Perceived safety of passengers in public transportation

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Abstract

Background: Passenger safety perception is a critical factor influencing the use of public transportation in Europe. Despite its importance, limited research has been conducted on the specific elements that affect passengers' perceived safety within public transport systems, especially in European contexts. This study aims to identify factors that directly or indirectly influence passengers' perceived safety in public transportation, thereby contributing to enhanced passenger satisfaction and increased public transport usage.
Methodology: A quantitative research design was employed using both primary and secondary data from public transport companies. Primary data were collected through passenger surveys, where passengers rated their perceived safety on a scale from 1 to 10. Secondary data included operational information such as schedules, staffing schedules, passenger counts, and the presence of security measures. The study examined factors like the presence of staff, frequency of ticket inspections, urban versus rural areas, seat availability, late travel times, and the presence of security cameras. Multiple regression analyses were conducted to test the hypotheses.
Findings: The analysis revealed that the presence of staff positively affects passengers' perceived safety. However, frequent ticket inspections negatively moderated this relationship, suggesting that excessive inspections may reduce the positive impact of staff presence on passengers' perceived safety. Overcrowding, indicated by lower seat availability, negatively influenced perceived safety, emphasizing the importance of managing seat availability. Contrary to expectations, factors such as urban areas, late travel times, and the presence of security cameras did not have a significant effect on passengers' perceived safety.
Conclusion: This study identified key factors that significantly affect passengers' perceived safety in European public transportation. By highlighting the positive impact of staff presence and the negative effects of overcrowding and excessive ticket inspections, the research provides valuable insights for public transportation providers. These findings offer practical recommendations to enhance passengers' perceived safety, such as optimizing staff visibility, balancing ticket inspection frequency, and managing overcrowding. Improving perceived safety is crucial for encouraging greater use of public transport, thereby supporting sustainable urban mobility and addressing broader environmental goals.

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1 Introduction

Millions of passengers use the public transport network in Europe every day. Due to the immense number of passengers, public transportation plays a crucial role in modern urban mobility (European Commission, 2023). The use of public transportation reduces pressure on other infrastructures, such as highways, and contributes to a more sustainable environment (Berg & Ihlström, 2019). Therefore, expanding and improving the public transportation network aligns with sustainable development goals acknowledged worldwide. To ensure that enough people will use the existing public transport network, it is important to continue researching passenger satisfaction and identifying opportunities for improvement.

Various factors appear to affect passengers' overall satisfaction with public transportation. For example, the reliability of public transportation is an important predictive factor; unexpected changes in the travel schedule regularly lead to frustration and dissatisfaction among passengers (Friman et al., 2001). Additionally, the level of comfort also influences the amount of passengers' satisfaction. This refers, for instance, to the availability of seats, electricity points, and the temperature and cleanliness of the vehicle (Brons & Rietveld, 2009). Finally, another essential factor for passenger satisfaction is the actual safety in the public transportation and the perception of safety among passengers (Lierop et al., 2017).

Several studies have shown that the sense of safety influences the extent to which a person is willing to travel by public transport (Delbosc & Currie, 2012; Lierop et al., 2017). From this, it can be concluded that improvements in safety measures may encourage passengers to use public transport more frequently. However, little research has been done on the specific elements that influence that sense of safety in public transport, especially within European settings. Most of the existing studies are based on non-European contexts. Lierop et al. (2017) have shown that there is a fundamental difference between the importance and factors of experienced safety in European and non-European contexts. Wang et al. (2020), for example, showed that safety awareness is an important predictor of safety behavior in China; however, whether these findings are applicable in Europe remains uncertain.

Delbosc and Currie (2012) also conducted research on safety perceptions in public transport, focusing on individual factors such as age, gender, and trust in others. While their study provides valuable insights into how personal characteristics influence feelings of safety, these are intrinsic factors that cannot be readily altered through policy or operational changes. Consequently, their research does not address the crucial question of what specific measures can be implemented to make passengers feel safer. This gap emphasized the need for studies that identify actionable strategies to enhance perceived safety in public transportation.

While actual safety measures are crucial, it is the passengers' perception of safety that often determines their travel choices. Even if statistical data indicate that public transport is safe, passengers may still opt for alternative modes of transportation if they perceive it as unsafe. Perceived safety can influence passenger behavior more significantly than actual safety statistics. Therefore, focusing on perceived safety allows for a better understanding of the psychological factors that affect passengers' decisions, enabling the development of interventions that enhance their sense of security. This gap in the literature requires further research on what influences passengers' sense of safety within European public transport. Without a clear understanding of these factors, efforts to improve perceived safety may be less effective, potentially impacting public transport usage negatively. Therefore, this research aims to identify factors that directly or indirectly affect perceived safety within public transportation in a European context.

In this study, hypotheses will be established by conducting a deeper investigation of the existing literature and a conceptual model will be developed. These possible factors will then be tested on operational and survey data from public transportation passengers in a European setting. By addressing this gap, the study seeks to contribute to the academic discourse on public safety and its antecedents. Insights from this research could inform effective interventions to increase perceived safety in public transport, ultimately enhancing passenger satisfaction and encouraging greater use of public transportation.

1.1 Research question

What factors directly or indirectly influence passengers' perceived safety within public transportation in a European context?

1.2 Practical relevance

This research will provide valuable insights into the factors influencing passengers' perception of safety while traveling on public transport. The findings can inform various stakeholders, enabling them to make well-informed decisions to enhance passenger safety and satisfaction. Public transport companies can use these insights to develop policies regarding optimal staff deployment at specific times and make decisions about the necessity of installing surveillance cameras in public transportation. Additionally, these insights can guide operational adjustments, influencing how personnel and resources are allocated, with the research outcomes shaping associated protocols.

Moreover, training centers may gain a deeper understanding of how staff can be deployed most effectively. The findings could also support governmental authorities in enforcing specific measures on transport operators, incorporating these requirements into tender specifications for transport contracts. This knowledge further contributes to discussions about the necessity of deploying staff and other personnel.

By enhancing the understanding of factors that affect perceived safety, effective interventions can be implemented that not only improve safety but also encourage the use of public transport. This contributes to sustainable urban mobility and supports policymakers and public transport companies in making informed decisions.

1.3 Academic relevance

This research addresses a critical gap in the academic literature on safety within public transportation, particularly in the European context. While existing studies have acknowledged that safety significantly affects overall passenger satisfaction and willingness to use public transport (Lierop et al., 2017), there is a significant gap in the literature concerning the specific operational and environmental factors that can be modified to enhance passengers' sense of safety within European public transportation systems.

Previous studies have focused on personal characteristics such as age, gender, and individual trust levels (Delbosc & Currie, 2012), which offer limited guidance for practical interventions. Moreover, much of the existing research is based on non-European contexts with different cultural, infrastructural, and regulatory frameworks (Wang et al., 2020).

This lack of knowledge is problematic because it limits the ability of policymakers and public transport companies to implement effective interventions tailored to the European context. Without empirical insights into what specifically affects passengers' perceived safety, efforts to enhance safety perceptions may be misguided or ineffective, potentially leading to persistent feelings of insecurity

among passengers. This can result in decreased public transport usage, hindering goals related to sustainable urban mobility and environmental sustainability.

By exploring and identifying the factors that directly or indirectly influence passengers' perceived safety within public transportation in a European context, this study aims to fill the existing gap in the literature. By using operational and survey data from European public transport passengers, the research will test and refine existing theories of safety perception within this specific context. The findings are expected to contribute to the academic debate by providing empirical evidence on the determinants of perceived safety, enriching theoretical models, and advancing scholarly understanding of public safety in transportation. Ultimately, this study will offer a foundation for future research and inform the development of targeted, effective interventions to enhance passengers' perceived safety in public transport systems.

