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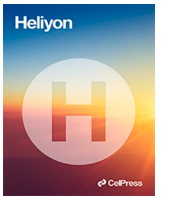

Research article

Factors affecting citizen safety of urban transportation service in Bangladesh: The case of Pabna municipality

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ABSTRACT

Background: With the rapid growth of cities, the extent of road accidents has increased, posing a threat to the safety of citizens. In Bangladesh, like many other countries, urban areas face a high incidence of road accidents, leading to loss of life, injuries, and economic costs. This research aims to investigate the factors affecting citizen safety of urban transportation service in Bangladesh.
Methods: This study utilized verbal interviews maintained by questionnaires to gather data on citizen perception regarding factors impacting transportation safety. The questionnaire consisted of two sections, collecting non-parametric data on travel behavior and socioeconomic factors, and parametric data on factors related to transportation safety. The dataset was subsequently analyzed using statistical devices such as descriptive statistics, Principal Component Analysis (PCA), Pearson's Correlation Matrix (PCM), and Cluster Analysis (CA).
Results and conclusion: The findings of the study indicate strong significant correlations among several pairs of variables. Notably, traffic rules and enforcement, and driver travel behavior demonstrate a strong positive correlation of 0.784. Similarly, vehicle condition and safety features, and traffic rules and enforcement display a robust positive association of 0.764. PCA demonstrate 23% of the total variance, with a significant positive loading affecting citizen safety, which is influenced by traffic rules enforcement and drivers' travel behavior. The research findings emphasize the implication of traffic rule enforcement and responsible driver behavior in ensuring citizen safety. In Bangladesh, inadequate transportation regulation enforcement has led to high rates of reckless driving and traffic accidents, especially among pedestrians, cyclists, and motorcyclists.

1. Introduction

Although safety holds significant importance across various human endeavors, it assumes an exceptionally prominent and indispensable role within the realm of transportation around the globe [1–5]. A safe transportation system not only safeguards the lives of individuals but also plays a decisive role in promoting economic growth, social connectivity, and sustainable development. Each passing year, the somber reality emerges that traffic accidents exact a grievous toll on humanity, with millions of lives being tragically cut short, representing an alarming annual fatality count of approximately 1.35 million worldwide [6,7]. Moreover, extending beyond the profound loss of human life, these harrowing incidents unleash a formidable economic burden, compelling nations to shoulder the weight of an estimated 3 % depletion in their Gross Domestic Product (GDP) on an annual basis [7]. With the ongoing trends of

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globalization, urbanization, and technological advancements, the demand for transportation services has been steadily increasing worldwide.

This growth is particularly pronounced in urban cities, which face unique challenges and complexities related to transportation. Population growth, fueled by natural increase and migration, has led to urban areas experiencing significant expansion [8]. As cities grow, the need for transportation services becomes more pronounced, as individuals must travel longer distances to access employment, education, and other essential services. Furthermore, the process of urbanization often results in the concentration of economic activities, leading to increased mobility requirements for both goods and people. As urban cities become hubs for commerce and employment opportunities, the demand for transportation services naturally follows suit [9,10]. Consequently, urban cities must grapple with the intricate task of providing efficient transportation systems to accommodate the increasing population. However, the convergence of diverse transportation modes, complex road networks, and limited space poses unique challenges in ensuring safe and reliable transportation services. The high volume of commuters, combined with various modes of transport operating in close proximity, increases the likelihood of accidents and incidents. Traffic congestion, inadequate infrastructure, lack of proper safety regulations and enforcement, and human factors such as driver behavior and pedestrian vulnerability all contribute to safety problems in urban transportation [11].

The issue exacerbates in developing nations due to the absence of appropriate and comprehensive measures. The concerning state of public transport safety in African and Asian countries is well-documented, highlighting issues such as inadequate vehicle maintenance, overloading, and insufficient driver training [5]. These issues contribute to the perception of public transportation as particularly hazardous in these regions. In Indonesia, the paratransit mode 'Angkutan Kota' plays a pivotal role in public transportation, notably in cities like Bandung and West Java. Public transport is crucial for a diverse demographic, including students and those with lower economic means, but faces criticism for its perceived impact on traffic congestion and the potential to compromise safety measures [5,12]. Similarly, in India, public transport faces overwhelming challenges, including issues of overcrowding, unreliability, sluggishness, inconvenience, lack of coordination, and compromised safety in bus and train services [13]. Furthermore, in Dominican Republic, citizens' experiences with crime-related incidents play a significant role in shaping their choice of public transportation for urban trips. This decision is also influenced by demographic factors, including age, education level, city or town size, and the perceived safety of the urban environment [14]. A similar pattern is observed in Colombia, with women feeling less safe than men due to the fear of crime in public transportation. Low-income individuals report the highest insecurity levels, while those with high incomes feel the safest. Additionally, younger and middle-aged respondents express more insecurity than older individuals [15].

