PARATRANSIT SAFETY AS A KEY RESOURCE FOR SUSTAINABLE MOBILITY IN DEVELOPING COUNTRIES

Md Tawkir Ahmed[1,*], Md Sifat Bin Siraj[2], Tiziana Campisi[3]

[1]College of Transportation Engineering, Tongji University, Shanghai, China
[2]School of Transportation and Logistics, Southwest Jiaotong University, Sichuan, China
[3]Faculty of Engineering and Architecture, University of Enna Kore, Enna, Italy

*E-mail of corresponding author: tawkir_ahmed@tongji.edu.cn

Md Tawkir Ahmed 0000-0002-5338-0882, Md Sifat Bin Siraj 0000-0002-7734-6590
Tiziana Campisi 0000-0003-4251-4838

Resume

A vital mode of transportation for short term mobility is paratransit. There are several studies on paratransit safety in developed nations but the developing nations like Bangladesh pay less attention to the issue. Therefore, the primary objective of this study is to evaluate the safety of paratransit using the perceptions of riders and drivers. Negative binomial model (NBM) was used to calibrate the safety of paratransit using 451 responses in Chittagong city. The study's findings highlight the significance of perceptions of travel safety in enhancing accessibility during the routine travel. Vehicle speed limits (km/h), which reduce the chance of accidents and having an institutional driver's license are among the variables that have emerged for the betterment of safety. Therefore, identifying factors that can makes these transportation systems safer will allow service managers and controllers to optimize passenger and driver safety.

Article info

Received 30 April 2022
Accepted 4 December 2022
Online 25 January 2023

Keywords:

paratransit
safety and security
negative binomial model
sustainable mobility

Available online: https://doi.org/10.26552/com.C.2023.018

ISSN 1335-4205 (print version)
ISSN 2585-7878 (online version)

1 Introduction

Paratransit is one of the emerging transportation modes among today's urban transportation systems. It is also known as informal or semi-formal public transportation. Paratransit encompasses a variety of modes including car sharing, bike sharing and micro transit. Which have developed largely in conjunction with new technologies (smartphones, GPS, electronic payments etc.) and includes on call services that are useful for low-demand areas, especially after the recent pandemic [1].

People who live in the rapidly increasing metropolitan world want efficient transportation. Travel demand has risen dramatically in developing countries, considerably outstripping available transportation options. As a result, in emerging countries, local public transit fails to match the demand for public mobility [2]. Poor service quality, low output, poor maintenance strategy and overcrowding have all been identified as contributing factors to public transportation failing to fulfill the demand [2-3]. Therefore, people have begun to embrace various paratransit modes (both motorized and non-motorized) that allows more time efficient transport to their intended location [2]. Based on paratransit's purpose, many experts have recommended incorporating it as a feeder for the public transit systems to improve the performance of urban transportation networks.

Several studies in the literature show that some segments of the population such as the elderly still have psycho-social problems that hinder the use of these means [2].

A study conducted by [3] developed a fail-safe methodology to help transport service operators identify and correct errors before they generate significant security problems.

Moreover, the recent pandemic has profoundly changed the frequency of travel and modal choices. In order to minimize the use of vehicle, it is useful to spread public transport and para-transit services. It is necessary to include modern vehicles and simple booking systems within everyone's reach. An excellent service is also connected to the training of drivers who must carry out the transport safely and punctually. To

date, most paratransit drivers are not well trained and, in some cases, lack adequate knowledge of traffic rules and passenger safety.

Paratransit is responsible for more than half of all the public transportation demand [4-8]. Many cities in emerging countries are experiencing this phenomenon. Rapid growth in metropolitan population and per capita income, along with insufficient existing transportation infrastructure, has boosted paratransit use as a low-cost and convenient means of public transportation. Paratransit is a low-cost means of transportation that gives passengers the impression of driving their own vehicle [5]. Paratransit options play a vital role in developing countries' urban transportation sectors by offering transportation services to a large number of people [6]. It offers considerable benefits to both drivers and riders based on accessibility, flexibility of movement, easy and unhindered lane movement, and inexpensive operation and maintenance costs [2].

Paratransit is a very important mode of transportation in developing countries because it is very accessible and cheap [7]. Most of the passengers are familiar with paratransit especially in developing countries [8-9]. However, most of the paratransit drivers are not well trained even they have no adequate knowledge about traffic rules and passengers' safety. As a result, there were frequent accidents and reckless driving on the roads [10]. Using the Binomial Logistic Regression model technique, Joewon et al. [10] conducted a study to represent the safety and security issues in paratransit operation based on user perception in a developing country. They analyzed the data considering two distinct models with and without experience of accidents to predict and explain users' future choices.

Joewono and Kubota [11] examined the mode choice behavior of four selected paratransit (becak, ojek, bajaj and angkot) drivers in terms of several policy interventions. A stated preference (SP) survey was carried out to conduct this study from two important point of views i.e., social and environmental aspects.

Several criticalities characterize the paratransit systems in general. Some of these challenges can lead to significant service failures that could endanger passengers, increase insurance costs and decrease productivity, as well as damage the reputation of the public transport system. Current technologies make it possible to control this transport service through sensors and software. Those things can reduce the errors committed that could compromise the safety of the paratransit service [9-12].

