Beyond the Platform: A Safety Perception Study for the First and Last Mile Mode Choice in Lucknow, India

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Abstract

With the rise of mass transit systems in India, numerous mode choices are available for commuters to cover the first and last mile of their trip. Factors such as age, gender, travel cost, and travel time, among others, influence these choices. Despite the extensive studies of various variables, there has been limited research into soft factors such as user attitudes and safety perceptions. The aim of this research is to investigate the impact of safety perception on mode choice for first and last-mile connectivity on the Lucknow Metro Red Line, using correlation and multinomial logit regression. The findings indicate that factors such as vehicle conditions, safety measures, driver characteristics, supporting infrastructure, and nearby traffic conditions influence commuters' safety perceptions and therefore should be explored further to foster a more sustainable mass transit feeder system.

Keywords: First and Last-Mile Connectivity; Safety Perception; Feeder Mode; Mode Choice; Transport Policy.

1. Introduction

Transportation is an essential part of our day-to-day lives, enabling us to commute to work, access basic services, and connect with others. However, rapid urbanisation and population growth have indeed strained existing transport infrastructure, leading to several challenges, such as delays and congestion, cost increases, longer travel times, accidents, and safety concerns, which can result in injuries, loss of life, and property damage, especially in developing and highly populated countries like India. Studies suggest that travellers' choice to use private vehicles rather than public modes of transport is due to their flexibility, comfort, and absence of barriers such as waiting time (Jin *et al.*, 2024).

Problems like traffic congestion and time delays while travelling have led to the introduction of the mass transit system in India. Systems like the Bus Rapid Transit System (BRTS), Mass Rapid Transit System (MRTS), Monorail, and many more have been established in various cities in India to cater to the developing population in urban

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centres. A transit system needs well-established first and last-mile connectivity to be successful. The first and last mile refer to the distance required to reach a public transportation stop from the starting location and the distance to the final destination, respectively (Kåresdotter *et al.*, 2022).

Various modes of transport, such as walking, bicycling, autos, taxis, auto rickshaws, and cycle rickshaws, offer a service from the metro stop to the door, linking the initial and final stages of travel. Studies show that travel costs, travel time, security, transportation infrastructure, surrounding land use, socio-economic activities, and traffic safety are a few of the factors that influence first and last-mile travel behaviours (Venter, 2020). There are a variety of studies that delve into the hard factors that influence first and last-mile connectivity; there are also studies that focus on the soft factors like users' risk perception, safety perception, attitude, and preference (Eren *et al.*, 2019).

In Asian countries, paratransit or non-motorised vehicles are often in poor condition and frequently overloaded, which compromises passenger safety and frequently results in accidents (Roger Behrens, Saksith Chalermpong and Daniel Oviedo, 2021). According to the World Health Organization, around the globe, nearly 1.3 million people die yearly because of road traffic crashes, costing a country around 3% of its gross domestic product, while putting users like pedestrians, cyclists, and motorcyclists at high risk (World Health Organization, 2022). In 2023, India's road accident statistics reported 0.46 million traffic accidents, resulting in 0.45 million injuries and 0.17 million deaths. The state of Uttar Pradesh itself had 37,764 road accidents, causing 23,947 deaths and 23,843 injuries (National Crime Records Bureau (NCRB), 2023). These statistics suggest that road accidents not only harm the lives and safety of commuters but also have a significant impact on the country's economy.

The desire for safe travel influences a commuter's choice of transportation mode. The safety perception of a passenger refers to the feeling of being secure from external harm, such as accidents or collisions, during travel. It is one of the many psychological factors in a commuter's selection of a specific mode (Pirdavani, Brijs and Bellemans, 2016). These road accident records affect users' perceptions of safety, which can change their choice of mode of transport for their daily lives. Understanding the contributing factors of mode choice for the initial and final legs of the trip becomes increasingly vital.

1.1 Contextual Background

In a metro system, there are three parts to a trip. The first part is from the journey's starting point to the metro station, known as the first mile. The next part involves travelling via metro from one station to another, and the last leg of the trip is from the metro station to the destination point, also known as the last-mile trip. First and last-mile connectivity refers to the trip's first and last leg. As commuters must use different modes of transport to make a trip to transit stations, the first and last-mile connections become fragile links that can significantly influence the overall ridership of transit systems. First and last-mile trips are essential for the mass transit system to grow, making feeder modes an integral part (Kanuri *et al.*, 2019).

A feeder mode refers to any mode of transportation that serves access to or from a transit system, such as a metro, bus rapid transit, or rail line. They may include walking, cycling, bikes, auto-rickshaws, e-rickshaws, buses, taxis, and even the commuters' private vehicles. An effective feeder connection improves the overall accessibility and ridership of mass transit systems by reducing total travel time and improving the experience. For a

multimodal transportation system to work successfully, commuters must have access to a wide range of feeder modes, which then enables their mode choice selection behaviour, a fundamental aspect of the commuter experience.

Mode choice refers to the process by which a commuter selects the most suitable mode of transportation for their trip. This includes two types of factors: “hard” and “soft”. The hard factors comprise of objective variables such as socio-economic, socio-demographic background of the commuter, number of trips, duration, mode of travel used, overall built environment, related infrastructure support, while soft factors focus more towards subjective variables like attitudes, preferences, and safety perceptions. These hard and soft factors collectively shape the overall travel behaviour and mode choice.

Safety perception is an integral and often-overlooked aspect of travel behaviour for commuters. As mentioned previously, a person’s perceptions and attitudes fall under the soft factor of human behaviour. Similarly, safety perception is defined as a passenger’s observed probability of having accident-free travel (Guo *et al.*, 2020). Research has suggested that safety perceptions are formed through multiple dimensions, including vehicle conditions, infrastructure quality, driver characteristics, environmental factors, and personal experiences (Márquez, 2016).