In Bangladesh transportation safety has been a crucial concern in urban areas, where rapid urbanization and population growth have led to increased demand for efficient and safe transportation services [16,17]. However, since the independence of Bangladesh in 1971, transportation safety in the country leaves much to be desired, with numerous challenges and issues that need to be addressed. Worldwide, the road traffic mortality rate in 2016 was more than 15 deaths per 100,000 population, with Africa and South-East Asia experiencing higher rates of 26.6 and 20.7, respectively, representing an increase from 2013 (Fig. 1) [7]. Statistics reveal that Bangladesh has a remarkably high number of road traffic accidents globally. According to the World Health Organization (WHO), road traffic accidents in Bangladesh resulted in 24,954 deaths and 374,310 serious injuries in the year 2016, with 15.3 deaths per 100,000 population due to poor transportation safety [7]. Especially in urban areas transportation safety facing diverse challenges, including deficient road design and maintenance with issues like inadequate signage, poor lighting, and insufficient traffic calming measures [4,18,19]. Reckless driving behaviors, such as speeding, overtaking, and disregarding traffic signals, are common among drivers [20]. The use of non-standardized and poorly maintained vehicles, such as buses, rickshaws, and motorcycles, further escalates road accidents [13,21,22]. These problems result from factors such as inadequate infrastructure development, rapid urbanization, ineffective urban planning, insufficient transportation system investment, weak traffic law enforcement, corruption, and a lack of awareness among road users. Policy failures have further hindered efforts to improve transportation safety in Bangladesh. Inconsistent implementation of existing policies, ineffective regulatory frameworks, and insufficient monitoring and enforcement mechanisms have all contributed to the persistence of the problem [19,23,24]. It negatively impacts the quality of life, exacerbates inequalities, and

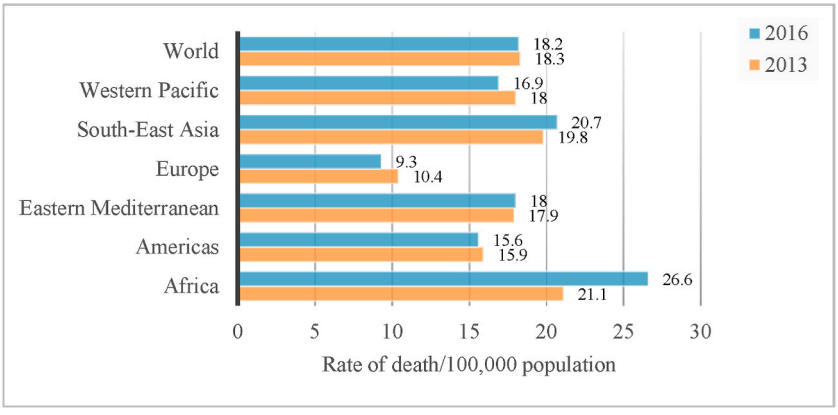

Fig. 1. Rates of road traffic death per 100,000 population by WHO regions, Source: World Health Organization, 2018.

hampers the overall development and progress of urban areas in Bangladesh.

However, despite the challenges posed by urban transportation and its impact on the lives of citizens, there is a lack of comprehensive studies systematically assessing the factors influencing the safety of public transportation services. Existing research on transportation safety is predominantly confined to city corporations in major urban centers, neglecting the crucial aspect of local government involvement in ensuring transportation safety in urban regions across Bangladesh. Consequently, a comprehensive study focusing on urban transportation safety at the grassroots level becomes imperative. This study aims to shed light on existing literature and address urban transportation safety concerns, with a specific focus on Pabna Municipality, Bangladesh.

1.1. Objective of the study

The main objective of this research was to identify key factors affecting citizen safety of urban transportation service in Bangladesh, with a specific focus on Pabna Municipality. In this study, we endeavored to evaluate citizen perspectives on various facets of urban transportation safety within Pabna Municipality, encompassing their travel behavior and safety-related factors. By identifying the key factors influencing transportation safety in Pabna Municipality, this study aims to contribute valuable insights that can inform the development of targeted interventions and policies to enhance the safety of urban transportation systems in Bangladesh.

2. Theoretical framework

Urban transportation safety is a multifaceted concern that demands a comprehensive examination of the factors influencing risk perception and behavior. In the literature, transportation theories, such as total safety culture, behavioral theory, system theory, and zero risk theory, are discussed as the philosophical lenses through which transportation safety is planned and facilitated [25,26]. In this study, we adopted the system theory perspective [27] to conceptualize urban transportation systems as dynamic, interdependent networks. This perspective is commonly recognized as the 'systems' approach to safety [28]. It studies the relationships and interactions between components within a complex system. Advocates of this theory [29,30] describe it as a comprehensive approach that encompasses road design, user behavior, and vehicles. The theory highlights the influential nature of these three components and emphasizes the potential for enhancing road safety through effective traffic management [31,32].

Santos et al. [33] pointed out that effective road design, policies, and conditions influence road user behavior, particularly that of the driver. This means that road infrastructure must be designed to accommodate human capacity and limitations, the vehicle must support task performance and provide protection in case of risks, and road users should be well-trained and informed, with necessary control measures when needed [34]. Furthermore, Wallius et al. [35] argued that human behavior plays a pivotal role in transportation safety. Individual risk perception and decision-making are shaped by cognitive processes, personal experiences, and external factors [36,37]. Factors such as the cost of transportation and the quality of driver training significantly influence an individual's perceived level of risk and their consequent safety-related choices. Additionally, social norms and peer influence are key determinants of behavior [36], impacting the choices made by road users, including pedestrians and cyclists.