Most transit systems in rural or small urban areas do not implement these modern technologies due to huge costs [8-12]. It is therefore necessary to hope that in the coming years, inexpensive but effective error prevention techniques that are easy to understand and implement, will be implemented.

Chittagong, like the rest of Bangladesh, is a heavily populated city where road users and travelers rely heavily on paratransit modes such as tempos, auto rickshaws and other similar vehicles to get around [12]. The widespread adoption of paratransit options in Bangladesh indicates people's trust and eagerness. The most casual kind of transportation is paratransit, which ranges from rickshaws (human-powered) to small minibuses with 25 seats. While safety mismanagement of paratransit is common in developed countries. This mismanagement has been happening in most of the growing cities including Chittagong for a long time. These problems cannot be solved in a short period of time. Hence, there is a need for long term planning to mitigate this problem.

The purpose of this study is to assess the attitudes of passengers and drivers regarding the safety concern of paratransit. Therefore, the current study concentrated on an initial literature search utilizing Google Scholar and university library databases that were focused on academic literature. Next, a survey was conducted based on passenger and driver perceptions about the safety of paratransit within Chittagong city. Furthermore, the safety of the paratransit system in Chittagong city was calibrated using the Negative binomial model (NBM).

2 Literature review

Several studies were found on paratransit safety subject matter [12-15]. A study based on the perception about safety and security of the road users and drivers of paratransit as well as that of non-users and civil servants in the city of Bandung, Indonesia. Factor analysis was carried out based on a questionnaire survey to find out significant factors. The results showed that the most fundamental attributes for improving the existing condition in developing countries are the passenger and driver awareness about the paratransit safety and security. Authors have also proposed three basic agendas for improving the paratransit safety namely technology, management, and institution [16].

The behavior of paratransit operators was evaluated using structural equation modeling in the region of Phnom Penh, Cambodia. The interviewed transport drivers expressed a desire to offer feeder service to the bus, regardless of the potential financial consequences. Moreover, the study was an attempt to evaluate driver perception about newly introduced public bus and their motive for operating as feeder service.

A face to face interview survey was carried out to enumerate the existing operational characteristics based on safety perceptions between paratransit operation and fare for motorized paratransit modes in Phnom Penh, Cambodia. Phun and Yai [17] showed that the fare of several paratransit was affected by distinct factors including trip attributes and working environment of drivers.

Priye and Manoj [18] studied passenger safety perceptions of three-wheeled electric rickshaws as a

paratransit mode using 388 participants in Patna, India. This research shows that the residing people of Patna in general were not pleased with the present condition and design of the vehicle based on the overall safety perceptions about the electric rickshaws.

To explore paratransit service, a study was conducted based on the public's reaction regarding the service quality, vehicle safety condition, driver performance, and cost of travels. They used binomial logistic regression model to find out significant factors regarding paratransit service. Additionally, they proposed some policy regarding paratransit system based on public requirements [19].

The sustainability criterion for establishing a new mode of transport "Locally Adapted, Modified and Advanced Transport (LAMAT)" is complex and diverse. Four basic factors should be concerned for establishing paratransit system as a sustainable transport i.e. improvements the service quality, integration with mass transit systems, promotion of electric paratransit modes and government support in Asian developing countries [20].

Based on the users' perceptions and the degree of acceptance of paratransit services, Phun, Kato and Yai [21] conducted a study exploring the characteristics and perceptions of two distinct paratransit modes (Motodop and Remork, N.B. Motodop is a motorcycle taxi while Remork consists of a two-wheeled carriage pulled by a motorcycle) in Phnom Penh. A questionnaire survey was conducted with 479 Motodop and 263 Remork users. They found that Remork users have a considerably lower probability of driving accidents than Motodop users do.

A study was conducted by Pramanik and Rahman [22], to evaluate the current situation and the operational features of battery-operated three-wheelers, or "E-rickshaws," in Rangpur, Bangladesh. They found that e-rickshaws are an effective mode of transportation because they offer last-mile connections (end of an individual trip made by public transport). However, it is very challenging to maintain the tariff structure because most drivers are not registered as paratransit drivers. Another study showed that transportation system should be included basis operation and strategic things namely technical specifications, age, equipment and safety rules [23].

They found that drivers are generally captive to Ojek and Bajaj (Motorcycle & Taxy manufacturing company) according to model estimation results and

Table 1 *Paratransit issue focused on previous literature*

References	Statistical Model	Developed (1)/ Developing (2) Country	Topic
Joewono and Kubota (2005) [10]	Binomial Logistic Regression.	2	Paratransit Safety and Security
Joewono and Kubota (2006) [11]	Factor Analysis	2	Paratransit Safety
Joewono and Kubota (2007) [19]	Binomial Logistic Regression Model	2	Paratransit Operation
Tangphaisankun, Nakamura and Okamura (2009) [31]	Structural Equation Model (SEM).	2	Paratransit Safety
Tubis and Werbinska (2014) [32]	Normal statistical analysis	2	Paratransit Safety
Phun and Yai (2015) [17]	Box-Cox Regression model	2	Paratransit Safety
Rahman et al. (2016) [33]	Structural Equation Modeling (SEM)	2	Paratransit Operation
Phun and Yai (2016) [16]	Structural Equation Modeling (SEM)	2	Paratransit Safety
Phun, Kato and Yai (2016) [20]	Normal statistical analysis	2	Paratransit Operation and Safety
Chowdhury, Uddin, Datta and Taraz (2018) [3]	Multinomial Logistic Regression (MLR)	2	Paratransit Operation and Safety
Chowdhury (2018) [34]	Multinomial and an Ordered Logit model.	2	Paratransit Safety
Pramanik and Rahman (2019) [35]	Normal statistical analysis	2	Paratransit Safety
Priye and Manoj (2020) [18]	Exploratory Factor Analysis (EFA) and Principal Component Analysis (PCA)	2	Paratransit Safety
Sharma, Pandit and Bose (2020) [28]	Structural Equation Modelling (SEM)-RIDIT technique.	2	Paratransit Operation and Safety
Wright (2021) [26]	Normal statistical analysis	2	Paratransit Safety
Priye (2021) [36]	Grey Relation Analysis	2	Paratransit Safety