Among the extensive studies on various modes of public transportation, only a limited number have examined individuals' travel behaviours throughout from first to last miles, particularly in developing nations. Despite the abundance of research on mode selection and first and last-mile trips in India, the dimension of safety perception is often overlooked or considered in conjunction with security (Das, Bhaduri and Velaga, 2023). A few studies do dwell upon safety perception; however, either they are based on a specific mode of transportation rather than covering all the mode choices (Phun, Kato and Yai, 2018), or they take a backseat to the other factors involved in the study, such as the socio-demographic characteristics of the traveller (Hidayati, Tan and Yamu, 2020), attitude (Guo *et al.*, 2020).

This research highlights the importance of safety perception in urban transit planning, particularly in relation to the first and last-mile connectivity of metro lines in developing countries. Exploring the multidimensional aspects of safety perception, this paper can enhance the overall safety of first and last-mile connections. The study emphasises on safety as a deterrent criterion, with multiple sections, including driver behaviour, safety precautions, supporting infrastructure, and more, rather than narrowing it to a mere security concern. This comprehensive approach makes the study novel, as it explores safety perception beyond single-factor considerations, offering policymakers specific criteria for actions to enhance multimodal transportation connectivity. Therefore, this study will investigate the relationship between safety perceptions and mode choice for the first and last-mile connectivity of Lucknow Metro.

Following this, Section 2 will provide a detailed literature review on urban transportation policies in India, along with case studies to support the contextual background. Section 3 will outline the selected site and methodological approach used in the study. Section 4 will focus on the analysis and discussion of the results obtained, and Section 5 will provide an extensive conclusion to the paper, highlighting the future potential in this area of study.

2. Literature review

Urbanisation in India has been under scrutiny in recent years; with the sudden explosion of unplanned areas and an ever-growing population it has to cater to. As the economic

condition of households improves, the urge to own a private vehicle increases. This creates issues in urban transportation networks, including accidents, congestion, increased travel time, tailpipe emissions along with other problems. This challenge has become a concern for governments worldwide, making sustainable transportation one of the viable solutions to work upon through various policy initiatives, where India is no exception.

The start of transportation planning in India can be traced back to the 1800s, when policies such as the Tramway Act (1886) and the (Indian) Motor Vehicle Act of 1914 (amended in 2019) were introduced. Post-Independence, the emphasis on urban transportation from a policy perspective led to the establishment of the Institute of Urban Transport in 1997, followed by the introduction of the National Urban Transport Policy (NUTP) in 2006. One of the pivotal points was the establishment of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005, which led to improvements in existing urban infrastructure that tackled the mobility issues. In the upcoming years, safety became a prominent concern due to the surge in vehicle numbers, prompting the formulation of the National Road Safety Policy (2010), which aimed to improve and review road infrastructure. These steps further strengthened the sustainable transportation solutions through policies such as Metro Rail Policy (2017), Transit-Oriented Development Policy (2017), and Auto Fuel Vision and Policy (2025) (Auguste Tano Kouamé, 2024).

These policy initiatives have increased metro investments by central and state governments, with currently 19 cities having metro-rail projects in operation, 4 under construction, and 10 at the planning stage. With the ever-changing urban transportation landscape in India, it is crucial to examine commuter travel behaviour and choice. The following literature review provides practical examples of how these concepts relate to the real-world transportation landscape.

2.1 Application and Empirical Evidence

The theoretical background of first- and last-mile connectivity, feeder modes, mode choice, and safety precautions can only provide a superficial understanding of these concepts. They need to be supplemented with case studies to provide an overall lens for the concept and a deeper understanding of the theory, with its applicability.

Research on first and last-mile connectivity has a significant gap in developing nations, due to their distinctive transportation challenges that cannot be correctly addressed by research conducted in developed nations. These issues concern the gap that exists between an individual's origin and destination points and the public transportation system. Studies have shown factors like age, gender, income, distance, cost, accessibility, nearby land use (Sogbe, Susilawati and Pin, 2024), supporting infrastructure, safety (Tilahun *et al.*, 2016), parking facilities (Meng, Koh and Wong, 2016), and the availability of feeder modes (Bhattacharjee *et al.*, 2022) are important factors that influence first and last-mile connectivity.

Various literature has also detailed different feeder modes in India and worldwide such as walking, e-rickshaws, bicycles, autos, taxis, two-wheelers, four-wheelers, buses, and many more (Fillone and Mateo-Babiano, 2018; Bhattacharjee *et al.*, 2022; Geeta Nair, 2022; Rahman, Akther and Recker, 2022). These can be local, near the station, or app-based ones that can be hired and called to the commuter’s location. Due to such extensive feeder modes, mode choice becomes integral to a commuter’s day-to-day trip.

Empirical research across diverse contexts demonstrates the complexity of first and last-mile mode choice. A 2016 study by Meng, Koh, and Wong from Singapore explores the effect of the surrounding streetscape and the socio-demographic characteristics of users on their mode choice, indicating that factors like distance to transit, the number of bicycles available, the socio-demographic characteristics of the passengers, and the number of feeder buses available at the site, along with the lack of access to a private vehicle for travel, prompt passengers to walk or cycle to and from the metro station (Meng, Koh and Wong, 2016). In 2018, research conducted in Manila examined the factors affecting first and last-mile trips to understand whether commuters walk or use Non-Motorised Transport (NMT) to travel. The most influential factors include cost and the time of access or egress, proposing three solutions to increase the influence of NMT and walking through improvement of supporting infrastructure, such as pedestrian walkways, assigning specified routes to NMT and promoting feeder modes like walking or pedicabs (Fillone and Mateo-Babiano, 2018). In 2018, Mo, Shen, and Zhao discuss the impact of the built environment on first and last-mile connectivity by considering four variables (Density, Design, Diversity, and Distance) that quantify the built environment around a metro station, stating that the people who have their destinations near the mass rail transit station or an area with mixed land use or a high socio-economic activity area prefer to walk to them (Mo, Shen and Zhao, 2018). In summary, the hard factors such as the area's built environment, the traveller's socio-demographic background, the commuter's socio-economic background, trip length, trip time, and many more alter the mode choices of the commuter, which shows that these factors can quickly be studied, while factors like safety and attitude are much more complex to assess and analyse but are also crucial in mode choice.