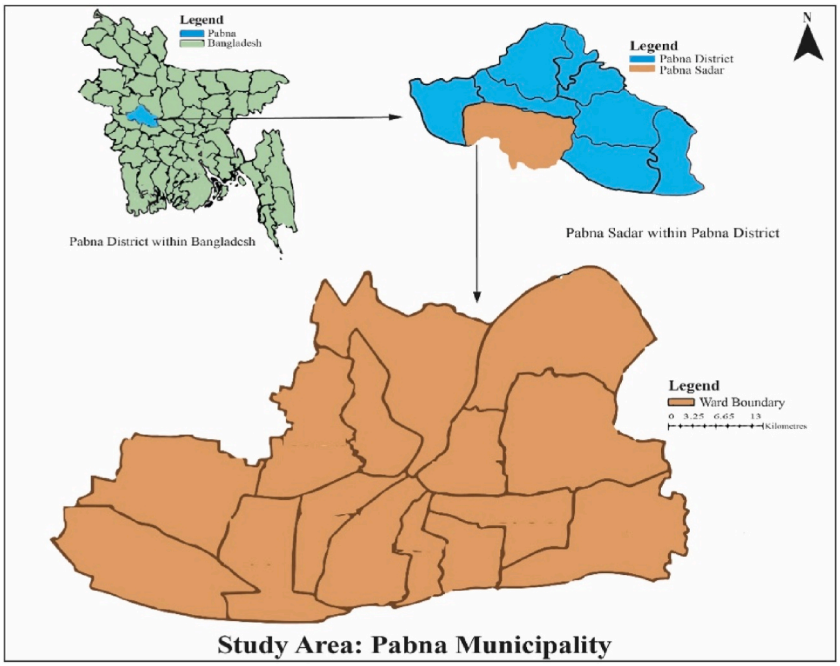

Fig. 2. Pabna municipality (study area), source: Authors, 2023.

In the context of road transport, safety is regarded as an issue of control, necessitating the implementation of adequate traffic management procedures [2,38]. Feng et al. [39] highlighted that the clarity and consistency of traffic rules, as well as their enforcement, significantly influence risk perception and adherence to safety regulations. The perceived risks associated with violations of these rules can shape road user behavior [36]. The condition of vehicles and the presence of safety features are also pivotal in shaping perceived safety levels [40]. Access to well-maintained and equipped vehicles can substantially impact an individual's risk perception and subsequent safety behaviors. This phenomenon is rooted in the system theory [41]. It emphasizes the importance of understanding how road users interact within the broader transportation control system and how their behaviors are influenced by the dynamics and components of the system.

Therefore, according the theory, safety is not exclusively the duty of frontline operators like drivers and other users. Instead, it is a collective responsibility distributed among stakeholders at various levels of the intricate socio-technical system, encompassing policymakers, designers, manufacturers, regulators, and frontline operators [28]. In practice, the promotion of urban road safety in Bangladesh is a joint responsibility shared by city planners and partners involved in road transport development. This theoretical framework allows us to examine urban transportation safety as a complex, interconnected system influenced by a multitude of factors. It underscores the need to consider human, infrastructure, regulatory, vehicle-related, and mobility factors collectively when addressing risk perception and behavior within urban transportation settings. As empirical research progresses, this framework will serve as a valuable foundation, enabling researchers to validate and refine these relationships for practical applications aimed at enhancing transportation safety, particularly within the context of Pabna municipality.

3. Research method

3.1. Study area

This study utilized data collected from the residents of Pabna City, located in Bangladesh. Situated approximately 153 km away from Dhaka, the capital of Bangladesh, Pabna city benefits from its close proximity to the Isamoti River, facilitating convenient access to road and waterway transportation, as well as railways (refer to Fig. 2). The municipality achieved its official status in 1876 and is recognized as one of the oldest settlements in the subcontinent. It has a population of 144,442, distributed across its 15 wards, as per the population and housing census of 2011, which was carried out by the Bangladesh Bureau of Statistics. The municipality of Pabna boasts a well-developed road network spanning 213 km, including 162 km of bituminous roads, 4.5 km of Herring-Bone-Bond (HBB) roads, 20.10 km of normal concrete roads, 1.8 km of Water Bound Macadam (WBM) roads, and 24.60 km of earthen roads [42,43]. As a result of rapid urbanization, the city is experiencing gradual expansion, characterized by busy roads and streets bustling with a diverse range of vehicles providing public transportation services.

3.2. Research design

The research employed a face-to-face survey method and utilized insights from the previous knowledge to develop a structured questionnaire comprising two segments [44]. The first segment aimed to collect non-parametric information on the socio-demographic properties of the informants, such as gender, age, income, and education. The second segment focused on parametric information concerning the citizens' perceptions of the factors influencing the safety of urban transportation systems. To assess these perceptions, citizens were asked to rate their experiences using a 4-point Likert scale, which provided them with four options: 'Poor,' 'Fair,' 'Good,' and 'Excellent' [45]. This scale allowed participants to indicate the extent to which they agreed or disagreed with statements related to their experiences with urban transportation safety, providing a clear understanding of the data collected. In terms of population and sampling, data collection for this study was conducted through structured questionnaires, specifically at the bus terminal. The choice of the bus terminal as a survey location was strategic, as it attracts individuals from various parts of the city who utilize the terminal's selected transit facilities, thus ensuring a diverse distribution of samples. Surveyors stationed themselves purposefully at various points within the bus terminal during operational hours. They courteously approached prospective respondents, informing them about the nature of the study and explaining the objective, voluntary nature, and approximate duration of the survey to obtain their consent. Given the study's primary objective of determining factors affecting transportation safety within the municipality, a purposive sampling approach was deemed appropriate. This method is often used when the researcher wants to ensure that the sample includes individuals who possess specific knowledge, experiences, or expertise related to the research topic. It allows researchers to purposively select individuals with varied experiences, ensuring that we capture a diverse range of perspectives and insights relevant to the study [46]. The emphasis was placed on gathering information from individuals with diverse experiences in accessing transportation services for various purposes. Thus, the survey respondents were selected based on the researcher's discretion and intended purpose [47]. From February 01, 2023, to February 28, 2023, surveyors employed purposive sampling techniques while maintaining a one-week interval between surveys. Collecting data from a large number of respondents is desirable; however, due to time and financial constraints, it was not feasible to include every individual from the population. According to Singh and Masuku [48], a sample size of 100 is considered sufficient for studies involving $>$100,000 participants, with a 95 % confidence level and a precision level of $\pm$10 %. In this study, the sample size consisted of 120 respondents out of a total population of 144,442, with a 95 % confidence level and a precision level of 7 %. To maintain the representativeness of the sample and address potential biases in the distribution of road actors, the purposive sampling approach was designed in a way to ensure a diverse range of perspectives. Respondents were selected from various backgrounds and roles within the transportation sector, including commuters, drivers, traffic police, and other stakeholders, in order to include individuals with specific knowledge and experiences related to transportation safety, as well as perspectives from various

Table 1
Respondents' profile and distribution of studied factors (N = 120).