subsidies for the low-emission vehicles have an impact on drivers' mode choice, especially paratransit [24].

As the paratransit system of transport plays a significant role in the urban area in the developing country, Victory and Ali [25] conducted a study using a Multinomial Logit Model (MNL) to forecast the paratransit utility. They considered three quantitative variables i.e. trip length (km), travel cost (rupees), and travel time (minutes) as well as four qualitative variables i.e. reliability, comfort, road condition, and convenience for this study. The results revealed that the travel costs, reliability, convenience, and comfort have mostly influenced the utility of the mode.

Wright et al. [26] studied on the types of modes in the public transport system in five Caribbean countries i.e. Jamaica, St. Lucia, Barbados, Guyana, Trinidad, and Tobago. They found that in these areas, paratransit modalities are more widely used and more reliable than public buses. They added that the peoples are still dissatisfied with the kind of service they deliver. From their suggestions, Governments must prioritize public transportation and invest in an efficient, well-planned infrastructure that can coexist with the emerging paratransit system [26].

Pramanik and Rahman [22] conducted a survey to determine the most important elements affecting paratransit passenger satisfaction in Sylhet, Bangladesh. They used a Multinomial and an Ordered Logit model to analyze passenger satisfaction and found that the female passengers were unsatisfied with current paratransit systems. They added that existing modes' fitness and cleanliness were judged to be influential attributes. They concluded that the fare structure makes this method of transportation popular, but operational flaws like congestion make the future of existing options uncertain [27].

Sharma, Pandit and Bose [28] used Structural Equation Model (SEM) to complete the analysis and found that paratransit can be implemented as a feeder system for mass transits and other public transits. They recommended some parameters, which need to be improved to make paratransit more efficient, namely safety, security policy, ease of accessibility, connection policy, paratransit comfort, and convenient service improvement policy [28].

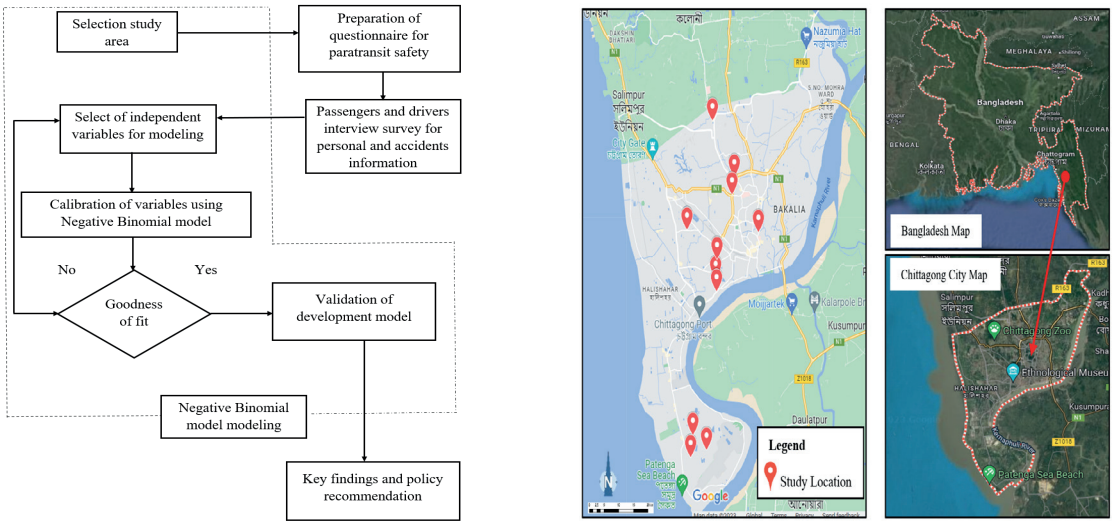
Table 1 summarizes several prior studies in developing countries for paratransit safety, security and operation. Based on previous literature review, safety for paratransit in developing countries is difficult to come by, especially in Bangladesh condition [27-30]. The authors discovered that no research has been done on paratransit safety in Chittagong city using Negative binomial model (NBM) (Table 1). Hence, this study is an attempt to explore the contributing factors for paratransit safety.

The third, fourth, and fifth sections will be discussed about study area and methodology, model development, and model validation respectively. The sixth section will be presented the analysis results using NBM. Finally, the last section of the paper will be discussed about the conclusion and recommendation of the study.