International evidence demonstrates significant variations in safety perceptions across contexts. To understand the safety and behavioural aspects of active mobility, research was conducted on the safety perceptions of bicyclists in Copenhagen and Brisbane, using data on behaviour and perception gathered from an online survey of cyclists in the two cities. The research resulted in Brisbane cyclists perceiving mixed traffic infrastructure layouts as less safe, fearing traffic more, and being more likely to avoid riding as a survival mechanism than Copenhagen cyclists (Chataway *et al.*, 2014). Later in 2016, Márquez examined the effect of safety perception on a commuter's choice of mode of transportation and discussed the factors that influence a person's safety perception, including driver characteristics, vehicle conditions, the use of safety precautions, and weather (Márquez, 2016). Following this, similar research was conducted in South Asian countries, such as an analysis of the risk perception and behavioural aspects of paratransit commuters in Phnom Penh, Cambodia, finding that people were dissatisfied with the current mode of transportation for motorcyclists and wanted to shift to a new mode of transportation for travel (Phun, Kato and Yai, 2018). A case study in Adana, Turkey, examines bicyclists' safety perceptions, revealing that enhancing infrastructure and promoting a positive public perception can lead to increased cycling adoption in the city (Eren *et al.*, 2019). A study conducted in Shenzhen, China, examines how safety perception and attitude influence the selection of feeder mode choices in a metro system and determined that walking is the most used mode of transportation to access a feeder. At the same time, there is a variance in the attitude and safety perception of commuters according to gender, location, and trip type (Guo *et al.*, 2020).

From the literature discussed above, a research gap was identified in the choice of feeder modes based on commuters' safety perception. While extensive literature is

available on what safety perception or risk perception is and how different modes have their own safety perceptions, there has been little or no research on the effect of safety perception on mode choice for first and last-mile connectivity. Throughout the literature, it is evident that assessing and analysing a commuter's safety perception is challenging. A few studies have been conducted on specific modes of transportation; however, these studies only examine one mode-specific perception, rather than a broader perception of safety for mode choice. A few additional studies describe safety perceptions, but they do so in conjunction with other factors, such as attitude and socio-demographic factors, including gender or specific trip types.

This study addresses this gap by examining how multiple dimensions of safety perception, including vehicle conditions, safety precautions, driver characteristics, supporting infrastructure, and other factors, influence the mode choice of commuters for first and last-mile connectivity in the Lucknow Metro.

3. Methodology

The aim of this research is to examine the unique relationship between safety perception and the mode choice of commuters for first and last-mile trips. The objectives to achieve the aim mentioned above are:

- To assess the role of safety perception in mode choice for first and last-mile connectivity,
- To identify different factors affecting the safety perception of a commuter and
- To analyse how safety perception relates to mode choice for Lucknow metro.

As the study is limited to safety perception, there will be no interrelation between safety perception parameters and other factors affecting mode choice, such as travel time, cost, age, and demographics. Additionally, due to geographical limitations, the results are based solely on data from the Lucknow Metro, which may not accurately reflect travel behaviour, safety perceptions, or infrastructure conditions in other cities.

Lucknow Metro represents a relatively new mass transit system that has been operational since 2017, making it an ideal case study for examining first and last-mile connectivity issues. The system faces documented challenges with last-mile connectivity, and recent reports have suggested expanding the system with an additional blue line, making this research immediately policy-relevant and potentially influential for future metro development strategies. The sites selected for this study were four metro stations in the operational length of the Lucknow Metro. Lucknow Metro has two corridors, the Red Line and the Blue Line (proposed network). The Red Line, also known as the North-South Line, is the current operational line of the Lucknow metro, with a length of 22.84 km. The Red Line has two terminal stations at Chaudhary Charan Singh Airport and Munshi Pulia. This line includes 22 stations, of which three are underground, and 19 are elevated. The Blue Line, also known as the East-West Line, is the second line proposed under the Lucknow metro, with a length of 11.1 km. The Blue Line will have terminal stations at Charbagh and Vasant Kunj, with 12 stations in between. Four stations along the Red Line are selected for the present study, as shown in the image below (refer to Figure 1).