Factors	Variable %	x^2 value	df	p value
Gender				
	Male = 59.05	2.14	1	0.143
	Female = 40.95			
Age				
	18-25 = 61.6	44.75	1	0.000
	26-40 = 38.3			
Literacy				
	Illiterate = 12.38	1.23	4	0.872
	Primary = 17.14			
	SSC = 23.81			
	HSC = 21.90			
	Undergraduate = 24.76			
Income				
	>5000 = 16.21	8.76	4	0.067
	5000-9999 = 22.85			
	10000-14999 = 27.61			
	15000-19999 = 17.24			
	<20000 = 17.24			
Travel Frequency				
	Daily = 20.0	3.23	3	0.357
	Weekly = 23.6			
	Monthly = 24.5			
	Occasionally = 31.8			
Travel Mode				
	Rickshaw = 16.4	25.41	3	0.000
	Auto-Rickshaw = 43.6			
	CNG = 12.7			
	Public Bus = 27.3			
Availability and accessibility (F1)				
	Poor = 11.6	28.20	3	0.000
	Fair = 37.2			
	Good = 36.4			
	Excellent = 14.0			
Cost and affordability (F2)				
	Poor = 11.6	62.86	3	0.000
	Fair = 37.2			
	Good = 47.1			
	Excellent = 3.3			
Road signage and markings (F3)				
	Poor = 20.7	16.25	2	0.001
	Fair = 49.6			
	Good = 28.9			
Road design and layout (F4)				
	Poor = 38.0	57.80	3	0.000
	Fair = 45.5			
	Good = 9.9			
	Excellent = 5.8			
Vehicle condition and safety features (F5)				
	Poor = 49.7	0.83	2	0.036
	Fair = 42.5			
	Good = 7.4			
Driver training and qualifications (F6)				
	Poor = 47.1	22.85	2	0.000
	Fair = 38.8			
	Good = 13.2			
Driver Travel Behaviour (F7)				
	Poor = 41.7	29.45	2	0.000
	Fair = 46.6			
	Good = 11.6			
Pedestrian and cyclist behaviour (F8)				
	Poor = 60.3	90.33	3	0.000
	Fair = 21.5			
	Good = 14.0			
	Excellent = 3.3			
Visibility and weather conditions (F9)				
	Poor = 22.3	52.86	3	0.000
	Fair = 24.0			

(*continued on next page*)

Table 1 (*continued*)

Factors	Variable %	x^2 value	df	*p* value
	Good = 49.6			
	Excellent = 3.3			
Emergency response (F10)				
	Poor = 52.9	82.33	3	0.000
	Fair = 35.5			
	Good = 9.1			
	Excellent = 1.7			
Travel Speed (F11)				
	Poor = 47.1	55.26	3	0.000
	Fair = 33.1			
	Good = 16.5			
	Excellent = 2.5			
Traffic rules and enforcement (F12)				
	Poor = 43.8	29.45	2	0.000
	Fair = 45.5			
	Good = 9.9			
Traffic flow and congestion (F13)				
	Poor = 47.9	47.53	3	0.000
	Fair = 21.5			
	Good = 25.6			
	Excellent = 4.1			

stakeholders within the municipality. This approach was implemented to minimize bias in the distribution of road actors and to obtain a comprehensive view of transportation safety.

3.3. Ethics

This study did not require formal ethical clearance from an Institutional Review Board (IRB) or Ethics Committee, as it did not involve any interventions, interactions, or data collection that would necessitate such approval. Nevertheless, ethical principles and guidelines were strictly adhered to throughout the research process. Before conducting the survey, all participants received comprehensive information about the study's purpose. Prospective participants were approached by surveyors who introduced themselves and explained the study's purpose in clear and simple terms. Participants were explicitly informed that their involvement in the survey was anonymous and voluntary, and they had the freedom to decline participation without any consequences. Only after obtaining verbal consent did the surveyors proceed with data collection. Furthermore, the survey questions were non-invasive and did not involve the collection of sensitive personal information or pose any potential harm to participants. The protection of confidentiality and anonymity of the collected data was prioritized. Only basic socio-demographic information was collected, and no data that could reveal the identity of respondents, such as names, addresses, or affiliations, were obtained. Additionally, all data collected during this study were managed and stored securely and responsibly. This encompassed restricting access to the data solely to the research team, and implementing stringent measures to ensure appropriate and ethical data usage, which included data anonymization and aggregation. The research team is committed to complying with data protection and privacy regulations, preventing data misuse, and adhering to best practices in data security.

3.4. Data analysis

The analysis employed various statistical procedures to gain insights into the respondents' travel pattern, socio-economic characteristics, and perception of safety behavior. To investigate these elements, descriptive statistics and the chi-square test were applied. Additionally, various statistical techniques were employed to investigate the association between transportation safety factors. To examine the relationship between factors of transportation safety, three methods were employed: Principal Components Analysis (PCA), Pearson Correlation Matrix (PCM), and Hierarchical Cluster Analysis (HCA). These methodological choices were made to align with the objective of the study and to effectively uncover patterns and relationships within complex data sets. While traditional approaches such as analysis of variance and logistic regression have their merits, the combination of PCA, PCM, and HCA was deemed most suitable for addressing the specific research objective. This approach not only allowed for a more comprehensive exploration of the data but also provided a more nuanced understanding of the relationships among factors, enhancing the depth of the analysis [49].