3 Study area and methodology

Chittagong is Bangladesh's most important seaport and the second-largest metropolis. It is located in South-East Bangladesh, on the north bank of the Karnaphuli River, on the Bay of Bengal's shore. The Bay of Bengal is on the west, Cox's Bazaar is on the south, Chittagong hill tracts are on the east and the Feni River is on the north side of Chittagong city (Figure 1). Its population is estimated to be 4.5 million and people live in an area of 184 square kilometers [29].

The city of Chittagong was selected as it has some critical issues related to public and shared transport



(a) *(b)*

Figure 1 *(a) Methodology flow chart, (b) Study area with survey location*

services. Some literature studies confirm that public transport services need a significant improvement in terms of quality and safety. A study was conducted [25] based on passengers experience of the existing service quality of paratransit. The results show that about 86% of the investigated population uses public transport due to its low cost. From this study it emerges that the behavior of the driver and the level of personal safety inside the bus have been assessed as very poor. While they found some factors have satisfactory service value namely speed of bus, availability information on buses, transport costs, lighting, and travel time.

Likewise, the present work aims to investigate the paratransit services in the Chittagong city. In particular the present research focused on an initial literature search centered on academic literature using Google Scholar and university library databases. Next, a questionnaire survey was conducted on passenger and driver perceptions of safety for paratransit used in the industrial city of Chittagong, Bangladesh. The Negative binomial model (NBM) was used to calibrate the safety for paratransit in Chittagong city (Figure 1).

3.1 Survey implementation and distribution

A questionnaire survey was conducted under the rigorous observation. The survey was carried out in eleven locations of Chittagong city which are prominent paratransit hubs. From the 10th of June 2021 to the 25th of August 2021, 277 driver and 174 passenger (total=451) were interviewed in the chosen locations (Figure 1) on weekdays and weekends. However, the sample size is sufficient for the study area [1-10].

Sample size for infinite population

$$S = \frac{z^2 \times p \times (1-p)}{M^2}.$$

$$S = \frac{(1.96)^2 \times 0.5 \times (1-0.5)}{(0.05)^2},\ S = 384.16. \tag{1}$$

Here:
S = Sample size for infinite population,
Z = Z- score (for 95% confidence level = 1.96),
P = Population proportion (assumed to be 50% = 0.5),
M = Margin of error (5% = 0.05).

$$\text{Adjusted sample Size} = \frac{(s)}{1+\left[\frac{(s-1)}{(population)}\right]} = \frac{(s)}{1+\left[\frac{(384.16-1)}{(4500000)}\right]} = 384.12 \approx 385 \tag{2}$$

Respondents were chosen at random from the survey sites. The survey includes several parameters including Gender, Age, Accident type, Interview person, Vehicle type, Passengers occupation, Education, Monthly income (BDT), Drivers driving experience (year), Speed of Vehicle (kmph), Reason of accidents, Vehicle involve with crush, Frequency of stopping per hour, Institutional driving training license, Driving on road in a day (hours), Drivers sleep in a day (hours), Time of accident and Road Condition.

3.2 Applied method

Negative binomial model (NBM) was used to calibrate the safety perception of paratransit users. Since NBM can handle over dispersed count outcome variables and is popularly used for safety related studies [1, 13, 25]. Hence, the NBM was used to determine the safety condition of paratransit in Chittagong city (Tempo, Laguna, Easy Bike, mini-Bus, and CNG) (Figure 2). Mainly, probability and loglikelihood distribution function was used to calibrate the model. Details of the NMB was discussed in section 4.

4 Model development

The i-th observation of the dependent variable has the following probability in the Negative binomial (NB) model distribution function yi [25-30].

$$p(yi) = \frac{\Gamma(yi+r)}{yi!\Gamma(r)}\left[\frac{\mu i}{\mu i + r}\right]yi\left[\frac{r}{\mu i + r}\right]r. \tag{3}$$

For the vector of observed independent variables, xi, the conditional mean of iy is given by:

$$E\left(\frac{yi}{xi}\right) = \mu i = e^{x/\beta}. \tag{4}$$

Figure 2 *Pictorial view of paratransit in Chittagong city (source: author elaboration)*

The disadvantage of the Poisson distribution in terms of equality of mean and variance is the reason for the investigators' preference for the NB distribution. The following is the connection between the mean and variance of the NB distribution:

$$V(Y) = \mu + \frac{1}{r}\mu^2 . \quad (5)$$

Since the variance of the NB distribution is always bigger than the mean, it fits data with more volatility. The dispersion parameter is $a = \frac{1}{r}$. The use of Poisson distribution helps to produce better results for accident data with modest dispersion, however, if there was excess dispersion in the data, the variance of the data will be bigger than the mean, in which case the NB distribution is preferable.

In addition to the regression parameters, the dispersion parameter should be computed in the NB regression model. Since r must be positive, $r = \ln r$ is approximated instead and it can take any value. The following equation yields the log-likelihood of the NB model:

$$L = \sum_{j=1}^{n}\left[\sum_{j=0}^{yi-1}\ln(e^{r^*}+j) - \ln yi! + yi\ln(\mu i) - \right. \\ \left. -(e^{r^*}+yi)\ln(\mu i + e^{r^*})\right] + ne^{r^*}\ln(e^{r^*}) \quad (6)$$

As in the Poisson model, the Newton-Raphson iteration process is used to estimate β and r [30].