2 Theoretical framework

Based on previous research, it seems that the perception of safety is an important influencer on travelers' overall satisfaction with public transport. Although several studies have investigated behavior in public transport, little research has been done on factors that influence the sense of safety of passengers in public transport. Besides that, most of the research is done outside of Europe, which creates uncertainties about the impact of these factors in Europe. This literature study will investigate which factors might influence the perception of passengers' safety in Europe's public transport. Based on these studies, hypotheses will be drawn up, and eventually, this will lead to a conceptual model that will be tested on actual public transport data.

2.1 Presence of staff and perceived safety

Since one of the described roles of the public transportation staff is to ensure safety on public transport, it looks likely that the presence of staff may affect the passengers' sense of safety. From the literature, this seems explainable from two theories: the Guardianship theory and the Social Presence theory. Various studies can support the evidence for a potential relationship between the presence of public transportation staff and the perceived safety of passengers.

The first theory is the Guardianship Theory. This theory states that people's sense of safety increases when competent guardians are present (Cohen & Felson, 1979). The staff can be seen as a protector in public transportation since they are the point of contact in case of emergencies, conflicts, and crime. The Guardianship Theory describes three elements necessary for crime prevention: a motivated offender, a suitable target, and the absence of a guardian/protector (Cohen & Felson, 1979). The presence of a guard can deter potential offenders because it increases the likelihood that the offender will be caught or stopped. Since a guard can intervene in case of an emergency, this can also increase the passengers' sense of security. Research has shown that the presence of a guard/protector can indeed reduce feelings of anxiety and stress, even when there is no immediate threat at all (Welsh & Farrington, 2009). A similar result was also found in a study by Newton (2004); namely, the presence of staff in public transportation and stations significantly reduces the fear of crime among passengers. Finally, the research of Smith and Clarke (2000) also supports the above research; it was also found that visible personnel should lead to crime deterrence.

The second theory is the social presence theory. This theory states that the visible presence of staff enhances passengers' sense of safety. In addition, this theory indicates that the presence of others in general also contributes to people's sense of safety. This can be explained in different ways. The first is related to the guardianship theory: the visible presence of people with authority and people who supervise provides a sense of security because they will intervene when something that is not allowed happens (Biocca et al., 2003). Based on this, an employee's presence contributes to travelers' perceived safety. Based on research by Smith and Clarke (2000), it can be said that checking tickets contributes to the prevention of criminal actions and, therefore, contributes positively to the traveler's sense of safety. In addition, the presence of a guard makes a traveler less anonymous, as the guard can ask the traveler to identify himself. People who feel less anonymous are less likely to exhibit antisocial and criminal behavior, contributing to the traveler's sense of safety. Research by Currie and Delbosc (2009) also indicates that the safety level increases when more visible staff members are present.

Based on the above research findings, it seems likely that the presence of public transportation staff could positively affect passengers' sense of safety. Therefore, checking tickets could be seen as a behavioral intervention from the staff member that could strengthen or weaken this previously described relationship (moderation effect). The following hypotheses can be formulated for this current research:

H1: The presence of sufficient staff positively affects the perceived safety of passengers.
H2: Ticket inspections by public transportation staff moderate the relationship between the presence of sufficient staff and the perceived safety of passengers positively.

2.2 Urban areas and perceived safety

The second factor that can affect passengers' sense of safety is the urban area in which they are located. An urban area is defined as a geographical area characterized by a high population density. It seems plausible that urban areas may negatively impact passengers' sense of safety.

First, in urban centers, with a high population density and many activities, crimes such as theft, vandalism, and violence are reported more often (Farrall et al., 2009). This most likely directly impacts the sense of safety on public transportation. Because criminal actions are reported more frequently, this can lead to a constant awareness of possible threats among passengers, which in turn can ultimately lead to increased anxiety and stress feelings. This is especially relevant around train and subway stations, as these are more often hotspots for this type of criminal activity (Watson & Wilson, 1988).

Second, people are more likely to feel more anonymous in urban areas, which can ultimately lead to a reduced sense of security. Higher anonymity in larger cities often leads to a weaker sense of social cohesion, which eventually means that people are less likely to intervene in incidents or suspicious activities (Mari, 2007). This can also be called the "bystander effect" because it suggests that individuals in a larger group are less likely to help someone in need. After all, they assume others will intervene. This may increase anxiety and insecurity among passengers, as they unconsciously feel less supported by their fellow travelers anyway (Whyte, 1980).

Finally, the media plays an important role in the sense of safety in urban areas. Indeed, negative media reports can magnify real risks, which can create a sense of fear among travelers. In the media, sensational mishaps and incidents in large cities are often mentioned, which can create the image that travelers in urban areas are more at risk. This overrepresentation of negative incidents can significantly affect public perception, which can create feelings of fear and cause travelers to feel unsafe, even in relatively safe situations (Ditton & Chadee, 2006).

Therefore, based on the above research results, the following hypothesis can be formulated for this current study:

H3: Urban areas negatively affect the perceived safety of public transportation passengers.

2.3 Overcrowding and perceived safety

In addition to urban areas, public transport overcrowding can potentially impact passengers' perceived safety. Overcrowding is a situation in which the number of people in each space exceeds the capacity for which that space was designed (Evans & Wener, 2021). The possible relationship between overcrowding and the sense of safety has previously been investigated scientifically from several perspectives.

First, passengers in overcrowded spaces may experience feelings of claustrophobia and anxiety. This is supported by Evans and Wener (2021), who showed that crowded environments can have negative psychological effects on individuals. In doing so, it has also been shown that crowded conditions create stress and discomfort as people struggle to maintain their personal space and navigate through the crowds. These feelings can be exacerbated by the perception of limited control and increased unpredictability in crowded situations, contributing to increased feelings of insecurity (Wener et al., 2006).

In addition, crowded places can lead to a decrease in social norms of behavior, which may result in undesirable acts such as pushing, shouting, or fighting. This is because the lack of space can generate frustration (Murji, 2000). Freedman (1975) has also previously shown that a high density of people can lead to aggression and antisocial behavior because people then start competing for the limited resources and limited personal space available. In crowded situations, passengers may feel more sensitive to possible dangers, increasing anxiety and decreasing their sense of safety (Wang et al., 2020). Overcrowding can also reduce the accessibility of facilities such as restrooms and seating, which can ultimately cause discomfort, especially for the elderly and people with disabilities (Mackett, 2014).

Finally, lack of space can make it difficult to evacuate in the event of an emergency since overcrowding reduces the speed and efficiency of evacuation processes, increasing the risk of injury (Gwynne et al., 1999). This can lead to increased insecurity among individuals (Still, 2000).

Therefore, based on the above research results, the following hypothesis can be formulated for this current study:

H4: Overcrowding in public transportation negatively affects the perceived safety of passengers.

2.4 Late travel times and perceived safety

The time at which individuals use public transportation may also affect the passengers' sense of safety. Traveling at a later time can lead to a decreased sense of safety, and there are several reasons for this.

First, there is often a limited degree of social control at a later time. According to Ellis and Newman (1974), the presence of other people plays a crucial role in enhancing a sense of security. Thus, once fewer passengers are at stations and on public transportation, social control decreases, which can lead to a higher sense of vulnerability and isolation (Cozens et al., 2004). According to routine activity theory (Cohen & Felson, 1979), people who travel alone during late hours also have a higher actual risk of victimization because there are fewer people nearby who can help in case of an incident.