PCM and HCA were valuable tools used to ascertain correlations between factors. PCM, a commonly exploited method, assigns values between −1 and 1, total negative correlation, representing no correlation, and, total positive correlation, respectively. This approach proves valuable in comprehending correlations between different variables, which may be challenging to discern from raw data alone. HCA, on the other hand, aimed to create a tree diagram illustrating the perceived similarities between factors. By grouping factors that were deemed similar by the study participants on branches close together, HCA revealed potential cause-effect relationships or previously undiscovered correlations. The use of a Dendrogram, a hierarchical diagram, further highlighted the hierarchical relationships among the data factors. Additionally, HCA helped determine the number of clusters likely to exist. PCA, a data reduction technique, facilitated the identification of important indicators and their significance in vast datasets [50]. By converting the

data into a new set of orthogonal variables, derived from covariance or correlation matrices, PCA organized the data based on their decreasing order of importance. Prior to conducting PCA, the need for this technique was confirmed through the Kaiser-Maier-Olkin (KMO) and Bartlett's Sphericity tests. The significance level of Bartlett's sphericity test ($p < 0.01$) and a KMO value larger than 0.5 (0.65 in this study) justified the application of PCA to the datasets [51]. Additionally, Cronbach's alpha was utilized to assess the stability and reliability of factor loadings. Moderate yet satisfactory standards of Cronbach's alpha vary from 0.60 to 0.80. In the context of social science research, Cronbach's alpha standards above 0.6 (0.65 in this study) are considered suitable indicators [52]. Furthermore, the survey instrument employed in this study is available for reference in Appendix A. It was developed based on insights from existing literature, and content validity was established by consulting experts, including academicians and researchers, to enhance the quality of data analysis. The analysis process was reliant on the utilization of the Statistical Package for the Social Sciences (SPSS) 25.0.

4. Results and discussion

With the aim of comprehensively examining the safety aspects of transport services, an internally devised inquiry was utilized to explore the diverse array of services and facilities linked to ensuring secure transportation within the municipality of Bangladesh. Moreover, the questionnaire encompassed fundamental socio-demographic factors, including age, gender, occupation, and education, as well as travel patterns such as frequency and mode of transportation. Table 1 provides a concise overview of respondent profiles and associated variables. The study exhibits a balanced gender distribution, with 59 % of respondents being male and 40.95 % being female. Similarly, the age category was also broad ranging from 20 to 40 years, with the largest proportion (61.6 %) falling within the 18–25 years age group. About 38 % belonged to the 26–40 years age group. Regarding education levels, 70.46 % of respondents had completed at least secondary school (SSC), while the remainder had completed primary or lower levels of education. The income distribution was diverse, with the majority falling within the income range of 10,000–14,999 BDT (27.61 %), followed by 5000–9999 BDT (22.85 %), and more than 20,000 BDT (17.24 %). Overall, the sample displayed diverse demographics, including age, education, income, and a representative gender distribution.

Furthermore, the questionnaire delved into various safety factors of urban transportation services, such as availability and accessibility, cost and affordability, road signage and markings, road design and layout, vehicle condition and safety features, driver training and qualifications, driver travel behavior, pedestrian and cyclist behavior, visibility and weather conditions, emergency response capabilities, travel speed, adherence to traffic rules and enforcement, as well as traffic flow management and congestion. In order to gain deeper insights into the participants' fundamental features, an examination of the factors and a Chi-square Test were performed. The Chi-square Test, performed at a significance level of $p < 0.05$ and a confidence interval of 95 %, facilitated the exploration of the interrelationships among the variables associated with the factors under investigation. Through a comparison of the obtained $\chi 2$ values with the predetermined threshold, the Chi-square test allowed for the determination of the significance of the relationships between the variables. Importantly, when the p-value is less than 0.05, it signifies a substantial association between the variables associated with the factors.

4.1. Correlation assessment

This study utilized the Pearson Correlation Matrix (PCM) to investigate the connection between the safety level and users' perceptions of municipal transportation services (Table 2). The results revealed a strong and statistically significant correlation among the majority of variable pairs. Notably, F12 and F7 demonstrate a strong positive correlation of 0.784. Similarly, F5 and F12 display a positive correlation of 0.764, underscoring the strong association between traffic rules and regulations, as well as drivers' travel behaviour and the condition and safety features of their vehicles. Furthermore, our analysis identified a moderate to strong relationship between F4 and F7, as well as F6 and F10. This suggests that road design and layout significantly influence drivers' travel

Table 2
Pearson correlation matrix of factors affecting transportation safety.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1	1												
F2	.398[a]	1											
F3	0.076	0.021	1										
F4	−0.073	−0.007	−0.105	1									
F5	0.051	−.190[b]	−0.085	.185[b]	1								
F6	.197[a]	0.109	.396[a]	−0.026	0.09	1							
F7	−0.148	−0.114	−0.102	.672[a]	.482[a]	.506[a]	1						
F8	.231[b]	0.072	.335[a]	−0.153	−0.079	.274[a]	−0.096	1					
F9	.355[a]	0.044	.545[a]	0.013	−0.016	0.155	−0.065	.309[a]	1				
F10	.212[b]	.278[a]	.296[a]	−0.072	−0.105	.611[a]	−0.084	.371[a]	.215[b]	1			
F11	0.124	.430[a]	.497[a]	−0.002	0.147	.295[a]	0.053	.198[b]	0.06	.243[a]	1		
F12	−0.031	−0.114	−0.083	.403[a]	.764[a]	0.091	.784[a]	−0.081	0.034	−0.137	0.053	1	
F13	0.179	−0.009	−0.045	−0.051	0.067	0.065	0.016	.543[a]	−0.002	−0.06	0.125	0.016	1