5 Model validation: loglikelihood ratio test

Loglikelihood is a measure of how well all of the independent variables affect the outcome or dependent variable. This can be assessed by comparing the fit of null model and given model. Likelihood of the null model is the likelihood of the observation if the independent variables had no effect on the outcome. Likelihood of the given model is the likelihood of obtaining the observations with all the independent variables incorporated in the model. The difference of these two is a goodness of fit index LL, χ^2 statistics with k degree of freedom [1, 8]. The equation can be written as follows.

LL = –2 (log likelihood of null model - log likelihood of given model). (7)

Table 2 *The response's descriptive statistics of demographic and trip characteristics*

Attributes	Category	N (%)	Codes
Gender	Male	394 (72.83)	2
	Female	57 (27.17)	1
Age	12-30	251 (55.65)	1
	31-40	131 (29.06)	2
	41-50	60 (13.30)	3
	>50	9 (2.00)	4
Interview person	Driver	277 (61.42)	1
	Passenger	174 (38.58)	2
Vehicle type	Tempo	290 (64.30)	1
	Laguna	102 (22.62)	2
	Easy Bike	59 (13.08)	3
Passengers occupation	Service holder	87 (50.00)	1
	Student	50 (28.74)	2
	Business	15 (8.62)	3
	Housewife	10 (5.75)	5
	Others	12 (6.90)	4
Education	Primary	158 (35.03)	2
	Secondary	168 (37.25)	1
	Higher Secondary	25 (5.54)	5
	Graduate	51 (11.31)	3
	Post Graduate	12 (2.66)	6
	Illiterate	37 (8.20)	4
Monthly income (BDT)	0-8000	170 (37.69)	1
	8000-20000	83 (18.40)	2
	>20000	198 (43.90)	3

$$\text{Chi-square, } x^2 = \sum \frac{(Oi - Ei)^2}{Ei} \quad (8)$$

Here, X^2= chi square, Oi = observed value, Ei = expected value.

$$\text{Pseud } R^2 = 1 - \frac{\ln(\text{likehood of filled model})}{\ln(\text{likehood of null model})} \quad (9)$$

6 Model results

Table 2 shows the analyzed variables and their statistical evaluations obtained by entering the specific coding. The proportion of male and female passengers was imbalanced, with 72.83 % male and 27.17% female. Majority of the passenger age was 12-30 years (55.65%). Most of the interviewed person was driver (61.42%). In terms of vehicle type, tempo (64.30%) was the dominant one because the mode is available on all roads in Chittagong city. In terms of passengers occupation, 50% was service holder, 28.74% was student. Because they used paratransit as their most used mode for travel. The majority of the survey people had primary (35.03%) and secondary education (37.25%). The highest monthly income group was more than 20 thousand (43.90%). In the fourth column of Table 2, the codes are used as substitutes of the attributes categories as required by the STATA software (Table 3).

Table 3 displays the respondent's descriptive statistics on paratransit safety related characteristics. Most of the accident observed by passengers and drivers were possible injury (52.99%) and property damage only (15.96%). While 2.44% passenger and drivers were death due to paratransit accident. In terms of drivers driving experience, 51.62% of the drivers had 6-15 years driving experience. The dominant speed limit of the paratransit vehicle was 30-40 km/h (74.37%).

According to the drivers and passengers perception, the major reason for accident was mechanical fault (24.39%), environmental effect (18.63%) and driven faster (16.63%). In terms of vehicle involved with crash, the dominant mode was bus (58.54%). Most of the paratransit drivers had tendency to stop vehicle frequently (59.21%) for picking passengers. 68.59% drivers had institutional training or they had knowledge about paratransit driving (Table 3). 64.62% drivers drove 3-8 hours (64.62%) in a day. Most of the drivers slept more than 8 hours (89.17%) in a day. Most of the accident occurred at night (72.06%) and the road condition was good (79.38%) in terms of passengers and drivers perception.

After processing the survey data, Negative binomial Model was applied to obtained the results shown in Table 4. The second column is the coefficient and the third column is the p value of variables.

For NBM, the type of accident (possible injury, property damage only, non-disabling injury, fatal, disabling, death) is considered as a dependent variable, while the other aspects are considered as independent variables.

The model used 17 independent variables including gender, age, respondent, vehicle type, occupation of passengers, education, monthly income (BDT), drivers' driving experience (year), vehicle speed (km/hour), vehicle involved with crush, crash frequency per hour, having institutional driving license, driving on road in a day (hours), drivers' sleep in a day (hours), accident time and road condition. The analysis shows that the P value (Probability) of Vehicle type (0.004), Reason of accidents (0.000) and Speed of vehicle (km/h) (0.003) are positively and statistically significant with the Type of accident. Which indicates, when the types/ number of vehicles, the reason for accidents and the speed of vehicles on the road increase, then the types of accidents increase. Furthermore, among the type of vehicle Tempo has large accident probability and Easy Bike has small accident probability. While having an institutional driver's license (0.042) is negatively and statistically significantly correlated with accident types. This indicates, when drivers with institutional driving license increase, then the types of accidents decrease. Log likelihood of Negative binomial model is (-709.239). Wald chi^2 Value is Significant (0.001) and the value is (38.30). Pseudo R^2 value for accident type in paratransit is found (0.73), which indicates a good model.

