

EVALUATION OF PEDESTRIAN CROSSING BEHAVIOR AT SELECTED CROSSING FACILITIES USING STATISTICAL TECHNIQUES IN CHATTOGRAM CITY CORPORATION

Sourav Das ^{*1} and Rafee Ahmed²

¹ *Assistant Professor, Department of Urban & Regional Planning, Chittagong University of Engineering & Technology, Chittagong, Bangladesh, e-mail: souravurp09@cuet.ac.bd*

² *Graduate Student, Department of Urban & Regional Planning, Chittagong University of Engineering & Technology, Chittagong, Bangladesh, e-mail: u1705022@student.cuet.ac.bd*

***Corresponding Author**

ABSTRACT

Pedestrians are among the most vulnerable road users, and their safety has not been given the necessary attention, particularly in developing countries. In Bangladesh, many pedestrians die yearly due to road crashes, many of whom die while crossing roads. There is a need for further research on pedestrian crossing behaviour in different cultural and social contexts, as well as the evaluation of different crossing facility designs and traffic control devices. The aim of this study is to evaluate pedestrian crossing behaviour at selected pedestrian crossing facilities using statistical techniques in Chattogram City Corporation. To achieve this objective, a survey was conducted on 350 participants, and factor analysis was carried out to categorize pedestrian behavior into five factors: violation, lapse, error, risk, and positive behavior. The questionnaire was prepared in both Bangla and English to enhance clarity and ensure more accurate responses, comprised a combination of open-ended and closed-ended questions. To determine the correlation between pedestrians' demographic features, behavioral characteristics and pedestrian perception, statistical tests such as Principal component analysis (PCA), Mann Whitney U test, Kruskal Wallis H test, Post hoc test (Dunn's test with Bonferroni correction) were performed using spreadsheet applications in combination with statistical software, particularly SPSS version 25. Consequently, Cronbach's alpha coefficient and Kaiser-Meyer-Olkin (KMO) metric were used to measure the questionnaire's reliability and data suitability for factor analysis. Nevertheless, The results showed that pedestrian behavior patterns such as violations, lapses, errors, and risks differ by gender. Men were found to make statistically more violations and lapses and take more risks than female road users. These patterns suggest that female pedestrians generally demonstrate greater caution and stronger adherence to traffic rules and regulations during road crossing. Moreover, pedestrians from the low-income group, who often lack formal education, exhibited more violations and risk-taking behavior than those from the higher-income group. Pedestrians belonging to higher-income brackets and older road users demonstrated a substantially greater demand for enhanced pedestrian facilities than those in lower-income groups, likely reflecting a heightened awareness of their civic rights and expectations regarding the quality of public infrastructure. Finally, it presents recommendations to ensure safe and efficient pedestrian movement in Chattogram city. In conclusion, this study reveals the significant impact of demographic features on pedestrian behavior and emphasizes the importance of developing targeted interventions to improve pedestrian safety, particularly in developing countries.

Keywords: *Pedestrian, Crossing Behaviour, Risk, Factor analysis, Road safety.*

1. INTRODUCTION

Pedestrian crossings are a vital component of road infrastructure, providing pedestrians with a safe and convenient way to cross roadways (Antić et al., 2016). Pedestrian crossings serve as essential links within the transport network integrating walking, cycling, and public transit modes, yet their effectiveness is often constrained by a range of challenges related to their implementation, operation, and long-term maintenance (Battistini et al., 2023). However, the exploration of traffic conflicts between vehicles and pedestrians is crucial in enhancing intersection safety and improving traffic flow, making it a valuable area of research (Yang et al., 2022). Pedestrian crossings also play a vital role in supporting sustainable mobility by encouraging people to walk and bicycle rather than drive (Zubaer et al., 2022). It may also be utilized to promote active commuting, which has various health advantages, including enhanced physical fitness, a decreased risk of heart disease, and enhanced mental health.

Pedestrian crossing behaviour is a topic of interest not only in Bangladesh but also globally. Understanding pedestrian behaviour at crossings is crucial for promoting pedestrian safety and ensuring the efficient functioning of transportation systems (Hoogendoorn & Bovy, 2004). Across the world, researchers have conducted studies on pedestrian behaviour and the factors that influence it. There is a need for further research on pedestrian crossing behaviour in different cultural and social contexts, as well as the evaluation of different crossing facility designs and traffic control devices. In many countries, researchers have used various techniques to evaluate pedestrian crossing behaviour, including direct observation, surveys, traffic simulations, and statistical analysis (Räsänen et al., 2007). Direct observation involves observing and recording pedestrian behavior at crossings, such as their walking speed, decision-making, and interactions with other pedestrians and vehicles (Hasan & Napiyah, 2018). Traffic simulations are specialized computer models that replicate pedestrian and vehicular movements at crossing facilities, enabling researchers to examine pedestrian behavior and interaction dynamics within a controlled, risk-free virtual environment (Hussain & Sinha, 2021). According to Antić et al., (2016), various statistical techniques are employed to understand the patterns and correlations in the collected data. Some of the commonly used statistical techniques include the Mann-Whitney test, also known as the Wilcoxon rank-sum test, which is a non-parametric statistical test used to compare the medians of two independent groups (Paschalidis et al., 2016). Again, it is used to determine if there is a significant difference between the medians of two groups and can be applied to continuous or ordinal data. Another test Kruskal-Wallis is a non-parametric statistical method used to assess if there are any significant differences in the median values among two or more independent groups (Zubaer et al., 2022). Similarly, in the field of data analysis, Principal Component Analysis (PCA) is a linear method that converts a group of potentially correlated variables into a smaller collection of uncorrelated variables (Hussain & Sinha, 2021), known as principal components, which capture the maximum amount of variation in the original data.