Additionally, lighting at stations and in vehicles tends to be lower in the later hours. This can contribute to feeling unsafe. When spaces are less well-lit, not only can this reduce visibility, but there are also more shadow spots and dark corners where potential danger could come from. When an environment is well-lit, people can better survey the surroundings and recognize potential threats (Farrington & Welsh, 2004; Painter, 1996).

Finally, certain types of crime, such as robberies and assaults, seem to occur more frequently during the late evening and night hours. It is not so much the actual incident that affects the feeling of safety but rather the perception of an increased crime risk during these later hours. This sense of insecurity may be additionally fueled by media reports and stories from others (LaGrange et al., 1992).

Therefore, based on the above research results, the following hypothesis can be formulated for this current study:

H5: Traveling at late hours negatively affects the perceived safety of passengers.

2.5 Security cameras and perceived safety

The final factor that may affect passengers' sense of safety is the presence of security cameras. These security cameras may provide an increased sense of security for passengers.

Based on the deterrence theory, which states that surveillance causes crime to be detected faster and increases punishment, making offenders less likely to commit a crime (Cohen & Felson, 1979), surveillance cameras may also serve as a deterrent to potential criminals. It shows that actions are monitored, which could make one less likely to display negative behavior on public transportation. This ultimately leads to a higher sense of security. The security camera can also influence the overall social norm of the entire group, which further encourages desirable behavior. Once passengers feel that there is surveillance, even if it is anonymous, they often adjust their behavior. This is also known as the Hawthorne effect and helps to increase general social order within public transportation (Mayo, 2004). This is likely to positively affect passengers' sense of safety. Indeed, Welsh and Farrington (2009) have also shown that security cameras can decrease the amount of crime in public areas, such as public transportation and stations. Finally, cameras may increase the sense of security because people feel controlled. People feel safer once they know there is a control mechanism that can protect them (Clarke, 1995; Jason & Emma, 2017).

Several studies have found a relationship between security cameras and perceived safety. First, Gill and Spriggs (2005) showed that the use of security cameras does indeed increase the sense of safety. Welsh and Farrington (2009) also showed that security cameras can lead to a huge decrease in crime and an increased sense of safety among passengers.

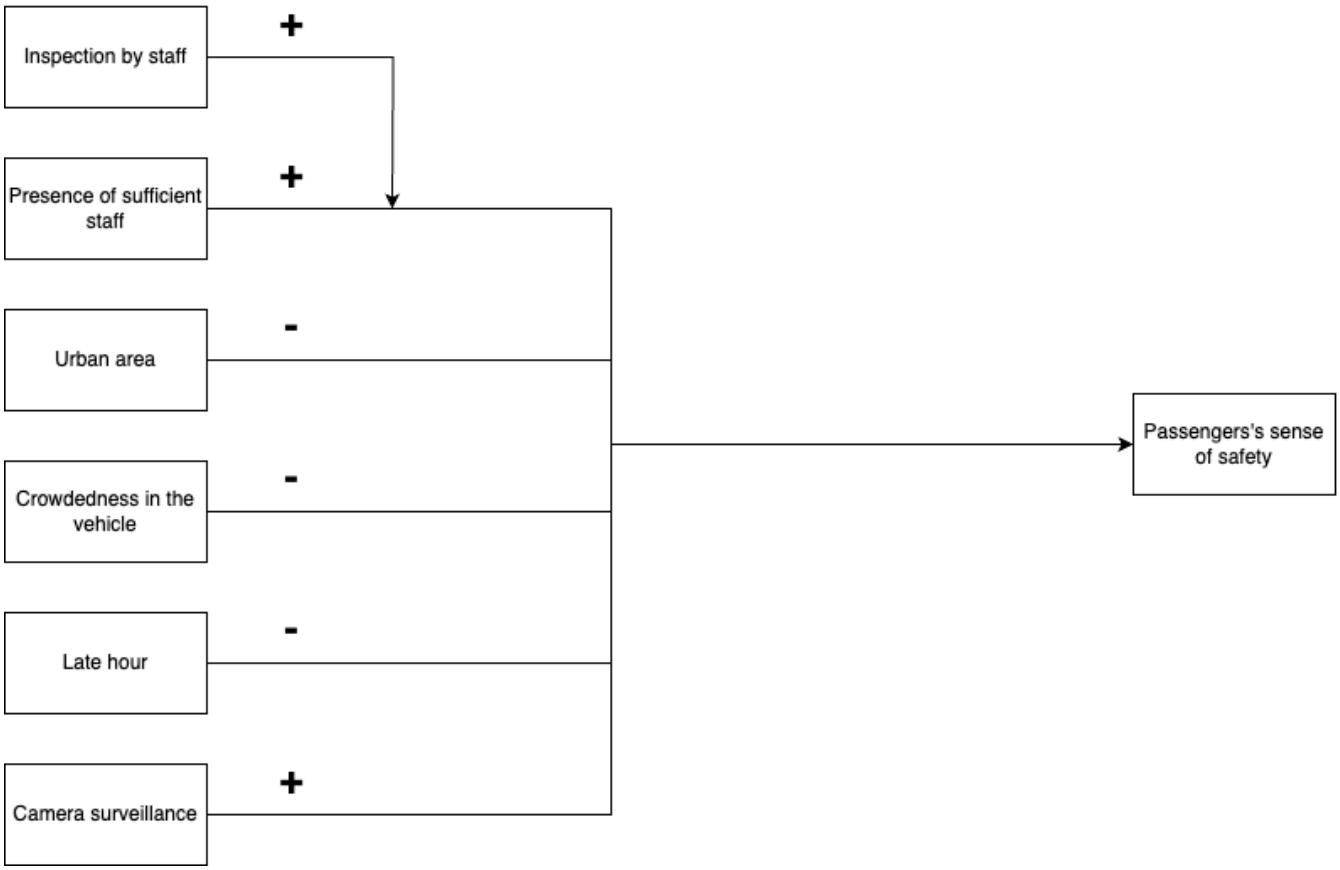
Therefore, based on the above research results, the following hypothesis can be formulated for this current study:

H6: The presence of security cameras positively affects the perceived safety of passengers.

2.6 Conceptual model

Based on the literature above, various factors influence passengers' perceived safety when traveling with public transport. In the conceptual model, various independent variables are included: the presence of staff, inspections by staff, urban areas, crowding, late travel times, and security cameras. In the model, the number of inspections moderates the possible relationship between the staff's presence and the passengers' sense of safety. The passengers' perceived safety is the dependent variable in this study. This study will further investigate these factors to provide insights that can be utilized within transport organizations to enhance customer satisfaction.

***Figure 1**: Conceptual model*



3 Methodology

3.1 Research design

This research adopts a quantitative design to test the hypotheses formulated in the theoretical framework using primary and secondary data sources. Factors that could affect the perceived safety of passengers in public transport are comprehensively analyzed. The basic design of this research involves primary data collection by surveying passengers at public transportation and secondary data collection using transportation data. The research will be based on data collected by public transportation companies.

3.2 Sample

The sample for this study is to be constructed using surveys to engage passengers in real-time. Passengers in public transportation will receive a survey at a random moment during their journey. This form of random interval sampling will ensure that data is collected at different points in time and under various travel conditions.

Random interval sampling has several key strengths. Response rates are also likely to be higher than in other ways that involve the traditional survey method since people are more likely to participate when they are notified about the survey, as opposed to when they are supposed to fill it out later. This spontaneous notification takes advantage of the passenger's availability and the experience at that particular time. Moreover, the random interval sampling will ensure data is collected at different points in time and under different travel conditions, thus collecting the sample across different timings of the day, weekdays, and diverse travel conditions. This will increase the sample's representativeness and reduce the risk of temporal bias. Real-time data collection also allows the capture of contextual variables that may influence safety perception, such as location, intensity of crowding, and presence of a staff member. It makes the data denser than the static, retrospective surveys.