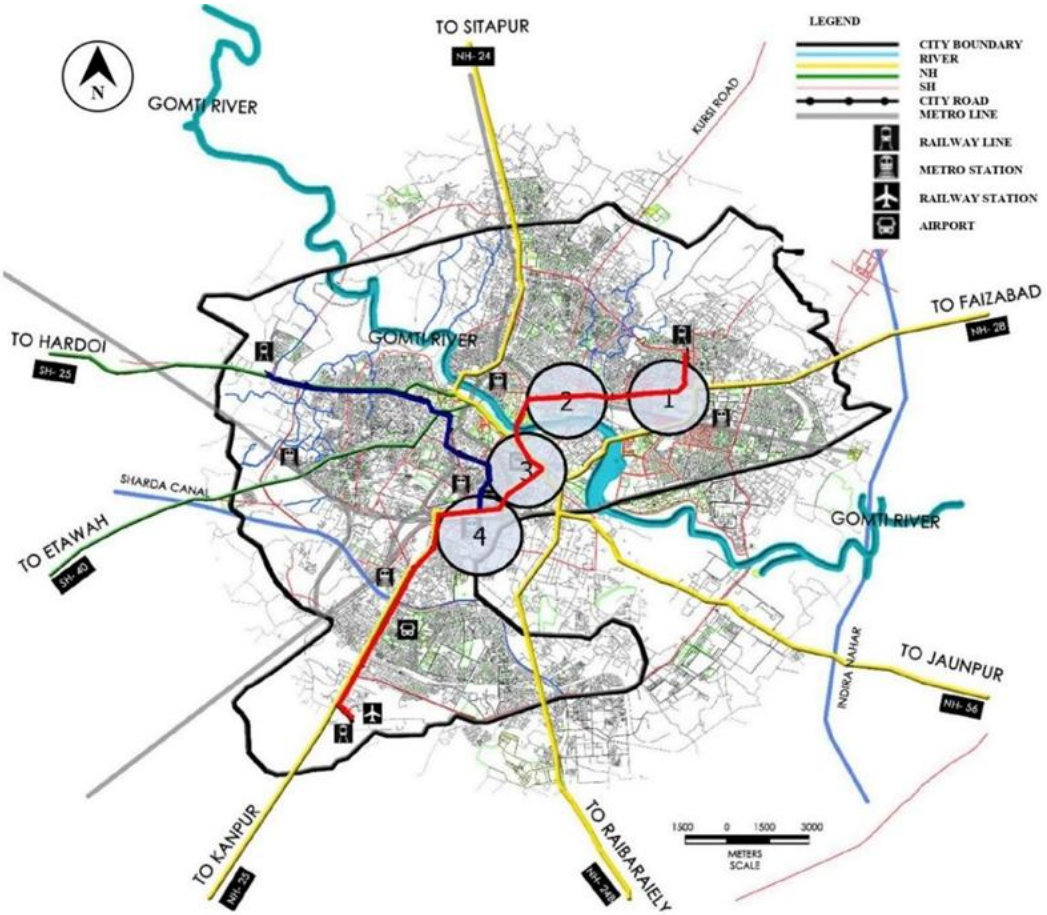

Figure 1: A base map of Lucknow highlighting Lucknow Metro stations for the survey. Source: Author.

The study employed a stratified sampling approach for station selection to ensure comprehensive representation across the Lucknow Metro's network characteristics. Metro stations were stratified based on two key criteria: land use characteristics (commercial, residential, and mixed-use dominance) and accessibility patterns (stations with varying feeder mode availability), namely the Indira Nagar Metro Station, which has neighbouring residential and industrial land use; the IT Chauraha Metro Station, which has three land uses around it (residential, recreational, and office); followed by the Hazratganj Metro Station, which neighbours four types of land uses (residential, commercial, recreational, and office); and the last metro station was the Charbagh Metro Station, surrounded by four types of land uses (residential, recreational, office, and transportation).

The data acquisition was done in a systematic three-phase approach: (1) Site inspection at each selected station, (2) Pilot survey administration with 30 respondents across station types to validate questionnaire clarity and completion time, and (3) Primary data collection through interviews positioned at strategic locations, including station entrances, feeder mode stops, and pedestrian pathways. The overall structure of the questionnaire was divided into three parts: the commuter's socio-economic and socio-demographic characteristics, detailed trip information, and a safety perception questionnaire. The safety perception questionnaire was developed following a systematic review of the literature and validated through a pilot survey. A total of fourteen (14) questions on the safety perception of the passengers were framed, covering five categories

of safety perception: vehicle conditions, safety precautions, driver characteristics, supporting infrastructure, and other factors (refer to Figure 2). Each question was carefully formulated to reflect parameters identified in previous studies on travel behaviour and mode choice, ensuring content validity and relevance to the Indian urban transit context. For reference, the full survey instrument has been included as an appendix to this paper.

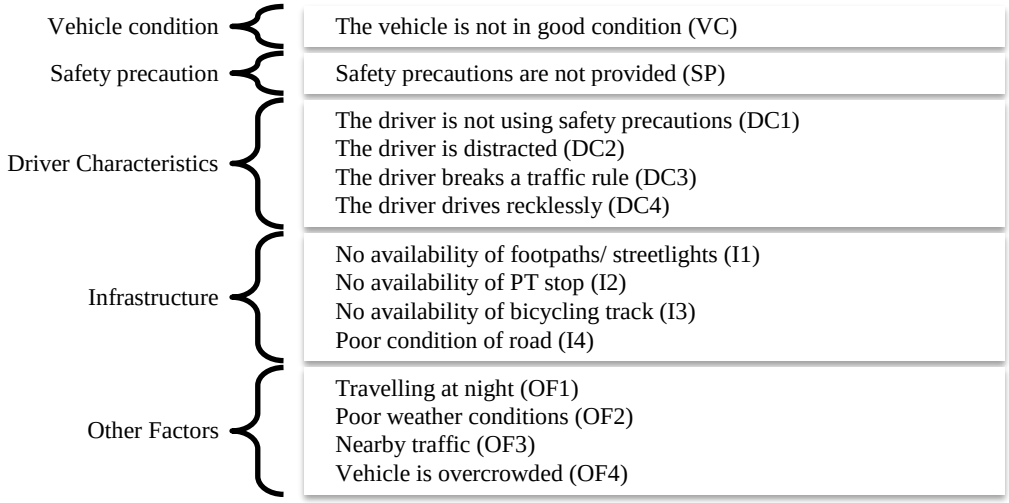

Figure 2: Categories and their respective parameters for safety perception.
Source: Author.