Furthermore, there has been inadequate evaluation of the effectiveness of various crossing infrastructures in enhancing pedestrian safety in the region, and few studies have employed statistical methods to examine pedestrian crossing behaviour and its influencing factors. Additionally, cultural and social aspects that have an impact on pedestrian behaviour have been largely overlooked in previous research. The aim of this study is to evaluate pedestrian crossing behaviour at selected pedestrian crossing facilities using statistical techniques in Chattogram City Corporation. The results of this research might be used to generate standards for boosting the safety and efficacy of pedestrian crossings, hence promoting more mobility.

2. LITERATURE REVIEW

Urban intersections are critical points in urban road networks, where pedestrians, motor vehicles, and non-motor vehicles converge, leading to a higher likelihood of traffic accidents compared to other road sections. Therefore, it is crucial to comprehend the characteristics of pedestrian crossing behavior at intersections to enhance pedestrian safety (Yang et al., 2022).

Pedestrian behavior refers to the actions and decisions made by individuals when they are walking, particularly in urban environments (Mindell et al., 2017). Over the years, there have been numerous

studies and articles that have investigated pedestrian behavior, with the aim of understanding the factors that influence it and developing strategies to improve pedestrian safety and mobility (Hussain & Sinha, 2021). Age is another important factor that influences pedestrian behavior. Additionally, studies have shown that individuals with impaired vision or hearing are more likely to have difficulty crossing roads, as they may have trouble seeing or hearing oncoming traffic. Distracted pedestrians, who may be using their smartphones or other electronic devices, are also more likely to make mistakes when crossing roads, such as failing to look both ways before crossing (Ma et al., 2020). Research studies have also shown that socioeconomic status can impact pedestrian behavior, with individuals from lower-income communities being more likely to engage in risky behaviors, such as crossing roads outside of designated crossing facilities (Antić et al., 2016).

The design of crosswalks and pedestrian bridges is an important part of crossing facilities. Crosswalks with contrasting colors and high-visibility markers are more successful in attracting attention and encouraging pedestrians to cross at authorized spots (Hussain & Sinha, 2021), shown in Figure 1(a). In addition, pedestrian bridges and overpasses may offer pedestrians a safe and convenient means to cross congested highways, therefore lowering the likelihood of accidents and injuries, Figure 1(b). Studies have shown that signalized crossings with timed crosswalks are more successful at encouraging pedestrians to cross at specified areas, but junctions with high traffic volumes may be less safe and less convenient for pedestrians (Ravishankar & Nair, 2018).

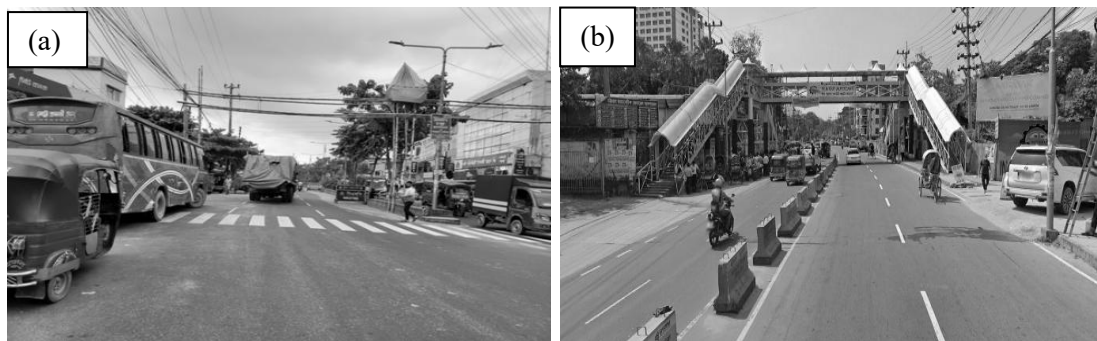


Figure 1: (a) Zebra crossing of Kaptai Rastar Matha Intersection, (b) Grade-separated crossing of Wireless Mor