In the third column of Table 4 (p-value ranking) is shown that the reason of accidents, vehicle speed (km/h), vehicle type, institutional driving license are strongly related to the type of accident. Moreover, there is no relationship with other variables (e.g., frequency of stopping per hour, time of accident, vehicles involved with crushing and road condition, etc.) according to P value.

7 Conclusion

The present research is a first step of investigation the safety of paratransit in the Chittagong city using the perception of passengers and drivers. Negative binomial model was used to evaluate the survey data. The results obtained underlined the importance of the perception of travel safety in determining the perceived accessibility of this mode of transport in daily travel.

Furthermore, both the type of vehicle and the reason for the accident but also the speed of the vehicle and the driving license are factors which contributes to the safety of paratransit. Moreover, it has emerged that some factors such as vehicle speed (km/h), the reason for the accident and the possession of a driving license are strongly correlated with the different types of accident. It is necessary to train deivers and maintain designated speed limit to minimize most of the paratransit accident. Additionally travel safety knowledge among drives and passengers should be increased by governmental and

Table 3 *The response's descriptive statistics on paratransit safety related characteristics*

Attributes	Category	N (%)	Codes
Accident type	Possible injury	239 (52.99)	1
	Property damage only	72 (15.96)	2
	Non incapacitating injury	58 (12.86)	3
	Fatality	48 (10.64)	4
	Incapacitating	23 (5.10)	5
	Death	11 (2.44)	6
Drivers driving experience (year)	1-5	130 (46.93)	1
	6-15	143 (51.62)	2
	>15	4 (1.44)	3
Speed of vehicle (km/hr)	20-30	20 (7.22)	1
	30-40	206 (74.37)	2
	>40	51 (18.41)	3
Reason of accidents	Talking with passenger	42 (9.31)	3
	Talking on phone	16 (3.55)	2
	Mental condition (anger, sleepy, etc.)	17 (3.77)	4
	Non-expert driver	54 (11.97)	6
	Driven faster	75 (16.63)	7
	Sound Effect	44 (9.76)	5
	Mechanical fault	110 (24.39)	9
	Environmental effect (smoke, fog, rain, etc.)	84 (18.63)	8
	Others	9 (2.00)	1
Vehicle involved in a crush	Bus	264 (58.54)	6
	Bike	97 (21.51)	5
	Truck	35 (7.76)	4
	Car	30 (6.65)	3
	Pedestrian	20 (4.43)	2
	Others	5 (1.11)	1
Frequency of stopping per hour	1-4	103 (37.18)	1
	5-7	164 (59.21)	2
	>7	10 (3.61)	3
Have institutional driving training license	Yes	190 (68.59)	2
	No	87 (31.41)	1
Driving on road in a day (hours)	3-8	179 (64.62)	1
	8-15	98 (35.38)	2
Drivers sleep in a day (hours)	5-8	30 (10.83)	1
	>8	247 (89.17)	2
Time of accident	Day	126 (27.94)	1
	Night	325 (72.06)	2
Road condition	Good	358 (79.38)	1
	Bad	93 (20.62)	2

nongovernmental initiatives.

The aim of the study is to investigate the current safety condition of paratransit. The results also lay the foundations for mitigating the critical issues related to safety and placing greater attention on those aspects of transport safety on which the greatest attention by transport companies, but also at the level of government authorities.

Therefore, a long-term planning and optimization approach to paratransit safety should be implemented

Table 4 *Negative binomial model for safety for paratransit*

	Coefficient	P value	P-value ranking
Constant (Accident Type)	0.833	0.010	(out of ranking)
Gender	0.098	0.417	9
Age	0.045	0.325	8
Interview person	0.234	0.214	6
Vehicle type	0.041	0.004	3
Passengers occupation	0.049	0.144	5
Education	0.017	0.561	10
Monthly income (BDT)	-0.057	0.288	7
Driving experience (year)	-0.037	0.637	13
Speed of vehicle (km/h)	0.226	0.003	2
Reason of accidents	0.000	0.000	1
Vehicle involved in a crush	-0.011	0.692	15
Frequency of stopping per hour	-0.019	0.795	17
Have institutional driving training license	-0.166	0.042	4
Driving on road in a day (h)	-0.047	0.592	11
Drivers sleep in a day (h)	-0.063	0.625	12
Time of accident	-0.031	0.737	16
Road condition	-0.036	0.674	14
	Model Fit Results		
Log likelihood	-709.239		
Wald chi^2 (Prob > chi^2)	38.30 (0.001)		
Pseudo R^2	0.73		

in the build, including continuous quality improvement based on contextual needs. The research also found that although there is a large literature describing paratransit services in general, some aspects remain unexplored to date. In particular, addressing issues such as data management and privacy for shared mobility is still under-researched. Therefore, the more research that can address these gaps, the better strategies and policy actions can be used to integrate and improve service for all users.

The study has some limitations such as the paratransit safety assessment survey was conducted within Chittagong city. However it would be better if the entire Chittagong division could be considered. Only the Negative binomial model (NBM) was used for the evaluation of paratransit safety, hence it will be better to use some random parameter models for further study. Overall, the internal effect of the model was not explored in the study, which could be useful for further evaluation. The relation between drivers and passengers perception can be explored in future study. Furthermore, future study should be carried out among different countries considering different factors.

Grants and funding

The authors received no financial support for the research, authorship and/or publication of this article.