[a] Correlation is significant at the 0.01 level (2-tailed).
[b] Correlation is significant at the 0.05 level (2-tailed).

behaviour, while drivers' training and qualifications are associated with their emergency response capabilities. Moreover, we observed moderate positive correlations between seven variable pairs: (cost and affordability & travel speed), (road signage and markings & visibility and weather conditions), (road signage and markings & travel speed), (road design and layout & traffic rules and enforcement), (vehicle condition and safety features & driver travel behaviour), (driver training and qualifications & driver travel behaviour), and (pedestrian and cyclist behaviour & traffic flow and congestion). Likewise, several major variables exhibited positive correlations to some extent: (availability and accessibility & cost and affordability), (road signage and markings & pedestrian and cyclist behaviour), (road signage and markings & emergency response), (driver training and qualifications & travel speed), (pedestrian and cyclist behaviour & visibility and weather conditions), (pedestrian and cyclist behaviour & emergency response), (visibility and weather conditions & emergency response), and (emergency response & travel speed).

4.2. Consistency of respondent's perception

The study used principal component analysis (PCA) and cluster analysis (CA), two multivariate statistical techniques, to examine the relationship between respondents' perceptions and factors influencing citizens safety. PCA was conducted using varimax rotation with Kaiser Normalization to maximize the variance of the component coefficients, providing a better understanding of potential influences on traffic safety. The computed factor loadings, cumulative percentages, and variation percentages are presented in Table 3. PCA identified a total of four variables or main components (PCs), which accounted for 67.425% of the total variance. To determine the appropriate number of PCs to retain and gain insights into the underlying variable structure, the scree plot (Fig. 3a) was employed. Additionally, the rotation matrix plot (Fig. 3b) illustrated the significant relationships between the investigated variables. The loadings score was categorized as strong (>0.75), moderate (0.75–0.50), or weak (0.50–0.30) [50].

The first principal component (PC1) explained 23% of the total variance, with a significant positive loading affecting citizen safety, which is influenced by traffic rules and enforcement (F12: 0.930) and drivers travel behavior (F7: 0.883); and moderate positive loading of vehicle condition and safety features (F5: 0.721) and road design and layout (F4:0.626). Citizen safety is strongly influenced by the level of enforcement of traffic rules and regulations, and the behaviour of drivers on the road. Bangladesh is known to lack strong enforcement of rules and regulations regarding transportation, resulting in poor driving behaviour and reckless driving without following rules and regulations. Banik et al. [53] also recognized that deficient rules and regulations constitute a significant driver affecting road safety. This lack of law enforcement and poor driving behaviour has contributed to a high rate of traffic accidents and fatalities in Bangladesh. The majority of these accidents involve pedestrians, cyclists, and motorcyclists [54]. Additionally, vehicle conditions, especially in urban areas, are poor without proper safety features offered to passengers. There is no separate lane for pedestrians, cyclists or motorcyclist. Existing road designs and layouts are not suitable for these vehicles and safe for passengers as well as citizens. Scott-Parker et al. [55] suggested that a well-designed road network and rigorous enforcement of rules and regulations are imperative for ensuring transportation safety.

PC2 explained 19% of the total variance, with strong positive loading of road signage and markings (F3: 0.813) and visibility and weather conditions (F9: 0.787); moderate positive affecting factor is availability and accessibility (F1: 0.715) and cost and affordability (F2: 0.684). This suggest that road signage and markings is key factors affecting passengers' safety in transportation system. This finding aligns with results obtained by Hamim and Ukkusuri [56], Hoque [16], and Lamm et al. [57]. Lack of proper road signage and markings increases the risk of accidents and traffic hazards as drivers may not be able to navigate safely or effectively [58]. This is especially true in adverse weather conditions where visibility is reduced. During adverse weather conditions such as heavy rain, or fog, visibility on the road is reduced. In such situations, road signage and markings become even more critical for the safety of drivers and

Table 3
Varimax rotated principal components analysis of the studied factors.

Factors	PC1	PC2	PC3	PC4
F12	0.930	0.007	−0.040	0.081
F7	0.883	−0.111	0.080	−0.120
F5	0.721	0.003	−0.049	0.390
F4	0.626	−0.038	0.014	−0.392
F3	−0.068	0.813	0.220	0.029
F9	0.030	0.787	−0.008	0.071
F1	−0.026	0.715	0.079	0.135
F2	−0.105	0.684	0.310	−0.304
F10	−0.134	0.186	0.817	−0.029
F6	0.102	0.308	0.815	−0.028
F11	0.104	−0.070	0.567	0.365
F13	0.022	−0.024	−0.006	0.651
F8	−0.112	0.314	0.347	0.551
Total	2.627	2.507	1.936	1.305
% of Variance	23.209	19.282	14.893	10.041
Cumulative %	23.209	42.491	57.384	67.425