In statistics, a reliability test refers to the degree to which a measuring instrument, such as a survey, test, or questionnaire, provides consistent findings if performed numerous times under identical circumstances (Hussain & Sinha, 2021). Typically, the results of a reliability assessment are expressed as a reliability coefficient ranging from 0 to 1, such as Cronbach's alpha, Pearson's correlation where values approaching 1 reflect a high level of dependability, indicating that the measurement instrument produces consistent outcomes, while values nearer to 0 signify weak reliability (Antić et al., 2016). Principal Component Analysis uses linear methods to transform the data into a new coordinate system, where the first principal component has the highest variance, followed by the second, and so on (Díaz, 2002). These new coordinates, known as principal components, are linear combinations of the original variables and their coefficients are called loadings. Therefore, the objective of PCA is to identify a smaller number of uncorrelated variables, or principal components, that capture most of the variation in the original set of variables. However, in factor analysis and PCA, the Varimax rotation approach is used to make the results more interpretable. The Kaiser-Meyer-Olkin test can be used to determine if a dataset is suitable for factor analysis, a technique for identifying patterns in a collection of data (Granić et al., 2014). If the findings of the KMO test are poor, it may suggest that the variables in the dataset lack adequate inter-correlation, necessitating the change of the dataset or the evaluation of other statistical approaches (Hussain & Sinha, 2021). The Mann-Whitney test is a non-parametric statistical technique used to compare the medians of two distinct samples. This test may be used to continuous and ordinal data when the sample size is limited or when the distributions of the two populations vary. If these conditions are not satisfied, an alternative statistical test may need to be used (Antić et al.,

2016). The Kruskal-Wallis H test is a non-parametric approach for comparing the statistical probability that two or more groups are statistically distinct. This approach is particularly effective when the data under investigation deviate from a normal distribution and when group variances are not comparable. The Kruskal-Wallis test is based on ordering the data, making it less vulnerable to outliers than tests that depend on actual values (Madhuwanthi et al., 2016). To dig further into the distinctions between subsets of participants, additional statistical analysis may be conducted using a post-hoc test. It's a common tool for figuring out which groups in an experiment are substantially different from one another (Zhuang & Wu, 2011). After an initial test has been performed and significant differences have been detected, post-hoc tests are utilized to do additional in-depth comparisons across groups.

3. METHODOLOGY

3.1 Study area profile

Chattogram is the second largest city in Bangladesh and serves as the country's commercial capital, is expanding at a rapid pace and facing similar environmental limitations to other cities in the country. The traffic system in Chittagong, Bangladesh can be chaotic and congested at times (Daily sun, 2023). The selection of the six sites: Kaptai Rastar Matha, Muradpur, Nasirabad 2nd Gate, BAWA School, Lalkhan Bazar and Wireless Morwas guided by citywide accident records and prevailing traffic conditions, ensuring that each location was appropriate and compatible for the study's objectives.

3.2 Sample size determination

Sampling is a statistical method of selecting a representative subset, or sample, from a larger population, in order to make inferences or draw conclusions about the entire population. Simple random sampling (Slovin's Formula) was used for determining the sample size (Yang et al., 2020), shown in Equation 01.

$$n = \frac{N}{1 + N(d)^2} \quad (01)$$

Where,

n = Sample size

N = Number of the population (6 million) according to CCC

d = Margin of error/confidence interval (0.05)

Total sample size = 350.

3.3 Data acquisition

A survey was conducted to examine the factors that contribute to the insufficient utilization of road crossing facilities. The questionnaire was created in both Bangla and English to ensure more accurate results. It consisted of a mix of open-ended and closed-ended questions, where respondents simply had to check a box for each question and could add additional details if desired. To avoid confusion, separate questionnaires were designed for different types of pedestrians, but with identical questions. The researcher was available to assist in case of any difficulties with answering the questions. Secondary data were gathered from several sources, including past theses, journals, books, and the internet. The maps of the research region, relevant plans, laws, etc. were compiled from secondary sources. Data analysis was performed using spreadsheet applications in combination with statistical software, particularly SPSS version 25.

4. DATA ANALYSIS AND RESULTS

Demographic features are the characteristics of a population used to describe and categorize groups of individuals. A randomly selected group of 350 pedestrians was used to represent the overall population. The majority of survey participants were male (178) and the age group with the highest representation was found to be 35–45 years.