The survey contains multiple questions, where passengers can give scores about the journey, the station, the travel information, and the safety perception. In this research, the score for the sense of safety will be used.

3.3 Data collection

3.3.1 Data resources

This study uses both primary and secondary data to investigate the factors influencing passengers' perceived safety in European public transportation. The primary data will be collected through a structured survey designed to measure passengers' sense of safety.

Data collection will occur at various times of the day and on different days of the week to account for temporal variations in passengers' experiences. This approach aims to capture a diverse range of travel conditions and passenger demographics, thereby enhancing the generalizability of the findings.

The secondary data comprises transportation statistics obtained from a public transportation companies and other public transportation authorities. This data will include information on the number of passengers, schedules, and staffing levels, providing the context within which the primary data will be analyzed.

3.3.2 Operationalization of variables

Perceived safety: Perceived safety is a subjective assessment of how safe an individual feels while using public transportation. To operationalize this construct, the study will utilize the approach outlined by Delbosc and Currie (2012), focusing on direct self-reported measures of perceived safety.

Passengers are asked to indicate their level of perceived safety by giving a score on a scale from 1 to 10, where 1 means “Not safe” and 10 means “Completely safe” to the following statement:

“I feel safe during my trip”

This single-item measure allows passengers to express their overall sense of safety numerically, providing a straightforward and easily interpreted metric. Delbosc and Currie (2012) demonstrated that such direct measures of perceived safety are effective in capturing passengers' safety perceptions and their impact on public transport ridership. By employing this method, the study ensures that the measurement of perceived safety is both simple for respondents and aligned with established research practices. The use of a 1 to 10 scale offers a fine-grained assessment of passengers' feelings, facilitating a detailed analysis of the data.

This study also includes several independent variables, which are listed below.

Urban areas: Depending on the route, the areas are categorized as urban or rural. The former is described as a place within a city with a high population density. At the same time, the rural area is outside city boundaries, with a low density of people.

Staff checks: The frequency of checks is determined by the number of ticket scans. This variable captures how frequently passengers meet with staff who check tickets during their travels.

Presence of staff: The number of staff present in the public transportation. All the uniformed staff present are counted.

Number of passengers: The average number of passengers present in the public transportation. This is based on an algorithm available to estimate the number of passengers based on ticket data.

Late travel times: Time of travel, either daytime, from 6 AM to 10 PM, or nighttime, from 10 PM to 6 AM. This variable captures the influence of differing travel times during the day on passengers' perceived safety.

Security cameras: This variable assesses the presence of security cameras based on the type of vehicle. It assesses whether security cameras have been installed in vehicle according to their specific type.

Lastly, this study includes one moderating variable: year. This variable will be included to control for differences that may affect perceived safety.

The variables used in this study, along with their measures and data sources, are summarized in the following table:

***Table 1**: Variables*

Variable	Measure	Data source
Independent variables		
Urban Areas	Urban of rural classification	Timetable data
Staff checks	Number of ticket inspections	Scan device
Presence of staff	Number of staff present	Duty data
Passengers	Number of passengers in the public transport	Ticket data
Seat availability	Number of passengers/number of seats available	Ticket and public transport data
Late Travel Times	Daytime (6 AM – 10 PM) or nighttime (10 PM-6 AM)	Survey, Timetable data
Security cameras	Awareness and visibility (True or False)	Vehicle data
Dependent variable		
Perceived safety	Safety rating (1-10 scale)	Survey
Moderator		
Year	In years	Survey

3.4 Data analysis

In this study, SQL and R will be used to collect the data, transform it, and perform the statistical tests.

3.4.1 Data preparation and assumption checking

Before running all statistical analyses, the normality, linearity, multicollinearity, and homoscedasticity assumptions will be checked. The required transformation of data will be made in the case of the violation of the assumptions. Alternatively, some data will be categorized manually.

3.4.2 Descriptive statistics

Descriptive statistics will be used to summarize the sample's characteristics and the distribution of responses for each variable. Measures of central tendency (mean, median) and dispersion (standard deviation) will be reported. There will also be a frequency distribution presented for the categorical variables.

3.4.3 Inferential statistics

To test the hypotheses and examine the relationships between the variables, statistical analyses will be conducted using multiple regression analysis. They will be carried out to explain the relationship between the independent variables and the dependent variable. It will explain to what extent factors such as urban areas, staff checks, the presence of staff, passenger crowding, late travel time, and security cameras impact passengers' perceived safety.

4 Results

This chapter presents a systematic analysis of factors influencing passengers' perceived safety in public transportation. The analysis commences with descriptive statistics to establish the fundamental characteristics of the dataset, proceeds with correlation analyses to examine variable relationships, and concludes with regression analyses for hypothesis testing. The analytical framework focuses on the relationships between operational factors, environmental conditions, and passengers' perceived safety.

4.1 Data collection

The data were collected through several methods. Passenger assessments, which serve as the foundation for this analysis, were gathered and subsequently published within the data warehouse. Additional variables were then compiled based on these assessments. Each assessment included the movement number and date, allowing data linkage to the schedule. From the schedule, the type of vehicle in service was identified, which made it possible to determine the number of available seats. ticket data, processed through an existing algorithm, provided estimates of the number of passengers on each vehicle, allowing for the calculation of seat availability probability.

Using the movement number, date, and the departure and destination stations, personnel scheduling records were analyzed to determine the number of staff assigned to each trip. This involved accessing the personnel planning system and cross-referencing the data with the specific journeys identified in the dataset. By aligning movement numbers and journey details with the scheduling records, the number of staff scheduled for each trip on a given date was accurately retrieved.

4.2 Descriptive statistics and correlations

4.2.1 Dataset composition

The dataset includes a total of **1587 observations** after necessary data cleaning and merging procedures. The data were sourced from multiple files, including passenger ratings, urban area indicators, camera surveillance presence, and journey schedules. The key variables in the dataset are as follows:

- **Perceived safety**: Passengers' rating of perceived safety on a scale from 1 to 10.
- **The presence of staff**: Number of employees present on the journey.
- **Staff checks**: Number of ticket inspections conducted.
- **Seat availability**: Probability of passengers obtaining a seat, represented as a percentage.
- **Urban**: Indicator of whether the journey operates in an urban area (0 = No, 1 = Yes).
- **Security cameras**: Presence of security cameras on the vehicle (0 = No, 1 = Yes).
- **Late travel times**: Indicator of whether the journey is a night journey (0 = No, 1 = Yes).
- **Dummy variables**: Created for categorical variables such as day abbreviations (**weekday**) and months (**month**), excluding one category to avoid multicollinearity.

4.2.2 Handling missing values

The dataset was thoroughly checked for missing values. The variable **Staff checks** had missing values, which were replaced with zeroes, assuming that the absence of data indicates there were no scans.

4.2.3 Descriptive statistics

The following table presents descriptive statistics for the main variables in the study, providing an overview of the dataset's characteristics and distributions.