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

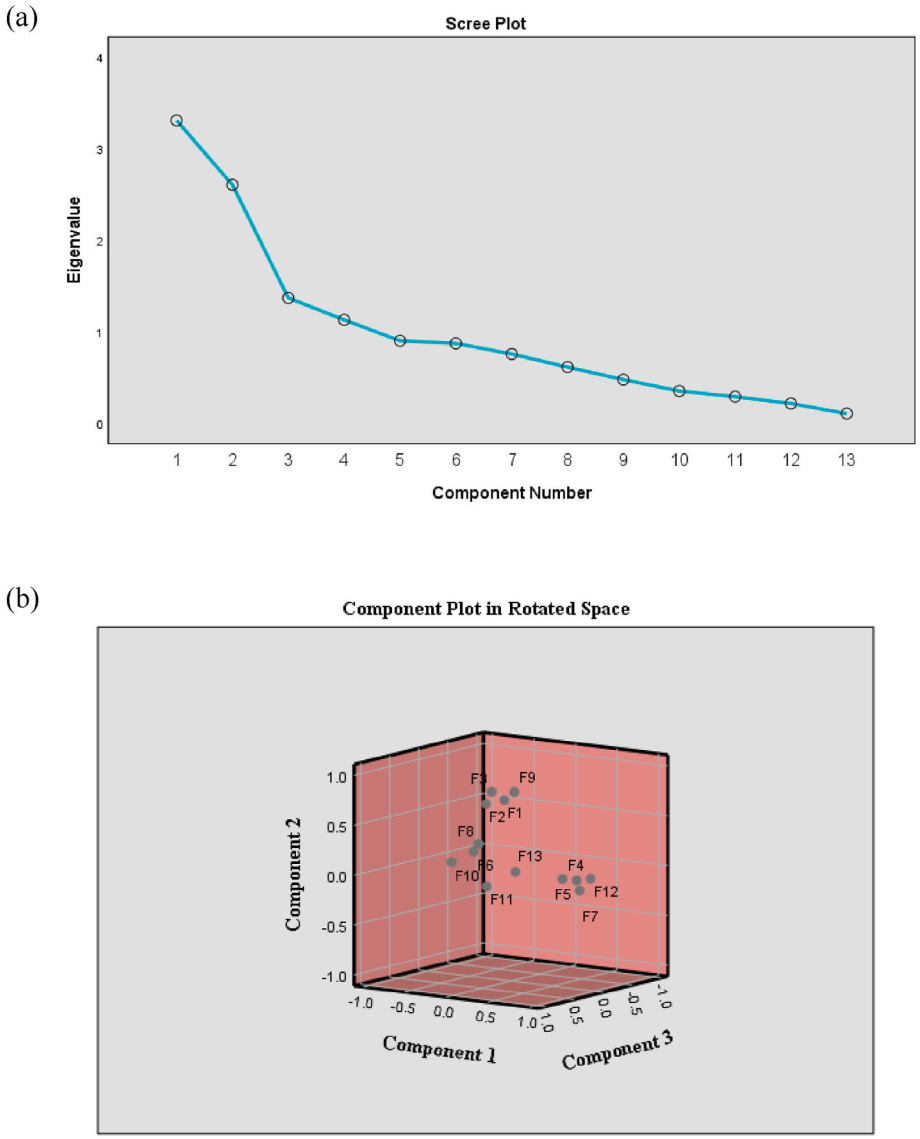

Fig. 3. Principal component analysis by (a) scree plot of the characteristic roots, and (b) component plot in rotated space. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

passengers. Proper road signage and markings provide essential information to drivers about the road conditions, potential hazards, and directions [57]. The third principal component (PC3), which has considerable positive loadings for emergency reaction (F10: 0.817) and driver training and qualifications (F6: 0.815), and a moderately positive loading for travel speed (F11: 0.567), accounts for 14 % of the total variation. This demonstrate that a majority of drivers lack proper training and qualifications, which results in their inability to effectively respond to unexpected situations. In Bangladesh, it is common for driver qualifications to be questionable, as they are often ill-prepared to handle the demands of driving at adequate speeds in busy city streets or other areas. Consequently, many incidents occur due to a lack of necessary knowledge and sufficient training [59]. There is an urgent need to prioritize driver training programs and enhance the qualifications of drivers in Bangladesh. Yeasmin [22] suggest that implementing comprehensive training initiatives and ensuring that drivers possess the required skills and expertise can greatly contribute to reducing the number of accidents and improving road safety across the country.

PC4 accounted for 10% of the total variance and exhibited a moderate positive influence on traffic flow and congestion (F13: 0.651) as well as pedestrian and cyclist behaviour (F8: 0.551). It is noteworthy that the study area lacks dedicated lanes for cyclists or pedestrians within the road infrastructure. Furthermore, there is a lack of specific guidelines or rules governing pedestrian crosswalks. Consequently, street crossings occur haphazardly and without defined protocols, significantly impacting the transportation safety system and leading to frequent traffic congestion in the study area. Zafri et al. [60] emphasized that these haphazard crossings risk the lives of the general citizens and lead to an increase in road accidents, particularly in busy street areas where a more well-planned road

infrastructure is required to reduce traffic congestion with appropriate pedestrian crossings. Moreover, studies have shown that implementing dedicated cycling lanes and pedestrian-friendly infrastructure not only enhances safety but also encourages more people to choose active modes of transportation, ultimately reducing overall traffic congestion in the area [61,62].

Additionally, cluster analysis (CA) was employed to elucidate the impact of the examined factors on transportation safety-related behaviours. The outcomes of the cluster analysis (CA) exhibited a significant association with the principal component analysis (PCA), resulting in the identification of three distinct clusters. Each cluster consisted of four distinct factors. Notably, one factor (F13) was categorized as an individual mode, as depicted in Fig. 4. In terms of the factors under investigation, each cluster demonstrates analogous characteristics. Statements F7, F12, F5, and F4 are encompassed in Cluster 1 and they are driver travel behaviour, traffic rules and enforcement, vehicle condition and safety features, road design and layout. This cluster is likely related to the broader topic of road safety and transportation effectiveness in the study area. Similar to Cluster 2 comprises (F6, F10, F8 and F11: driver training and qualifications, emergency response, pedestrian and cyclist behaviour and travel speed) of travel behaviour related to the transportation safety of the passenger. Cluster 3 includes F3, F9, F2, F1 (road signage and markings, visibility and weather conditions, cost and affordability, availability and accessibility) which are related to basic safety features of transportation service to the study area. Overall, the analysis collectively provides a comprehensive approach to transportation safety, revealing interdependencies between factors like traffic rules enforcement, vehicle conditions, and road design. These collectively form crucial elements in transportation safety, particularly in Bangladesh where traffic management and enforcement are significant challenges [16,63]. Additionally, it emphasizes the importance of driver training, emergency response, behaviour, signage, visibility, cost, and accessibility, all of which are vital for transportation safety. These findings highlight the multifaceted nature of transportation safety, emphasizing the need for a holistic approach to road safety improvement.