Conflicts of 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.

References

[1] ANWARI, N., AHMED, M. T., ISLAM, M. R., HADIUZZAMAN, M., AMIN, S. Exploring the travel behavior changes caused by the COVID-19 crisis: a case study for a developing country. *Transportation Research Interdisciplinary Perspectives* [online]. 2021, **9**, 100334. ISSN 2590-1982. Available from: https://doi.org/10.1016/j.trip.2021.100334

[2] KALTHEIER, R. M. Urban transport and poverty in developing countries: analysis and options for transport policy and planning. Eschborn: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) Gmb, 2002.
[3] CHOWDHURY, T. D., UDDIN, M. S., DATTA, D., TARAZ, M. A. K. Identifying important features of paratransit modes in Sylhet City, Bangladesh: a case study based on travelers perception. *Civil Engineering Journal* [online]. 2018, **4**(4), p. 796. ISSN 2476-3055, eISSN 2676-6957. Available from: https://doi.org/10.28991/cej-0309134
[4] ISLAM, M. R., AHMED, M. T., ANWARI, N., HADIUZZAMAN, M., AMIN, S. The aspiration for happy train journey: commuters' perception of the quality of intercity rail services. *CivilEng* [online]. 2022, **3**(4), p. 909-945. eISSN 2673-4109. Available from: https://doi.org/10.3390/civileng3040052
[5] SHIMAZAKI, T., RAHMAN, M. Operational characteristics of paratransit in developing countries of Asia. *Transportation Research Record*. 1995, **1503**, p. 49-56. ISSN 0361-1981.
[6] AREOS, P. Design of a paratransit system for rural areas design of a paratransit system for rural areas. Journal of Transportation Research Board, (August 2006), 86.
[7] CERVERO, R., GOLUB, A. Informal transport: a global perspective. *Transport Policy* [online]. 2007, **14**(6), p. 445-457. ISSN 0967-070X. Available from: https://doi.org/10.1016/j.tranpol.2007.04.011
[8] SAKIB, N., PAUL, T., AHMED, M. T., MOMIN, K. A., ISLAM, M. R., WANG, L. Evaluating University Students' Safety Behavior on Three-Wheel Electric Rickshaw. In: TRB 102nd Annual Meeting; Transportation Research Board (TRB): Washington, DC, USA 2023.
[9] ANWARI, N., AHMED, M. T., ISLAM, M. R. Investigating the Characteristics and Opinions of Public Transit Users in an Industrial City of a Developing Country. In: TRB 101th Annual Meeting; Transportation Research Board (TRB): Washington, DC, USA 2022.
[10] JOEWONO, T., KUBOTA, H. The Characteristics of paratransit and non-motorized transport in Bandung, Indonesia. *Journal of the Eastern Asia Society for Transportation Studies* [online]. 2005, **6**, p. 262-277. eISSN 1881-1124. Available from: https://doi.org/10.11175/easts.6.262
[11] JOEWONO, T. B., KUBOTA, H. Safety and security improvement in public transportation based on public perception in developing countries. *IATSS Research* [online]. 2006, **30**(1), p. 86-100. Available from: https://doi.org/10.1016/s0386-1112(14)60159-x
[12] NWAOGBE, O. R., IBE, C. C. UKAEGBU, S. I. Quality of the paratransit service (tricycle) and its operation in Aba, Nigeria: an analysis of customers' opinions. *Journal of Transport and Supply Chain Management* [online]. 2012, **6**(1), p. 1-9. Available from: https://doi.org/10.4102/jtscm.v6i1.64
[13] SIRAJ, M. S., HASAN, M., AHMED, M. T. Understanding the Mode Choice Behavior for Short Distance and Regular Travel in a Developing Country. In: 3rd Annual Conference on Regional Science (ACRS 3). 2021. DOI: https://doi.org/10.21203/rs.3.rs-2029143/v1
[14] HOSSAIN, M. K., SIRAJ, M. S. B., HASAN, M., CHOWDHURY, M. M. H., UDDIN, M. H. Mode choice behavior of Chittagong City Dwellers in Bangladesh. *Journal of Transportation Systems*. 2021, **3**(3), p. 55-64.
[15] SAKIB, N., PAUL, T., AHMED, M. T., ISLAM, M. R., WANG, L. Assessment of the Pedestrian Walkway Level of Service for Sustainable Development in Urban Area. In: TRB 102nd Annual Meeting: Transportation Research Board (TRB): Washington, DC, USA 2023.
[16] PHUN, V. K., YAI, T. Intention of paratransit drivers to operate as feeder service of public bus in Phnom Penh. *Transport Policy Studies' Review*. 2016, **19**(2), p. 2-14. ISSN 1344-3348, eISSN 2433-7366.
[17] PHUN, V. K., YAI, T. The characteristics of paratransit operation and fare in Phnom Penh. *Journal of the Eastern Asia Society for Transportation Studies* [online]. 2015, **11**, p. 1307-1327. eISSN 1881-1124. Available from: https://doi.org/10.11175/easts.11.1307
[18] PRIYE, S., MANOJ, M. Passengers' perceptions of safety in paratransit in the context of three-wheeled electric rickshaws in urban India. *Safety Science* [online]. 2020, **124**, 104591. ISSN 0925-7535. Available from: https://doi.org/10.1016/j.ssci.2019.104591
[19] JOEWONO, T. B., KUBOTA, H. Exploring public perception of paratransit service using binomial logistic regression. *Civil Engineering Dimension*. 2007, **9**(1), p. 1-8. eISSN 1979-570X.
[20] PHUN, V. K., YAI, T. State of the art of paratransit literatures in Asian developing countries. *Asian Transport Studies* [online]. 2016, **4**(1), p. 57-77. eISSN 2185-5560. Available from: https://doi.org/10.11175/eastsats.4.57
[21] PHUN, V. K., KATO, H., YAI, T. Traffic risk perception and behavioral intentions of paratransit users in Phnom Penh. *Transportation Research Part F: Traffic Psychology and Behaviour* [online]. 2018, **55**, p. 175-187. ISSN 1369-8478. Available from: https://doi.org/10.1016/j.trf.2018.03.008
[22] PRAMANIK, M. A., RAHMAN, M. S.-U. Operational characteristics of paratransit in medium-sized city: a case study on e-rickshaws in Rangpur City, Bangladesh. *Journal of Bangladesh Institute of Planners*. 2019, **12**, p. 45-62. ISSN 2075-9363.
[23] TUBIS, A., WERBINSKA - WOJCIECHOWSKA, S. Safety measure issues in passenger transportation system performance: case study. In: European Safety and Reliability Conference ESREL 2013: proceedings. Vol. Safety, reliability and risk analysis: beyond the horizon. 2013.