Table 1: Demographic profile of the respondents

Demographic profile of Percentage (%)		
Gender	Male	50.86
	Female	49.14
Age	<18	8.86
	18-25	23.14
	25-35	23.14
	35-45	30.86
	45-55	8.57
	>55	5.43
	Education	Class 8
SSC		10
HSC		22
Others		53.71
Monthly Income	0-20000	42
	20000-40000	33.14
	40000-60000	17.43
	>60000	7.14
Marital Status	Married	66.86
	Unmarried	33.14
Mobile Phone User	Yes	97.71
	No	2.29
Dwelling Condition	Personal	32.86
	Rental	40
	Slum	18.57
	Office Quarter	5.71
	Others	2.57
Purpose of travel	Necessity	94.57
	Pleasure	5.43
Daily Distance Walked	<300m	4
	300-800m	25.14
	800-1300m	36.57
	>1300m	34.29

4.1 Pedestrian crossing behaviour

The questionnaire consisted of two sections: the first collected participants' socio-economic and demographic information (Table 1), while the second explored their behaviors and perceptions at junctions. The latter section included 15 questions divided into five categories: violations, lapses, mistakes, risk-taking, and safe conduct with responses recorded on a 5-point Likert scale ranging from "Never" to "Always." Cronbach's alpha is a measure of internal consistency that evaluates the dependability of a multi-item scale by comparing the consistency of its items to the overall scale score. The study was conducted to assess the reliability of the 15-item perceived task values scale. Cronbach's alpha coefficient was used to measure the questionnaire's reliability and the score obtained was 0.898. This score indicates that the questionnaire's reliability is satisfactory, meaning that the items in the questionnaire are consistent in measuring the same construct. Using factor loadings, principal component analysis (PCA) determines which initial variables are most closely related with each principal component. Multiplying the eigenvectors (principal components) by the inverse of the eigenvalues yields the factor loadings. The range of factor loading values is from -1 to 1. A factor loading of 1 implies a perfect positive correlation between the original variable and the main component, whereas a factor loading of -1 shows a perfect negative correlation. Upon examination of the individual items in the questionnaire, the majority were deemed worthy of retention. However, one exception was noted, Item no 13 appeared to be problematic, as its removal would increase Cronbach's alpha to 0.910, indicating improved overall reliability. The Kaiser-Meyer-Olkin (KMO) metric is used

to determine if a data set is suitable for factor analysis. In general, a KMO value larger than 0.6 indicates that a data set is suitable for factor analysis, while a low number indicates the less suitable condition.

Principal Component Analysis (PCA) selects independent variables, known as principal components, which capture most of the variability present in the complete set of variables. After proving dependability (Cronbach's alpha = 0.898), all 14 parameters were subjected to a principal component analysis using orthogonal varimax rotation. The first "violation" factor accounted for 23.9% of the total variance. Three elements described the infraction; two of them concerned the method by which the offender crossed the street (for example, "I cross the street diagonally to save time"; factor loading: .656), while the second item was general in nature (e.g., "I do not cross the street at the marked pedestrian crossing even though there is one within 50m."; factor loading: .757). Everything loaded along this axis was doing so on purpose, either because it was dangerous or because it was illegal shown in Table 2. The second factor, "Error," accounted for 18.9 percent of the total variance. The "Error" was characterized by three factors. Mistakes happen when pedestrians cross the roadway based on faulty assumptions (e.g., "On a two-way street, I cross the first section and wait in the center of the road to cross the second section", factor loading: 0.737). The third factor, "lapse," was responsible for 13.3% of the dispersion. There were three main characteristics of the slip-up. Misconduct caused by momentary disengagement from an activity was categorized as a "lapse" ("Before crossing the street, I did not glance left and right because I was talking to a friend"; factor loading: 0.807). As the fourth factor, "Risk" was responsible for 11.9% of the variance. There were three questions in the survey dedicated to defining error, which was described as "an action connected with an elevated probability of loss or injury" (e.g., "Cross between cars stopped on the street," factor loading 0.802). The fifth component, exemplary actions, accounted for 10.9% of the total variance. Three traits were used to characterize positive actions. The term "positive behavior" was defined as activities that result in favorable social outcomes (e.g., "I am thankful to the drivers that let me cross the street first"; factor loading: .890).

The distribution of respondents' answers across the five response categories ranging from Never to Always as presented in Table 3, reveals several critical behavioral patterns that significantly influence pedestrian safety. Although 40.92% of respondents reported that they never use a mobile phone while crossing the road, a notable proportion nearly 16% indicated that they often or always engage in this behavior, thereby substantially increasing their exposure to the risk of serious road accidents (Table 3). Moreover, the persistent absence of pedestrian Traffic signals in cities such as Chattogram appears to exacerbate unsafe pedestrian practices, as evidenced by the considerable percentage of respondents who admitted to actions like "crossing the road diagonally" or "proceeding without checking for oncoming vehicles due to being in a hurry" behaviors that collectively highlight a widespread tendency to disregard established traffic regulations at crossing points. These pedestrian behaviors are further compounded by observational findings indicating that vehicles frequently move through intersections and over marked crosswalks without stopping at the designated stop line, creating conditions in which pedestrians are compelled to navigate through traffic in unsafe ways. For instance, practices such as crossing between vehicles halted in traffic congestion or attempting to use zebra crossings even when vehicles have already crossed the stop line and obstructed the crosswalk illustrate the complex interplay between driver non-compliance and pedestrian risk-taking. The findings indicate that more than 75% of respondents engage in behaviors such as crossing between moving vehicles or using the crosswalk when it is already encroached upon by traffic actions that collectively heighten their vulnerability to severe accidents.