5. Conclusion

The primary objective of this study was to evaluate the various factors that impact the safety of passengers in urban transportation services within the selected study area of Bangladesh. The findings highlight the crucial role played by the enforcement of traffic rules and responsible driver behavior in ensuring the safety of citizens. In Bangladesh, the inadequate enforcement of transportation-related regulations has resulted in reckless driving habits and a disregard for traffic rules. Consequently, this has contributed to a high occurrence of traffic accidents and fatalities, with pedestrians, cyclists, and motorcyclists being particularly vulnerable. Furthermore, the research identified issues concerning vehicle conditions and safety features, especially in urban areas where appropriate safety measures for passengers are often absent. The absence of dedicated lanes for pedestrians, cyclists, and motorcyclists, coupled with inadequate road designs and layouts, further exacerbates the safety concerns for passengers and citizens alike. The study emphasized the significance of appropriate road signage and markings in ensuring a safe and efficient transportation system. In summary, this

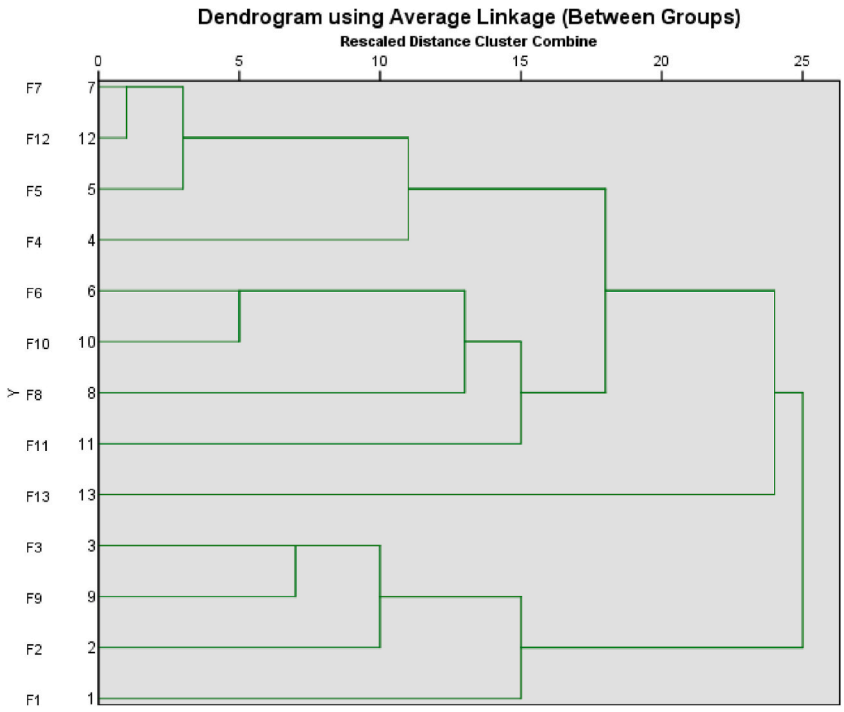

Fig. 4. A dendrogram illustrating the parameters' hierarchical clustering. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

research offers valuable insights into the factors influencing passengers' safety in urban transportation services of Bangladesh. Addressing these factors will contribute to enhancing passengers' safety and reducing the incidence of accidents and fatalities on the roads of urban region, thereby improving the overall urban transportation experience for citizens. For the government to enhance passenger safety in urban transportation services, it is imperative to implement effective policies and guidelines. To accomplish this, it is suggested that the government of Bangladesh strengthen the enforcement of traffic rules and regulations, particularly focusing on curbing reckless driving behaviors and promoting responsible driver conduct. This can be accomplished through increased surveillance, stricter penalties for traffic violations, and comprehensive driver training programs. Furthermore, there is a pressing need to improve the overall condition and safety features of vehicles, particularly in urban areas. This can be attained by implementing regular vehicle inspections, enforcing mandatory safety standards, and encouraging vehicle manufacturers to prioritize safety in their designs. Additionally, initiatives should be taken to create separate lanes for pedestrians, cyclists, and motorcyclists, along with the development of well-designed road layouts that prioritize safety and minimize the risk of accidents. By implementing these policy references, the government can create a safer and more secure transportation system, thereby improving the safety of life for citizens and reducing the occurrence of accidents and fatalities throughout the country.

6. Limitations of the study

The study contains some limitations. One limitation of this study is that data collection relied on face-to-face surveys, potentially introducing response biases or social desirability effects, as participants may have been influenced by the presence of interviewers, potentially affecting the accuracy and honesty of their responses. Additionally, the sample size, while valuable for initial insights related to urban transportation safety in Bangladesh, may not fully represent the entire population. To mitigate these limitations, future research endeavors could benefit from larger and more diverse samples, the inclusion of objective measures to complement self-report data, and the exploration of alternative data collection methods.

Declarations

6.1. Ethics statement

Ethical approval was not required for this paper.

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

Data availability statement

The data that has been used is confidential.

CRediT authorship contribution statement

Md Ashraful Islam: Writing - review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Md Al-Fahad Bhuiyan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e24697.

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