[24] LI, G, NUGROHO, S. B., FUJIWARA, A., ZHANG, J., LINH, T. N. Analysis of paratransit drivers' stated job choice behavior under various policy interventions incorporating the influence of captivity: a case study in Jabodetabek Metropolitan Area. *Journal of the Eastern Asia Society for Transportation Studies* [online]. 2011, **8**, p. 1-5. eISSN 1881-1124. Available from: https://doi.org/10.11175/easts.9.1144

[25] VICTORY, W., AHMED, M. A. Forecasting paratransit utility by using multinomial logit model: a case study. *International Journal of Engineering and Technology* [online]. 2016, **8**(5), p. 2193-2198. ISSN 2319-8613, eISSN 0975-4024. Available from: https://doi.org/10.21817/ijet/2016/v8i5/160805233

[26] WRIGHT, L., TANGWELL, J., DICK, A. Public transportation in the Caribbean: dominance of paratransit modes public transportation in the Caribbean. *The West Indian Journal of Engineering*. 2021, **43**(2), p. 31-41. ISSN 0511-5728.

[27] SIKDAR, M. S., ASHRAFI, T. J., DAS, S. Trip Generation analysis of Shughonda residential area in Chittagong City, Bangladesh: user's perspective. In: 4th International Conference on Advances in Civil Engineering 2018: proceedings. 2018. p. 908-914.

[28] SHARMA, D., PANDIT, D., BOSE, T. Determination of service quality attributes based on user perception for paratransit services in developing country like India. *Transportation Research Procedia*, 2020, **48**, 3577-3594.

[29] CHOWDHURY, P. A. Future growth trend and potential residential area identification of a city: a case study of Chittagong. *Current Urban Studies* [online]. 2014, **2**(3), p. 168-177. ISSN 2328-4900, eISSN 2328-4919. Available from: https://doi.org/10.4236/cus.2014.23017

[30] AYATI, E., ABBASI, E. Modeling accidents on Mashhad urban highways. *Open Journal of Safety Science and Technology* [online]. 2014, **4**(1), p. 22-35. ISSN 2162-5999, eISSN 2162-6006. Available from: https://doi.org/10.4236/ojsst.2014.41004

[31] TANGPHAISANKUN, A., NAKAMURA, F., OKAMURA, T. Influences of paratransit as a feeder of mass transit system in developing countries based on commuter satisfaction. In: 8th International Conference of Eastern Asia Society for Transportation Studies: proceedings. Vol. 7. 2009. p. 236-236.

[32] TUBIS, A., WERBINSKA-WOJCIECHOWSKA, S. Safety measure issues in passenger transportation system performance: case study. In: 22nd Annual Conference on European Safety and Reliability ESREL: proceedings. 2014.

[33] RAHMAN, F., DAS, T., HADIUZZAMAN, M., HOSSAIN, S. Perceived service quality of paratransit in developing countries: a structural equation approach. *Transportation Research Part A: Policy and Practice* [online]. 2016, **93**, p. 23-38. ISSN 0965-8564, eISSN 1879-2375. Available from: https://doi.org/10.1016/j.tra.2016.08.008

[34] CHOWDHURY, T. D. Identifying injury risk factors of bicyclists in bicycle-motor vehicle crashes in Alaska using logistics regression. PhD dissertation. Anchorage: University of Alaska Anchorage, 2018.

[35] PRAMANIK, M. A., RAHMAN, M. S. U. Operational characteristics of paratransit in medium-sized city: a case study on e-rickshaws in Rangpur City, Bangladesh. *Journal of Bangladesh Institute of Planners.* 2019, **2075**, 9363. ISSN 2075-9363.

[36] PRIYE, S. An investigation into the usage patterns and safety perceptions of the users of electric rickshaws in Indian cities: case studies from Patna and New Delhi. PhD dissertation. Delhi: IIT Delhi, 2021.