4.2 Association of gender with pedestrians' behaviour

Gender-based statistical comparison of pedestrian crossing behaviors represents that males exhibits statistically significant amount of violations ($Z = -2.26$, $p = 0.023$), mistakes ($Z = -3.40$, $p = 0.001$), risks ($Z = -3.97$, $p = 0.010$), and positive behaviors ($Z = -2.92$, $p = 0.003$) than females, indicating greater behavioral variability among male pedestrians (Table 4). In contrast, the lapse ($Z = -0.260$, $P = 0.795$) reveals no statistical significance across gender difference.

Table 2: Factor analysis of 14 items (Varimax rotation)

How often do the presence of/how often do you	Component				
	1 Violation	2 Error	3 Lapse	4 Risk	5 Positiv Behavior
Cross the road diagonally in order to save time	0.656				
I do not cross the street at the marked pedestrian crossing even though there is one at the distance smaller than 50m.	0.757				
Use mobile phone while crossing the road	0.730				
I start street crossing at the marked pedestrian crossing but I finished outside of it		0.799			
When I want to overtake a slow-moving person and I do not have enough space to do it, I go into the road		0.622			
On a two-way street, I cross the first part and wait in the middle of the roadway to cross the second		0.737			
Cross the road and did not look left and right because I was in a hurry			0.811		
Cross the road and did not look left and right because I was talking to a friend			0.807		
Cross the road and did not look left and right because there were pedestrians moving in front me			0.857		
Cross between vehicles stopped on the roadway in traffic jams				0.802	
Start road crossing at the marked pedestrian crossing but finished outside of it				0.744	
Use crosswalk (zebra crossing) when the vehicle crosses the stop line and occupies the crosswalk				0.722	
While crossing the road I give priority to vehicles even though I am at the marked pedestrian crossing					0.890
While there is a crowd at the pedestrian crossing, I give priority to the pedestrians from the opposite direction					0.880
Percent of explained variance in rotated sums of squared loadings	23.9%	18.9%	13.3%	11.9%	10.9%

Table 3: Distribution of participants' responses

Item (How often do you. . .)	Answers to (%)				
	Never	Rarely	Some times	Often	Always
	01.	02.	03.	04.	05.
01 Cross the road diagonally in order to save time	26.86	25.00	15.71	17.43	15.00
02. I do not use pedestrian crossways at the distance smaller than 50m	30.14	24.43	26.71	10.72	8.60
03. Use a mobile phone while crossing the road	40.92	23.45	18.41	13.92	3.30
04. I start street crossing at the marked pedestrian crossing but I finished outside of it	10.57	27.37	31.17	21.22	9.67
05. When I want to overtake a slow-moving person and I do not have enough space to do it, I go into the road	11.43	30.14	25.71	20.86	11.86
06. On a two-way street, I cross the first part and wait in the middle of the roadway to cross the second part	12.12	24.82	32.67	21.86	8.53
07. Cross the road and didn't look left and right because you were in a hurry	24.57	21.57	29.57	17.00	7.29

08.	Cross the road and didn't look left and right because you were talking to a friend	29.86	25.71	17.57	20.47	6.39
09.	Cross the road and didn't look left and right because pedestrians were moving in front of me	27.89	26.95	32.63	8.27	4.26
10.	Cross between vehicles stopped on the roadway in traffic jams	25.30	22.37	33.37	11.82	7.14
11.	Start road crossing at the marked pedestrian crossing but finished outside of it	23.51	28.73	20.47	16.74	10.55
12.	Use the crosswalk when the vehicle crosses the stop line and occupies the crosswalk	22.53	21.62	27.22	21.25	7.38
13.	While crossing the road I give priority to vehicles even though I am at the marked pedestrian crossing.	7.46	10.09	38.05	29.73	15.25
14.	Give priority to the pedestrian from the opposite direction when there is a crowd at the pedestrian crossing	50.11	20.80	13.71	8.51	6.85

Table 4: Association of gender with pedestrians' behaviour

GENDER		VIOLATION	ERROR	LAPSE	RISK	POSITIVE BEHAVIOUR	
FEMALE	Median	2.000	3.000	2.000	3.000	3.000	
	Percentiles	25	2.000	2.000	1.000	2.000	2.000
		75	4.000	3.000	4.000	4.000	4.000
	Median	3.000	3.000	2.000	4.000	4.000	
MALE	Percentiles	25	2.000	2.000	1.000	2.000	2.000
		75	5.000	4.000	4.000	5.000	5.000
	Mann-Whitney U test	Z	-2.267	-3.407	-0.260	-3.977	-2.927
	P	0.023	0.001	0.795	0.010	0.003	

Furthermore, Based on the mean ranks, males exhibit higher frequencies of violations, errors, lapses, and risk-taking behaviors compared to females. The analysis indicates that male pedestrians generate statistically significantly more violations, errors, and lapses, while also engaging in greater risk-taking, highlighting gender-based differences in road-crossing behaviors.

