing facilities regularly. The factor of WDF has a significant (at a 10% level of significance) and a positive structural relationship with IUCF. This structural relationship depicts that proper consideration of design requirements concerning the local weather and physical environment would attract pedestrians to use the available crossing facilities. Other researchers have also reported that a better and reasonable design of facilities can enhance the use of crossing facilities [27]. Sheltered pedestrian facilities would be an additional element to encourage pedestrians, as it is difficult to walk for long in hot weather. The design should also consider suitable aesthetic requirements. Improved design and aesthetic features would help to enhance the pedestrians' comfort, security, and convenience in using the footbridges and underpasses, as other studies have also argued on the same design and service requirements of pedestrian crossing facilities [11,12].

The credibility of the developed structural model was checked by using the goodness of fit parameters. For example, the ratio of the chi-square test to the degree of freedom (chi-square/DF) is between two and five; the GFI, AGFI, and CFI values are near or more than 0.9; and the RMR and RMSEA values are less than 0.08. This comparison of the goodness of fit parameters' indices with their permissible values show that the developed structural model has good reliability in predicting pedestrians' behavior toward pedestrian facilities.

5. Conclusions

This research was conducted to identify the significant factors affecting the pedestrians' preferences to use pedestrian crossing facilities, especially footbridges and underpasses. For this purpose, a questionnaire survey was designed and conducted in Nizwa city, Oman. The survey results revealed that most of the pedestrians belong to the worker category and they frequently cross the roads to visit different shopping places at main activity centers.

The main reasons for pedestrian accidents included the absence of crossing facilities, aggressive driving behavior, and a lack of respect from drivers for spaces shared with pedestrians. The roads in front of Nizwa Grand Mall, and between Lulu and Mukhtar gift center are found to be critical for crossing, as there are no crossing facilities.

At a young age, pedestrians do not find it hard to use a pedestrian footbridge and an underpass for crossing roads. However, the situation for old-aged pedestrians might be different. The factors of pedestrians' priorities regarding the safety of crossing, health conditions, proper cleaning and lighting, and good design of the facilities are significant predictors of the pedestrians' intentions to use crossing facilities. The developed structural model has good reliability in predicting pedestrian behavior toward crossing facilities. There is a need to provide a pedestrian footbridge or an underpass in front of Nizwa Grand Mall and the road between Lulu and Mukhtar gift center, as these locations have a significant volume of pedestrians who cross these roads on a regular basis. The crossing facilities needed to be maintained properly such that it is required to install proper lighting systems and ensure that proper cleaning is conducted at regular intervals. There is also a need to ensure a proper drainage system in underpasses as they usually become blocked after rain during rainy seasons. Properly sheltered crossing facilities would help to protect the pedestrians from high temperatures, especially in the summer season.

A proper and efficient design of crossing facilities would help in promoting their usage. It is necessary to keep the length of a footbridge and an underpass short for pedestrians in order to avoid longer walking times. Longer walking times discourage pedestrians from using crossing facilities [10]. Additionally, the height of a footbridge is required to be low, or they may be equipped with an elevator. The provision of an elevator would even encourage aged pedestrians to use footbridges.

Climatic and environmental factors have a significant impact on the efficient design of crossing facilities. The walking ability of the pedestrians is related to their age and the temperature of a particular area. Therefore, proper consideration should be given to the local climatic conditions of an area while planning and designing pedestrian facilities. Proper awareness regarding the benefits of using crossing facilities should to be highlighted among pedestrians. There is also a need to create a sense of respect among vehicle drivers for pedestrians to ensure pedestrians' safety in shared spaces. The language barrier between the researchers and the target respondents should be kept in mind as the majority were uneducated and they needed a translation for each sentence.

This study is based on a small sample size and the extracted findings may have limitations in implementation. Future studies should focus on assessing pedestrian behavior with a large sample size across different age groups. The distraction aspects of pedestrians also need to be assessed in future studies. Pedestrians' flow, physical, health, and attitudinal characteristics require consideration while assessing the design requirements of the various crossing facilities. Future studies should also consider pedestrians' crossing behavior at unsignaled and signaled intersections. In this regard, a comparison may be made between different types of crossing facilities considering pedestrians' perceptions. Despite limitations, the findings of this research study have significant implications for the design of efficient and safe crossing facilities for pedestrians in Nizwa, Oman.

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