Table 2: *Descriptive statistics of key variables*

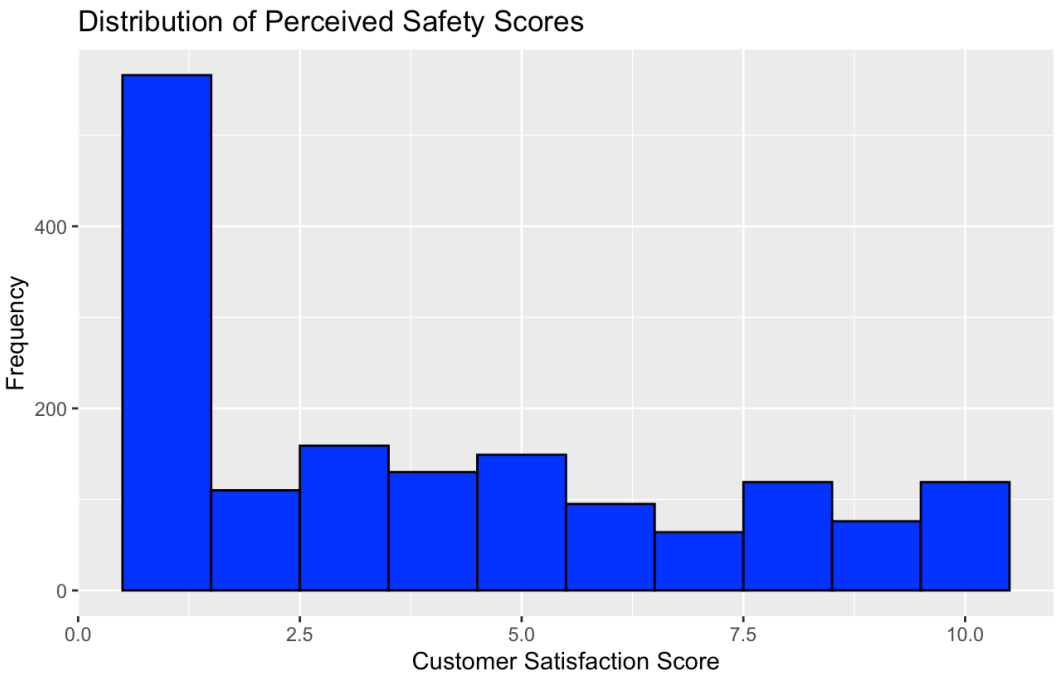
Variable	N	Min	Median	Mean	Max	Std Deviation
Perceived safety	1587	1.0	3.0	4.015	10.0	3.06
Holiday	1587	0.0	0.0	0.017	1.0	0.13
Year	1587	2022	2023	2023	2024	0.72
Presence of staff	1587	0.0	1.0	1.043	3.0	0.54
Staff checks	1587	0.0	0.0	27.96	321.0	53.34
Seat availability	1587	0.063	1.0	0.953	1.0	0.13
Late travel times	1587	0.0	0.0	0.136	1.0	0.34
Urban	1587	0.0	1.0	0.69	1.0	0.46
Security cameras	1587	0.0	1.0	0.76	1.0	0.43

4.2.4 Key observations

The primary dependent variable in this study is **perceived safety**, which reflects the overall satisfaction of passengers. To better understand the distribution of perceived safety scores, Figure 2 displays the frequency distribution of **perceived safety**.

- **Perceived safety:** Passengers' sense of safety, scored from 1 to 10, has a mean of 4.015, indicating a generally low perception of safety among respondents with a high standard deviation of 3.06, suggesting wide variability in safety perceptions. Notably, many passengers frequently rated their perceived safety a 1, indicating that a significant portion of travelers feel very unsafe.

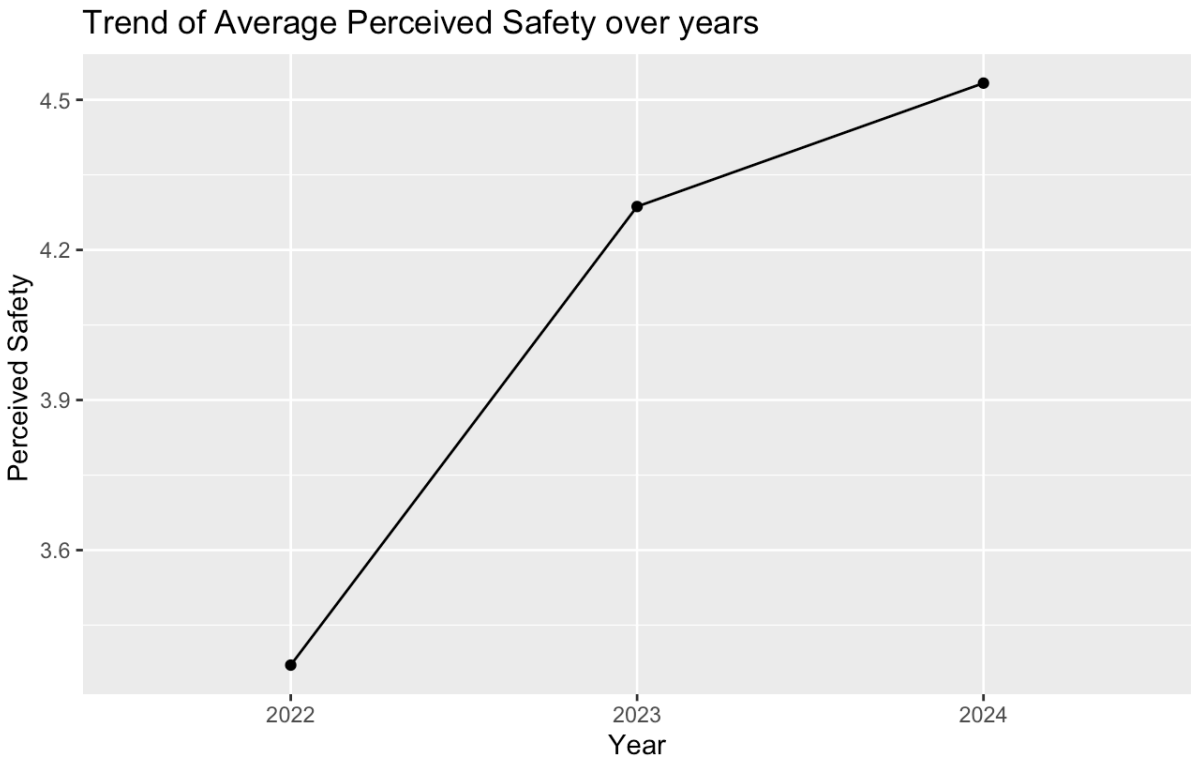
Figure 2: *Distribution of perceived safety scores*



- **The presence of staff:** The mean number of staff present is 1.043, with a median of 1, showing that most vehicles typically have one staff onboard.
- **Staff checks:** The average number of ticket inspections is 27.96, but this variable displays significant variability, as shown by the maximum value of 321 and a high standard deviation. This suggests that while some trips have frequent inspections, others may have none.
- **Seat availability:** With a mean of 95%, seat availability rates are generally high, indicating that passengers have a seat available most of the time, which may influence passengers' comfort and perceived safety.
- **Urban vs. non-urban:** About 69% of observations relate to urban areas, which indicates that more people rate their journey in urban areas.
- **Security cameras:** With a mean of 76%, security cameras are present in most vehicles, potentially contributing to a sense of oversight and monitoring.
- **Late travel times:** The low mean of 14% for late travel times suggests that most data points are from daytime journeys, which might differ in passenger perception compared to nighttime trips.

As shown in Figure 3, the average perceived safety exhibits an upward trend over the years, which may indicate improvements in perceived safety.

Figure 3: *Perceived safety over the years*



4.2.5 Correlation analysis

To explore interrelations among key variables, a Pearson correlation matrix was computed (Table 3).