Table 5 : Association of age and pedestrian behaviour

Age group (years)		Violation	Lapse	Error	Risk	Positive Behavior	
<18	Median	4.00	3.00	4.00	4.00	5.00	
	Percentile	25	3.00	2.00	3.00	4.00	4.00
		75	5.00	4.00	4.00	5.00	5.00
18-25	Median	4.00	3.00	3.00	4.00	5.00	
	Percentile	25	2.50	2.00	3.00	3.00	4.00
		75	5.00	4.00	4.00	5.00	5.00
25-35	Median	3.00	2.00	3.00	3.00	5.00	
	Percentile	25	2.00	2.00	2.00	2.00	4.00
		75	4.50	4.0	4.00	4.00	5.00
35-45	Median	2.00	2.00	3.00	2.00	4.00	
	Percentile	25	2.00	1.00	2.00	1.00	3.00
		75	3.00	3.00	3.00	4.00	5.00
45-55	Median	2.00	2.00	2.00	2.00	5.00	
	Percentile	25	1.00	1.00	2.00	1.75	3.00
		75	3.00	2.00	3.00	3.00	5.00

Kruskal Wallis Htest	Median		1.00	1.00	2.00	1.00	5.00
	Percentiles	25	1.00	1.00	2.00	1.00	5.00
		75	2.00	2.00	3.00	2.00	5.00
	P		0.00	0.00	0.00	0.0	0.01

4.3 Association of age with pedestrians' behaviour

The analysis indicates a significant positive correlation between age and various types of pedestrian behavior, including violations, lapses, errors, risk-taking, and positive behaviors, with all corresponding *p*-values falling below 0.05, shown in Table 5. To further assess the impact of specific age ranges on these behavioral variables, Dunn's test with Bonferroni adjustment was conducted (Table 6) to adjust for multiple comparisons, ensuring that the observed differences are statistically significant. The results revealed pedestrians under 18, between 35–55, and intermediate age ranges are significantly less likely to commit violations than those between 18-25 and over 55 older pedestrians exhibit riskier crossing behaviors, potentially due to reduced situational awareness. Besides, pedestrians aged 18–25 and >55 were found to contribute to a higher incidence of accidents than other age groups, likely due to lapses in judgment, a finding consistent with previous studies (Adjusted $p < 0.05$) (Hussain & Sinha, 2021). Furthermore, Analysis of pedestrian behavior indicates that individuals aged 18–25 and over 55 represents significantly higher levels of errors and risk-taking compared to other age groups. Additionally, pedestrians aged 35–45 and those over 55 reported greater concerns regarding inadequate pedestrian amenities.

Table 6: Multiple comparisons of age with pedestrian behavior (Dunn's test with Bonferroni correction)

Age group (years) Sample1 & Sample 2	Violation	
	P-value	Adjusted p value
>55 & 18-25	.000	.000
>55 & <18	.000	.000
	Lapse	
	P-value	Adjusted p value
>55 & 18-25	.000	.000
45-55 & 18-25	.000	.006
35-45 & 25-35	.002	.023
>55 & 25-35	.002	.028
	Error	
	P-value	Adjusted p value
>55 & 18-25	.000	.002
	Risk	
	P-value	Adjusted p value
>55 & 45-55	.000	.000
>55 & 35-45	.000	.000
>55 & 25-35	.000	.000
>55 & <18	.000	.000
>55 & 18-25	.000	.000
35-45 & 18-25	.000	.002
45-55 & 18-25	.002	.028
	Positive Behavior	
	P-value	Adjusted p value
25-35 & 35-45	.002	.037

25-35 & >55	.000	.000
18-25 & >55	.000	.000
<18 & >55	.000	.000
45-55 & >55	.000	.001
35-45 & >55	.000	.004

4.4 Association of monthly income with pedestrian behaviour

Monthly income and pedestrian behaviours were found to have positive correlation among violations, lapses, risks, and errors (Adjusted $p < 0.05$) and no statistically significant correlation between positive behaviour and income suggesting that individuals with income levels (>60000) and (<20000) are more likely to engage in risky crossing behaviours (Table 7). The most prominent finding across the Violation, Lapse, and Risk categories is the highly significant difference exhibited by the income bracket ($>60,000$) and (<20000) compared to the middle-income (20000-40000) groups (Table 8). This suggests that individuals in this category may engage in more deliberate forms of rule-breaking. In contrast, the Error behaviour category showed the most complex pattern of differences, primarily involving the mid-low (20,000–40,000) and lowest ($<20,000$) income groups which often experience economic strain, extended working hours, and greater physical fatigue, thereby increasing the likelihood of Errors (Table 8).