The survey was conducted over multiple days, with individuals accessing the station from different feeder modes during both peak and off-peak hours. The survey was conducted as a personal one-on-one interview using PAPI (Paper-Assisted Personal Interviewing), taking an average of 15 minutes to complete. Each of these survey sessions was limited and spanned multiple rounds and days to summarise the temporal variations in safety perceptions. As per Schwab (2002), the sample size guidelines for multinomial logistic regression recommend a minimum of 10 cases per independent variable (Schwab, 2002). As the study has 14 independent variables, 184 samples were recorded and analysed.

The statistical analysis of the survey data was conducted utilising correlation and multinomial logit regression techniques. Before regression, the study examined the correlation among the 14 factors to ensure the absence of multicollinearity in the model. Regression analysis was performed to determine whether an independent variable has a significant influence on the dependent variable. The multinomial logit model has been chosen for this investigation because the dependent variable is mode choice, which is an unordered categorical variable. Subsequently, the outcomes were analysed, and the correlation between the safety perception and the transportation mode selection was evaluated using the odds ratio.

The proposed research methodology offers a strong replicability possibility. The finalised factors of the safety perception can be standardised and adapted across different metro systems and developing country contexts. The survey-based data collection methodology employs a multinomial logistic modelling approach and takes into account safety perception factors; collectively, these elements create a template that other researchers can apply in similar urban transportation environments.

The study's dataset comprised demographic variables, including gender, age, level of education, income, and monthly transportation expenses. The survey was conducted to

obtain information about trip-related data, including trip type, purpose, frequency, and the feeder mode utilised. Table 1 presents a summary of the information.

Table 1: Descriptive Survey Outcome.

Name	*Category*	*Number of respondents*	*Percentage*
Age	Youth (15-24 age)	68	**36.96%**
	Adult (25+ age)	116	**63.04%**
Gender	Male	97	**52.72%**
	Female	87	**47.28%**
Education	8th	30	**16.30%**
	12th	25	**13.59%**
	Graduate	88	**47.83%**
	Postgraduate	41	**22.28%**
Income	<₹25,000 ($292 approx./€281 approx.)	66	**35.87%**
	₹25,000-₹50,000 ($292-$584 approx./€281-€562 approx.)	69	**37.50%**
	>₹50,000 ($584 approx./€562 approx.)	49	**26.63%**
Monthly expenditure on transport	<₹2,000 ($23 approx./€22 approx.)	48	**26.09%**
	₹2,000-₹4,000 ($23-$47 approx./€22-€45 approx.)	116	**63.04%**
	>₹4,000 ($47 approx./€45 approx.)	20	**10.87%**
Trip type	First Mile	86	**46.74%**
	Last Mile	98	**53.26%**
Trip Purpose	Home	20	**10.87%**
	Work	50	**27.17%**
	Recreation	66	**35.87%**
	Education	48	**26.09%**
Trip Frequency	Regularly	95	**51.63%**
	Occasionally	83	**45.11%**
	Rarely	6	**3.26%**
Feeder Mode	Private	57	**30.98%**
	Public	127	**69.02%**

Source: Author.

4. **Results and Discussion**

The analysis of the accumulated data has been divided into two parts. The descriptive analysis of the collected data is followed by a correlation analysis between the factors of safety perception and concludes with a multinomial logit regression model.

4.1 Correlation

This section details the correlation performed on the 14 factors used in the study to see if any of these factors are correlated. The model should be free of multicollinearity before proceeding to regression. There are four methods available for correlation:

- Pearson correlation
- Kendall rank correlation
- Spearman correlation and
- Point-Biserial correlation

As the data collected is on a Likert scale, rank correlation can be performed on this data to see if there is any multicollinearity. The correlation can be either positive or negative. Hence, the primary aim is to determine if any of the correlations exceed 0.8 or -0.8, as

these values would indicate a high correlation between those factors and would not be pursued in the study.

In Table 2, the highest positive correlation is 0.50 between the factors of travelling at night (OF1) and the vehicle being overcrowded (OF4). The highest negative correlation is -0.36 between safety precaution (SP) and the presence of a footpath (I1). Even though there is collinearity between different factors, it does not cross the mark of 0.8 or -0.8. Hence, the factors are considered individually and taken forward for the regression analysis.

Table 2: Correlation Matrix.

	VC	***SP***	***DC1***	***DC2***	***DC3***	***DC4***	***I1***	***I2***	***I3***	***I4***	***OF1***	***OF2***	***OF3***	***OF 4***
VC	1	0.47	0.36	0.26	0.23	0.18	-0.26	-0.04	-0.05	0.05	0.33	0.29	0.17	0.12
SP	0.47	1	0.46	0.21	0.30	0.34	-0.36	-0.07	-0.08	-0.05	0.46	0.16	0.15	0.28
DC1	0.36	0.46	1	0.17	0.36	0.30	-0.16	-0.04	-0.19	0.23	0.36	0.15	0.18	0.21
DC2	0.26	0.21	0.17	1	0.60	0.24	-0.08	0.13	0.05	0.01	0.37	0.33	0.14	0.22
DC3	0.23	0.30	0.36	0.60	1	0.37	-0.29	0.10	-0.21	0.02	0.43	0.42	0.22	0.35
DC4	0.18	0.34	0.30	0.24	0.37	1	-0.19	0.15	-0.10	-0.12	0.31	0.04	0.00	0.29
I1	-0.26	-0.36	-0.16	-0.08	-0.29	-0.19	1	0.33	0.52	0.18	-0.32	-0.13	-0.13	-0.16
I2	-0.04	-0.07	-0.04	0.13	0.10	0.15	0.33	1	0.19	-0.06	-0.07	0.17	0.02	0.14
I3	-0.05	-0.08	-0.19	0.05	-0.21	-0.10	0.52	0.19	1	0.04	0.00	-0.10	-0.13	-0.07
I4	0.04	-0.05	0.23	0.01	0.02	-0.12	0.18	-0.06	0.04	1	0.20	-0.08	0.06	-0.06
OF1	0.33	0.46	0.36	0.37	0.43	0.31	-0.32	-0.07	0.00	0.20	1	0.47	0.19	0.50
OF2	0.29	0.16	0.15	0.33	0.42	0.04	-0.13	0.17	-0.10	-0.08	0.47	1	0.22	0.41
OF3	0.17	0.15	0.18	0.14	0.22	0.00	-0.13	0.02	-0.13	0.06	0.19	0.22	1	0.12
OF4	0.12	0.28	0.21	0.22	0.35	0.29	-0.16	0.14	-0.07	-0.06	0.50	0.41	0.12	1

Source: Author.