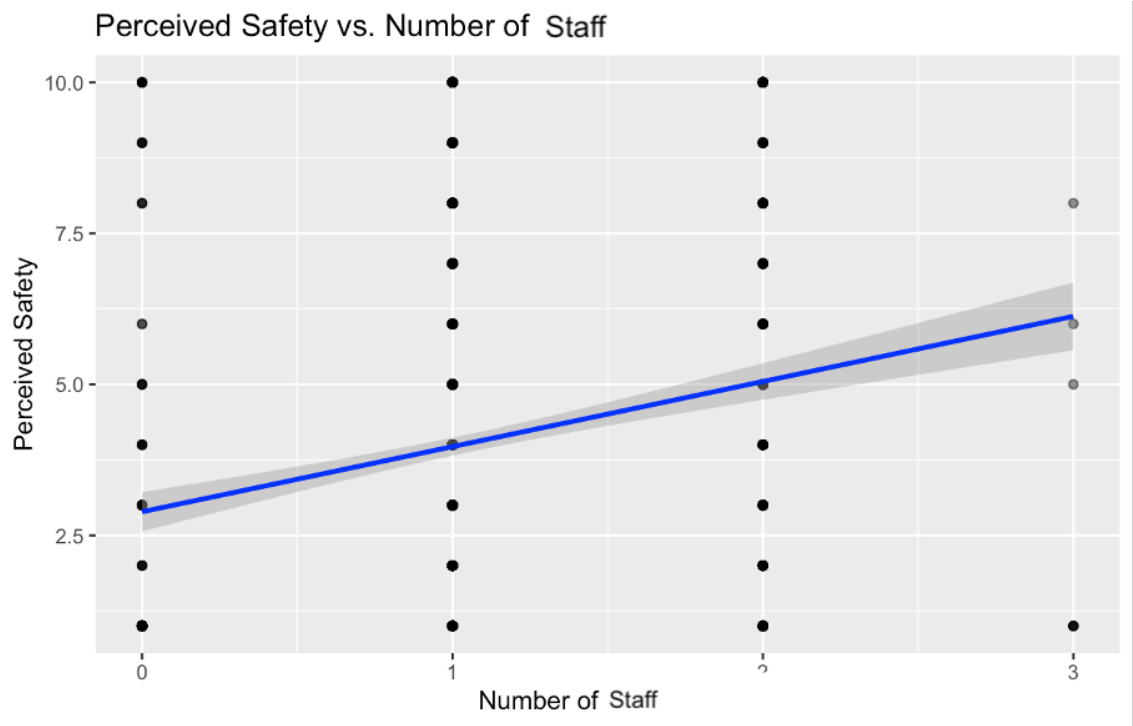
***Table 3**: Pearson correlation matrix*

Variables	Perceived safety	Presence of staff	Staff checks	Urban	Security cameras	Late travel times	Seat availability
Perceived safety	r = 1.0000	r = 0.1890**	r = 0.1936**	r = 0.1066*	r = -0.0522*	r = 0.0598*	r = 0.1921**
		p < 0.001	p < 0.001	p = 0.0106	p = 0.0376	p = 0.0171	p < 0.001
Presence of staff		r = 1.0000	r = 0.1575**	r = 0.4217**	r = -0.2661**	r = 0.2388**	r = -0.0730
			p < 0.001	p < 0.001	p < 0.001	p < 0.001	p = 0.100
Staff checks			r = 1.0000	r = 0.1008*	r = -0.0723**	r = -0.0150 ns	r = 0.1017*
				p = 0.029	p = 0.004	p = 0.550	p = 0.025
Urban				r = 1.0000	r = -0.2669**	r = 0.1265**	r = -0.0046
					p < 0.001	p < 0.001	p = 0.856
Security cameras					r = 1.0000	r = -0.0443	r = 0.0154
						p = 0.078	p = 0.540
Late travel Times						r = 1.0000	r = 0.1088**
							p = 0.007
Seat availability							r = 1.0000

*$p < 0.05$ ** p < 0.01

Perceived safety and the presence of a staff: A significant positive correlation (r=0.189, p<0.001) exists between perceived safety and the presence of staff, suggesting that passengers feel safer when staff are present on board. Figure 4 visually demonstrates this relationship.

***Figure 4**: Perceived safety vs number of staff*

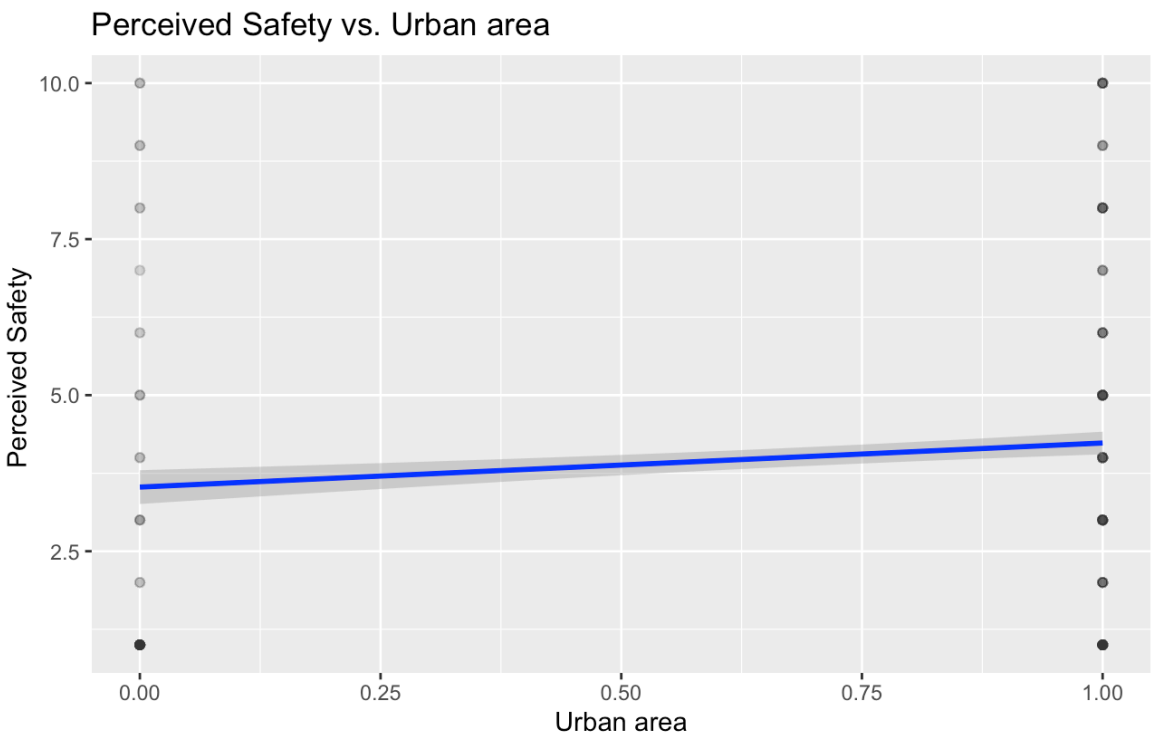


Perceived safety and staff checks: Perceived safety also correlates positively with the frequency of staff checks (r=0.194, p<0.001), indicating that more frequent checks make people feel safer. This finding underscores that active monitoring may reassure passengers, thereby elevating perceived safety levels. Figure 5 visually demonstrates this relationship.