Table 7: Association of monthly income and pedestrian behaviour

Monthly income (in taka)		Violation	Lapse	Error	Risk	Positive Behavior	
<20000	Median	4.00	3.00	3.00	4.00	5.00	
	Percentile	25	3.0	2.00	2.00	3.00	4.00
		75	5.00	4.00	4.00	5.00	5.00
20000-40000	Median	2.00	2.00	3.00	2.00	4.00	
	Percentile	25	2.00	2.00	2.00	2.00	3.00
		75	3.00	3.00	4.00	4.00	5.00
40000-60000	Median	2.00	1.00	2.00	1.00	5.00	
	Percentile	25	1.00	1.00	2.00	1.00	4.00
		75	2.00	2.00	3.00	2.00	5.00
>60000	Median	1.00	1.50	3.00	1.00	5.00	
	Percentile	25	1.00	1.00	1.75	1.00	4.00
		75	2.00	4.00	3.00	2.00	5.00
Kruskal Wallis H test		P	0.00	0.00	0.00	0.11	

Table 8: Multiple comparisons of monthly income with pedestrian behavior (Dunn's test with Bonferroni correction)

Monthly income (in Taka) Sample 1 & Sample 2	Violation	
	P-value	Adjusted p-value
>60000 & 40000-60000	.004	.018
>60000 & 20000-40000	.000	.000
>60000 & <20000	.002	.007
	Lapse	
	P-value	Adjusted p-value
>60000 & 20000-40000	.000	.000
40000-60000 & <20000-40000	.003	.008
	Risk	
	P-value	Adjusted p-value

>60000 & 20000-40000	.000	.003
	Error	
	P-value	Adjusted p-value
<20000 & 40000-60000	.000	.001
20000-40000 & <20000	.000	.001
20000-40000 & 40000-60000	.005	.032
20000-40000 & >60000	.002	.011

5. FINDINGS

This study investigates pedestrian road-crossing behaviours across locations equipped with pedestrian infrastructure and reveals notable gender-based differences. The findings show that males exhibit a higher tendency to engage in violations, lapses, and risk-taking behaviours compared to females. These patterns suggest that female pedestrians generally demonstrate greater caution and stronger adherence to traffic rules and regulations during road crossing. Similar gender disparities in pedestrian behaviour have been consistently reported in previous research (Granié et al., 2014; Hussain & Sinha, 2021). There is a statistically significant relationship between an individual's age and each of five unique pedestrian behaviours. The results revealed pedestrians under 18, between 35–55, and intermediate age ranges are significantly less likely to commit violations than those between 18-25 and over 55 older pedestrians exhibit riskier crossing behaviours, potentially due to reduced situational awareness. Furthermore, analysis of pedestrian behaviour indicates that individuals aged 18–25 and over 55 represents significantly higher levels of errors and risk-taking compared to other age groups. The group of pedestrians with lower incomes was seen to commit more violations and take greater risks than the group with higher incomes. Such groups often experience economic strain, extended working hours, and greater physical fatigue that sometimes leads them to catastrophic error in judgements. On the other hand, the group of pedestrians with higher incomes was shown to be more demanding of pedestrian facilities than the group with lower incomes, maybe due to a stronger grasp of the civil rights, reported in previous research (Hussain & Sinha, 2021).

6. CONCLUSIONS

Pedestrian safety represents a critical public health concern as pedestrians are inherently vulnerable within traffic environments and incidents involving them often result in severe injuries or fatalities. The study findings indicates that the provision of traffic signals is a critical concern for older pedestrians and individuals from higher-income groups, while lower income pedestrian groups exhibit higher risk-taking and rule violations in Chattogram city. Consequently, the research can provide evidence-based guidance for urban planners and policymakers to prioritize pedestrian oriented infrastructure and integrate safety considerations into urban transport planning. However, the study is limited by its focus on a specific urban context and a larger sample size would further strengthen the robustness and representativeness of the results. In conclusion, the adoption of comprehensive measures including the enhancement of pedestrian infrastructure, enforcement of traffic regulations and the promotion of road safety awareness can play a pivotal role in significantly improving pedestrian safety.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to the Thesis Board Members of the Department of Urban and Regional Planning (CUET) for their guidance and valuable comments. The authors declare that there is no conflict of interest and no external funding was received for this study.

DECLARATION OF USE OF AI

The authors declare that no artificial intelligence (AI) tools were used in the research methodology, data analysis or research process; only standard software was used for formatting or language editing.