4.2 Multinomial logit regression

As previously stated, the multinomial logit model has been selected for this study because the dependent variable is a categorical, unordered mode choice. The regression analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, and various tests were conducted on different combinations of variables to determine the significance of the model. Ultimately, the mode choice was clubbed and divided into three sections: walking, public transport, and private vehicle. These three were taken as the dependent variable, the 14 safety perception factors were taken as independent variables, and the regression was performed.

The Model Fitting Information indicates the validity and significance of the regression model performed. The model is null and void if the final value exceeds 0.000. Here, our model passes this test with the observed value 0.0. Hence, it is significant and suitable for our study. The Goodness-of-Fit is also a test for the significance of the model, as here, the Pearson and Deviance values should be more than 0.05 for the model to be significant. The model yields significance values of 0.317 and 1, respectively, indicating significance in this test as well. After passing all the previous tests for regression, the researcher found that out of fourteen (14) factors that were considered for the study, only eight (8) of them came significantly into the regression model (refer to Table 3). A variable is considered to affect the study only when its significance value is less than 0.05.

Table 3: Likelihood ratio tests for the regression model.

Effect	***Model Fitting Criteria***	***Likelihood Ratio Tests***		
	-2 Log Likelihood of Reduced Model	***Chi-Square***	***df***	***Sig.***
Intercept	182.401	3.979	2	0.137
VC	185.264	6.842	2	0.033*

SP	205.154	26.733	2	0.000*
DC1	189.957	11.535	2	0.003*
DC2	178.649	0.228	2	0.892
DC3	184.173	5.751	2	0.056
DC4	182.559	4.138	2	0.126
I1	179.521	1.099	2	0.577
I2	188.796	10.374	2	0.006*
I3	182.730	4.308	2	0.116
I4	192.880	14.459	2	0.001*
OF1	179.139	0.718	2	0.699
OF2	186.515	8.093	2	0.017*
OF3	184.556	6.135	2	0.057
OF4	178.832	0.411	2	0.814

Note: Level of Significance: *P<0.05.
Source: Author.

The six significant variables are vehicle condition (VC), safety precaution (SP), a driver not using safety precaution (DC1), presence of public transport stops (I2), condition of the road (I4), and weather conditions (OF2). There are also two near-significant variables, namely, driver breaking a traffic rule (DC3) and nearby traffic scenario on the commuting road (OF3). Given the significance of these eight variables, the research can now focus on determining which mode of transportation they will impact.

Through Table 4, we can understand that if walking is taken as a reference category, then people are likely to change to a private mode of transportation due to two factors. The factor SP observes a positive effect, suggesting that when safety precautions are provided in the vehicle, commuters are more likely to choose private transport. In contrast, DC1 indicates a negative effect, meaning that less safe driver behaviour makes private transport less attractive compared to walking.

For commuters to switch from walking to a public mode of transport, six factors have been deemed significant. The factor VC shows a negative effect, suggesting that poor vehicle condition makes commuters less likely to use public transport compared to walking. SP again observes a positive effect, entailing that higher safety raises the likelihood of choosing public transport. DC1 and DC3 exert a negative influence, meaning that unsafe driver behaviour reduces public transport utility relative to walking. I2 also shows a negative effect, indicating that the absence of supporting infrastructure, such as a stop area, makes people less likely to use public transport. Additionally, I4 displays a positive effect, indicating that people would rather take public transportation than walk if road conditions are poor.

Table 4: Multinomial logit regression with reference category as walk.

Feeder Mode		***B***	***Std. Error***	***Sig.***
Private Vehicle	Intercept	16.522	12.258	0.178
	VC	-0.208	1.151	0.857
	SP	2.437	0.939	0.009*
	DC1	-2.257	0.819	0.006*
	DC2	-0.484	1.037	0.641
	DC3	-0.004	0.726	0.995
	DC4	-1.544	1.316	0.240
	I1	-0.390	0.728	0.592
	I2	-0.526	1.014	0.604
	I3	-1.527	0.830	0.066
	I4	0.434	0.689	0.529
	OF1	-0.079	0.687	0.908
	OF2	-1.576	1.044	0.131

	OF3	-0.876	0.633	0.167
	OF4	0.551	1.354	0.684
Public Transport	Intercept	-2.309	3.150	0.463
	VC	-0.889	0.365	0.015*
	SP	1.616	0.387	0.000*
	DC1	-0.641	0.307	0.037*
	DC2	-0.033	0.342	0.922
	DC3	-0.540	0.242	0.026*
	DC4	0.512	0.436	0.239
	I1	0.145	0.207	0.485
	I2	-0.638	0.205	0.002*
	I3	-0.230	0.257	0.369
	I4	0.848	0.245	0.001*
	OF1	-0.185	0.221	0.404
	OF2	0.507	0.319	0.112
	OF3	0.302	0.199	0.129
	OF4	-0.143	0.430	0.739

Note: Level of Significance: *P<0.05.
Source: Author.

Through Table 5, we can understand that if a private vehicle is taken as a reference category, then people are likely to change to a public mode of transportation due to three factors. DC1 shows a positive effect, indicating that improved driver safety increases the likelihood of choosing public transport over private vehicles. OF2 observes a positive effect, representing that weather may make public transport more attractive than private, and OF3 displays a positive effect, indicating that when traffic is heavy, commuters may prefer public transport to avoid driving stress.