***Figure 5**: Perceived safety vs. staff checks*

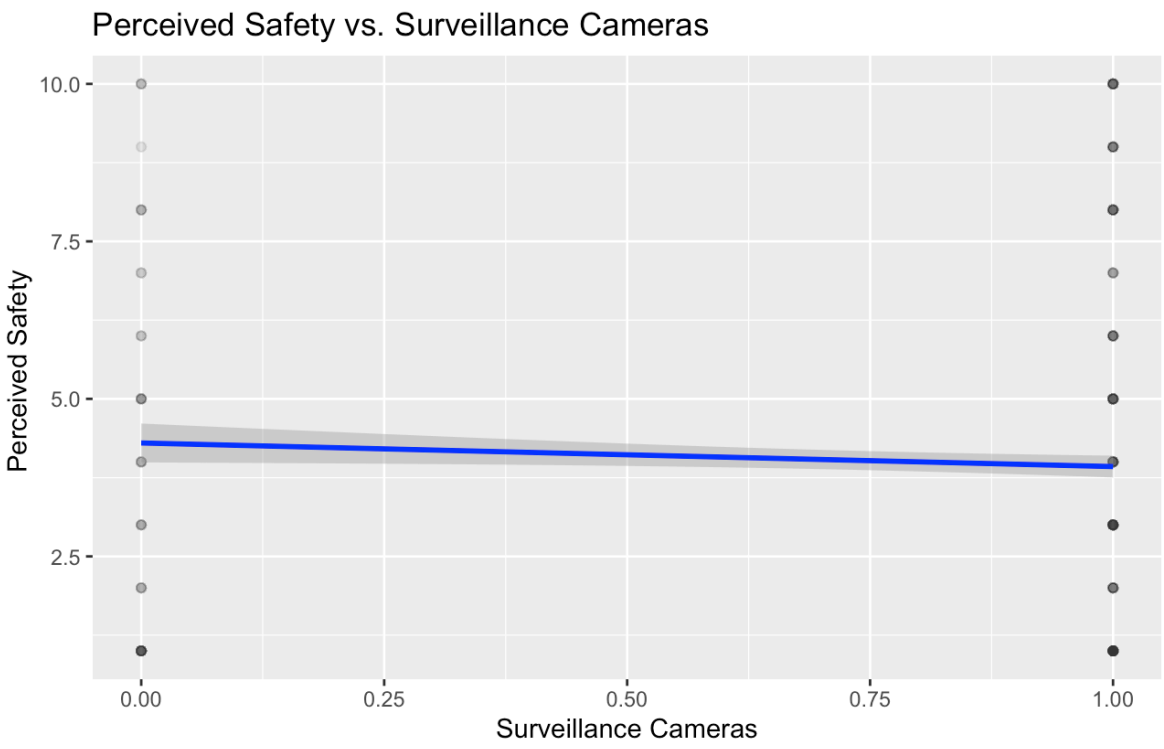
Perceived safety in urban areas: A smaller yet significant positive correlation (r=0.107, p=0.011) is noted between perceived safety and urban travel. This trend implies that passengers may feel marginally safer in urban areas, potentially due to better lighting and a denser presence of both staff and fellow passengers, which could contribute to a heightened sense of safety (see Figure 6).

Figure 6: *Perceived safety vs Urban area*



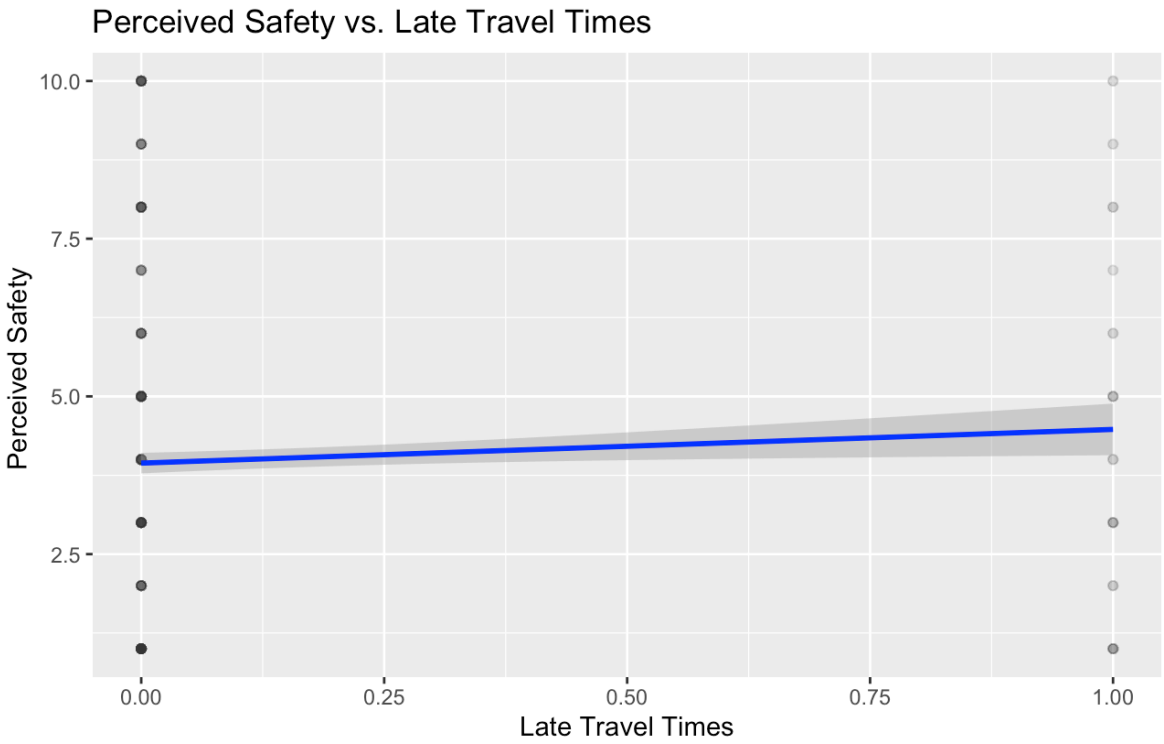
Perceived safety and security cameras: A slight negative correlation exists between perceived safety and the presence of security cameras (r=−0.052, p=0.038). This finding suggests that while cameras are intended to enhance security, passengers may interpret their presence as a signal of potential risk areas or feel they are insufficient without direct human oversight (see Figure 7).

Figure 7: *Perceived safety vs. surveillance cameras*



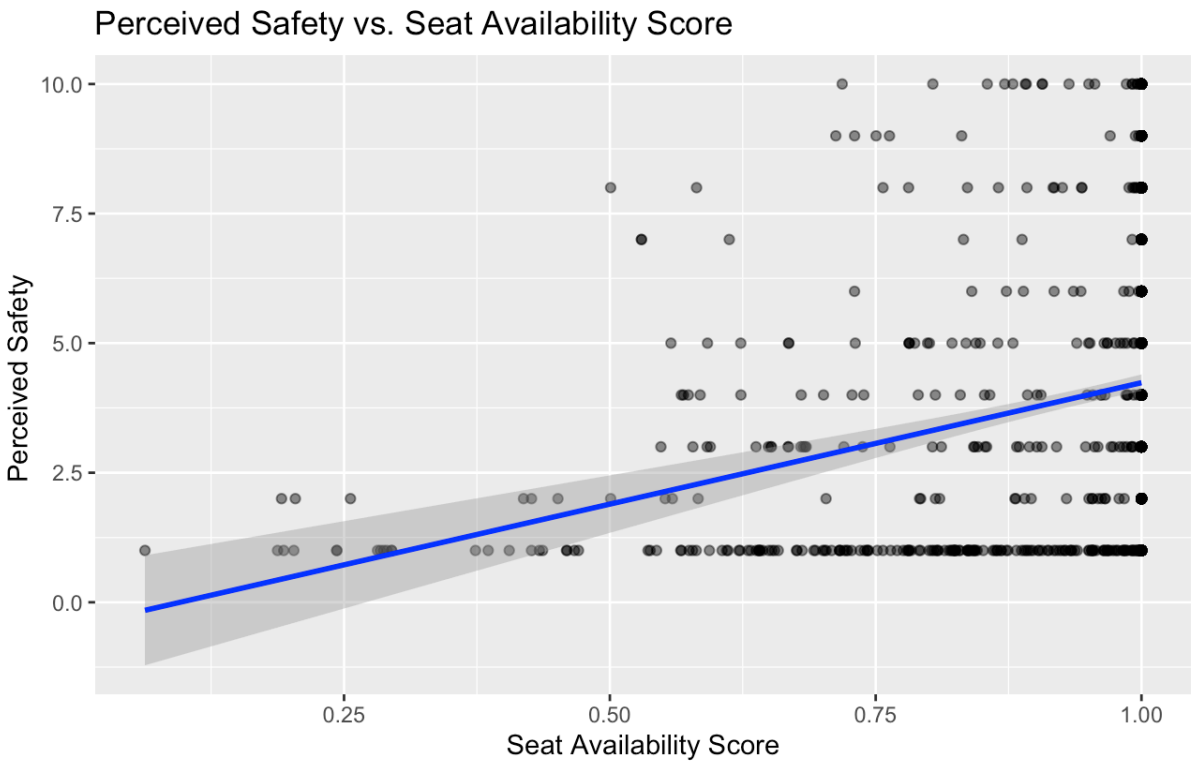
Late travel times and perceived safety: A positive correlation (r=0.060, p=0.017) is found between perceived safety and travel during late hours. Passengers report feeling slightly safer at night, which could reflect factors such as less crowding or the specific allocation of staff during these hours (see Figure 8).