REFERENCES

Antić, B., Pešić, D., Milutinović, N., & Maslač, M. (2016). Pedestrian behaviours:

- Validation of the Serbian version of the pedestrian behaviour scale. *Transportation Research Part F: Traffic Psychology and Behaviour*, 41 (PartA), 170–178. <https://doi.org/https://doi.org/10.1016/j.trf.2016.02.004>
- Battistini, R., Lantieri, C., Simone, A., Dondi, G., & Vignali, V. (2023). A Decision Support System for the safety evaluation of urban pedestrian crossings. *Transportation Research Procedia*, 69, 655–662. <https://doi.org/10.1016/j.trpro.2023.02.220>
- Daily sun. (2023). Traffic system still runs manually in Ctg, [https:// printversion/details/309366/Traffic-system-still-runs-manually-in-Ctg](https://printversion/details/309366/Traffic-system-still-runs-manually-in-Ctg), Accessed October 17, 2025.
- Demiroz, Y. I., Onelcin, P., & Alver, Y. (2015). Illegal road crossing behavior of pedestrians at overpass locations: Factors affecting gap acceptance, crossing times and overpass use. *Accident Analysis & Prevention*, 80, 220–228. <https://doi.org/10.1016/j.aap.2015.04.018>
- Díaz, E. M. (2002). Theory of planned behavior and pedestrians' intentions to violate traffic regulations. *Transportation Research Part F: Traffic Psychology and Behaviour*, 5(3), 169–175. [https://doi.org/10.1016/S1369-8478\(02\)00015-3](https://doi.org/10.1016/S1369-8478(02)00015-3)
- Granić, M.-A., Brenac, T., Montel, M.-C., Millot, M., & Coquelet, C. (2014). Influence of built environment on pedestrian's crossing decision. *Accident Analysis & Prevention*, 67, 75–85. <https://doi.org/10.1016/j.aap.2014.02.008>
- Hasan, R., & Napiyah, M. (2018). The perception of Malaysian pedestrians toward the use of footbridges. *Traffic Injury Prevention*, 19(3), 292–297. <https://doi.org/10.1080/15389588.2017.1373768>
- Hoogendoorn, S. P., & Bovy, P. H. L. (2004). Pedestrian route-choice and activity scheduling theory and models. *Transportation Research Part B: Methodological*, 38(2), 169–190. [https://doi.org/10.1016/S0191-2615\(03\)00007-9](https://doi.org/10.1016/S0191-2615(03)00007-9)
- Hussain, A., & Sinha, S. (2021). Investigation of Pedestrian Crossing Behavior at Crossing Facilities in India. *Civil Engineering and Architecture*, 9(5), 1442–1455. <https://doi.org/10.13189/cea.2021.090517>
- Ma, Y., Lu, S., & Zhang, Y. (2020). Analysis on Illegal Crossing Behavior of Pedestrians at Signalized Intersections Based on Bayesian Network. *Journal of Advanced Transportation*, 2020, 1–14. <https://doi.org/10.1155/2020/2675197>
- Madhuwanthi, R. A. M., Marasinghe, A., Rajapakse, R. P. C. J., Dharmawansa, A. D., & Nomura, S. (2016). Factors Influencing to Travel Behavior on Transport Mode Choice. *International Journal of Affective Engineering*, 15(2), 63–72. <https://doi.org/10.5057/ijae.ijae-d-15-00044>
- Mindell, J. S., Anciaes, P. R., Dhanani, A., Stockton, J., Jones, P., Haklay, M., Groce, N., Scholes, S., & Vaughan, L. (2017). Using triangulation to assess a suite of tools to measure community severance. *Journal of Transport Geography*, 60, 119–129. <https://doi.org/10.1016/j.jtrangeo.2017.02.013>
- Paschalidis, E., Politis, I., Basbas, S., & Lambrianidou, P. (2016). Pedestrian compliance and cross walking speed adaptation due to countdown timer installations: A self report study. *Transportation Research Part F: Traffic Psychology and Behaviour*, 42, 456–467. <https://doi.org/10.1016/j.trf.2015.07.010>
- Räsänen, M., Lajunen, T., Alticafarbay, F., & Aydin, C. (2007). Pedestrian self-reports of factors influencing the use of pedestrian bridges. *Accident Analysis & Prevention*, 39(5), 969–973. <https://doi.org/10.1016/j.aap.2007.01.004>
- Ravishankar, K. V. R., & Nair, P. M. (2018). Pedestrian risk analysis at uncontrolled midblock and unsignalised intersections. *Journal of Traffic and Transportation Engineering (English Edition)*, 5(2), 137–147. <https://doi.org/10.1016/j.jtte.2017.06.005>
- Yang, W.-C., Lin, C.-N., & Hu, P.-H. (2020). Willingness and Obstacles of Food and Farming Education in Leisure Farm Management: Viewpoint of Experience Activities. *Open Access Library Journal*, 7(6), 1–14.
- Yang, Z., Gong, Z., Zhang, Q., & Wang, J. (2022). Analysis of pedestrian-related crossing behavior at intersections: A Latent Dirichlet Allocation approach. *International Journal of Transportation Science and Technology*, S2046043022001034. <https://doi.org/10.1016/j.ijst.2022.12.003>
- Zubaer, A. R., Mahi, R. F., Ratri, S. A., & Aziz, T. I. (2022). An Overview of Foot Over-Bridges at Dhaka City. *Journal of Advances in Civil Engineering and Management*, 5(1), 1–11. <https://doi.org/10.5281/ZENODO.6087177>.