For commuters to switch from private vehicles to walking, the two factors that remain constant are SP, indicating a negative effect, meaning that poor safety provisions decrease the likelihood of walking compared to private transport, and DC1, showing a positive effect, stating that the driver compromising safety increases the likelihood of walking compared to private transport.

Table 5: Multinomial logit regression with reference category as private vehicle.

Feeder Mode		***B***	***Std. Error***	***Sig.***
Public Transport	Intercept	-18.832	12.077	0.119
	VC	-0.681	1.112	0.540
	SP	-0.821	0.898	0.361
	DC1	1.616	0.758	0.033*
	DC2	0.451	0.997	0.651
	DC3	-0.536	0.710	0.451
	DC4	2.057	1.264	0.104
	I1	0.535	0.714	0.454
	I2	-0.112	1.006	0.911
	I3	1.296	0.809	0.109
	I4	0.414	0.662	0.532
	OF1	-0.105	0.664	0.874
	OF2	2.083	1.040	0.045*
	OF3	1.178	0.619	0.047*
	OF4	-0.694	1.307	0.596
Walk	Intercept	-16.522	12.258	0.178
	VC	0.208	1.151	0.857
	SP	-2.437	0.939	0.009*
	DC1	2.257	0.819	0.006*
	DC2	0.484	1.037	0.641
	DC3	0.004	0.726	0.995
	DC4	1.544	1.316	0.240

I1	0.390	0.728	0.592
I2	0.526	1.014	0.604
I3	1.527	0.830	0.066
I4	-0.434	0.689	0.529
OF1	0.079	0.687	0.908
OF2	1.576	1.044	0.131
OF3	0.876	0.633	0.167
OF4	-0.551	1.354	0.684

Note: Level of Significance: *P<0.05.
Source: Author.

These findings suggest that a person is more likely to choose a private mode of transportation over walking as a feeder mode, primarily due to the presence of safety precautions and their active use by drivers which can be seen in Figure 3. This suggests that the presence and use of safety precautions become the primary reason for a commuter to shift from walking to using a private vehicle. This trend contrasts with the commuters' shift from walking to public transport, as the condition of the vehicle emerges as a critical determinant in this scenario. Commuters selecting a public mode of transportation are primarily influenced by factors such as the condition of the vehicle, the presence of safety precautions during travel, the driver's adherence to traffic rules and safety protocols, the availability of public transport stops, and the condition of the road. Prominent reasons, such as weather conditions and traffic congestion on the road, as well as safety precautions, can influence a commuter's shift from private to public transportation. Together, the results emphasise that safety perception plays a critical role in determining commuter preferences across different feeder modes.

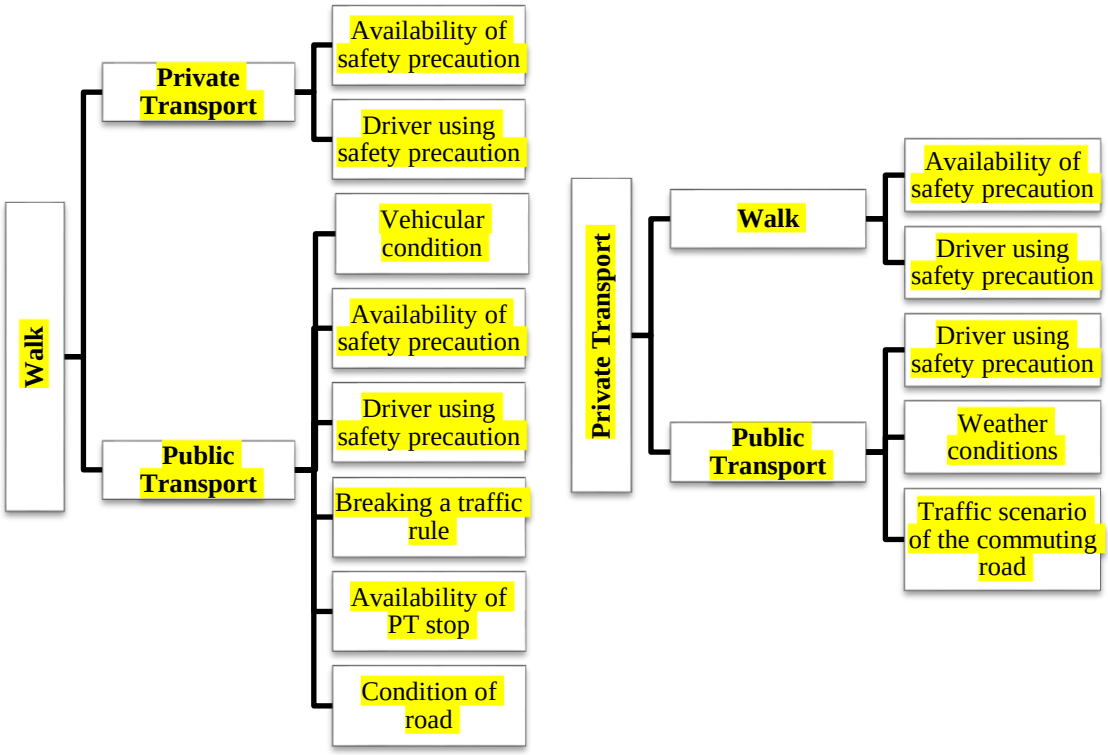

Figure 3: The division of factors under walking, public and private modes of transport.
Source: Author.

The conducted regression analysis also indicates that commuters' mode choice decisions are micro-economically correct and responsive to perceived safety. Significant variables, including safety precautions, driver behaviour, weather changes, supporting infrastructure, and traffic congestion, demonstrate the expected directions. Perceived safety and enabling conditions increase the likelihood of shifting to alternate modes, while barriers such as poor safety, inadequate infrastructure, and hostile travel conditions discourage mode use. For instance, the positive relationship between safety-oriented factors and adverse travel conditions and public transport choices reflects commuters' preference for secure and convenient options when faced with risk. Similarly, negative coefficients for safety gaps and infrastructure issues highlight the obstructive effect on walking.

These results highlight the importance of incorporating commuter safety perception into urban transportation planning through policy interventions. Improvements in terms of how people perceive safety include maintaining public transportation and infrastructure, strictly adhering to safety rules, ensuring sufficient lighting, and providing auxiliary infrastructure such as bike and pedestrian lanes. Public and non-motorised modes could therefore be marketed as reliable feeder options. Initiatives that enhance the perceived and actual safety of public transit systems should therefore receive top attention from municipal leaders.

5. Conclusion and Recommendations

The research aimed to understand if safety perception affects the mode choice of a Lucknow metro commuter for first and last-mile connectivity. The study showed that although past literature addressed the safety perception of travellers, no concrete research had been conducted, focusing solely on safety perception as a factor. This study establishes that, although safety perception is a soft factor and challenging to analyse, it does influence the mode choice of commuters. It suggests that eight factors influence the commuter's mode choice for the first and last-mile connectivity of the Lucknow metro, namely vehicular condition, presence of safety precaution, using safety precaution, driver breaking a traffic rule, presence of public transport stops, condition of the road, weather conditions, and nearby traffic scenario on the commuting road, as listed in Figure 4. Urban transport policies aiming to strengthen multimodal connectivity must recognise that commuters' perceptions of risk often outweigh considerations of pure convenience or cost.

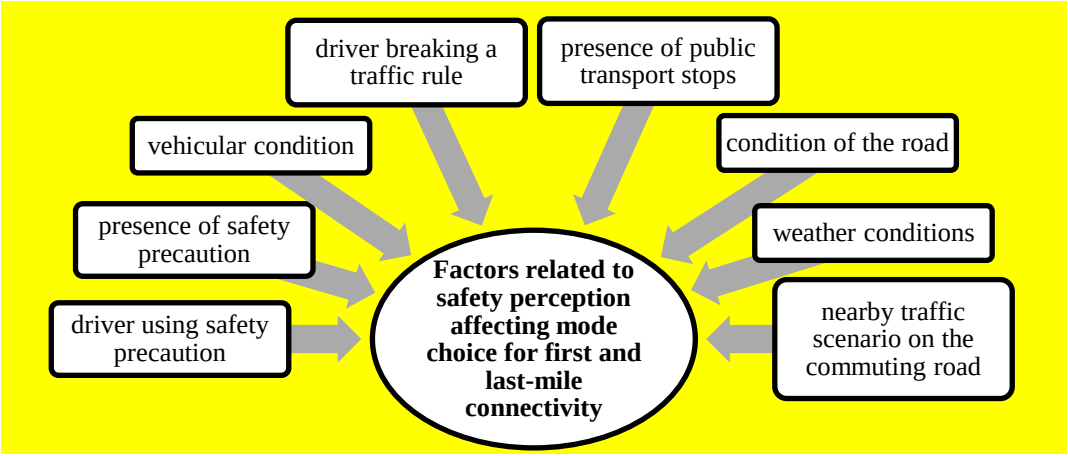

Figure 4: Eight factors affecting Lucknow Metro's first and last-mile connectivity.
Source: Author.

Factors such as vehicular condition, driver compliance with traffic rules, availability of safety precautions, and drivers using safety precautions can be improved under the Motor Vehicles (Amendment) Act, 2019, which regulates vehicle testing, design standards, and maintenance and regulates penalties, along with the National Road Safety Policy (2010) that implements the public awareness aspect of safety by educating drivers about it. Availability of public transport stops, condition of roads, and nearby traffic scenarios can be improved with the help of policies like the National Urban Transport Policy (2006), Smart City Mission (2015), and Transit-Oriented Development Policy (2017) that can look into the enhancement of the accessibility and availability of public transport, improve the public transportation sector, and use intelligent transportation systems to reduce traffic congestion and smooth the movement of traffic. Initiatives such as Cycles4Change, Streets4People, and Transport4All promote non-motorized transportation and pedestrian-friendly infrastructure nationwide.

Aspects such as the condition of the public transportation infrastructure, driver characteristics regarding safety precautions and adherence to the law, supporting infrastructure like collection points, and constant surveillance must be investigated and improved to enhance the perception of safety for commuters using public transport, particularly in first- and last-mile connectivity. An action plan for road safety can be developed, comprising both short-term and long-term objectives. Short-term goals can include improving traffic law enforcement or educating people on road safety through workshops. In contrast, long-term goals may consist of evaluating and improving current road safety standards and developing minimum vehicle safety standards. These initiatives can be implemented with the assistance of the Ministry of Road Transport and Highways under the Government of India, in collaboration with the Uttar Pradesh State Government's Police Department, Public Works Department, and other relevant administrative bodies.

In urban transportation research, special attention is required when expanding the results beyond the studied population, as factors used in this study may perform differently under varying geographical conditions and contexts. Although this study captures the Lucknow Metro’s heterogeneous nature, its replication in different urban settings is essential to validate its applicability. Future research should consider conducting similar studies across cities with differing transport systems, climatic conditions, and urban forms to assess the robustness of the observed relationships and the validity of the research. Furthermore, they can examine safety perceptions in relation to other factors influencing mode choices, such as trip characteristics, socioeconomic status, gender, and various other variables. This can illuminate the importance of safety across these multiple parameters and form a more sustainable future that is safety-oriented.

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