Figure 8: *Perceived safety vs. late travel times*



Seat availability and perceived safety: Lastly, a significant positive correlation (r=0.192, p<0.001) is observed between perceived safety and seat availability (see Figure 9).

Figure 9: *Perceived safety vs. seat availability score*



Other notable correlations:

Presence of staff and urban areas: A strong positive correlation (r=0.422, p<0.001) indicates that staff are more frequently present on journeys operating in urban areas.

Presence of staff and surveillance cameras: A negative correlation (r=−0.266, p<0.001) is observed between staff presence and the presence of surveillance cameras. Vehicles with more staff onboard tend to have fewer surveillance cameras.

Night journeys and seat availability: A positive correlation (r=0.109, p=0.007) exists between nighttime travel and seat availability, indicating that passengers on night journeys are more likely to find available seating.

4.3 Regression analysis

To test the hypotheses, multiple regression analyses were conducted with **perceived safety** as the dependent variable.

Regression model 1
A multiple regression model was applied with perceived safety as the dependent variable and several predictors, including the presence of staff, staff checks, seat availability, urban area, late travel times and security cameras. The results are summarized in table 4.

***Table 4**: Regression results*

Variable	Estimate	Std. Error	t-value	p-value
(Intercept)	-1.937	0.636	-3.046	0.002**
Presence of staff	1.123	0.159	7.083	<0.001***
Seat availability	5.072	0.595	8.518	<0.001***
Urban	-0.180	0.179	-1.002	0.316
Security cameras	0.026	0.183	0.143	0.886
Late travel times	-0.117	0.224	-0.521	0.603

R-squared: 0.079
Adjusted R-squared: 0.076
F-statistic: 27.15 ($p < 0.001$)

The presence of staff: This variable emerged as a significant positive predictor of perceived safety (β=1.123, p<0. 001), supporting the hypothesis that visible staff presence enhances passengers' sense of safety. Each additional staff on board is associated with an average increase of approximately 1.12 points in perceived safety.

Seat availability: As a proxy for overcrowding, seat availability shows a significant positive effect (β=5.072, p<0.001), indicating that higher seat availability correlates with higher perceived safety. This finding underscores that less crowded environments contribute to passengers' comfort and overall sense of security.

Other variables: Urban area, late travel times, and security cameras were not statistically significant predictors in this model. This suggests that while these factors may influence operational considerations, they do not independently predict passengers' perceived safety.

4.3.1 Interaction model

To investigate potential moderating effects, an interaction term between the presence of staff and staff checks was introduced to the model. Table 5 summarizes the results.

***Table 5:** Regression results for H2*

Variable	Estimate	Std. Error	t-value	p-value
(Intercept)	2.593	0.171	15.144	<0.001***
Presence of staff	1.088	0.147	7.389	<0.001***
Staff Checks	0.022	0.004	5.754	<0.001***
Presence of staff: Staff Checks	-0.010	0.003	-3.520	<0.001***

R-squared: 0.071
Adjusted R-squared: 0.069
F-statistic: 40.02 ($p < 0.001$)

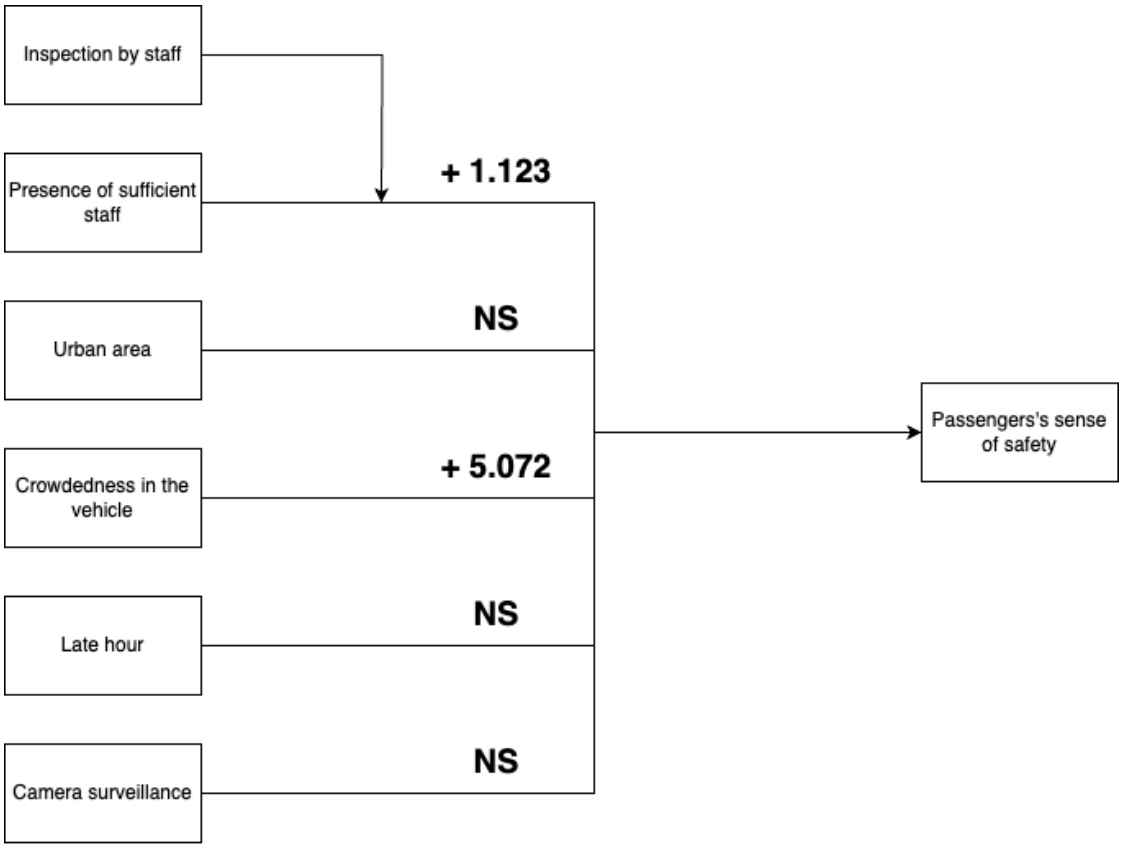
Interaction between the presence of staff and staff checks: The interaction analysis revealed a significant negative interaction effect ($\beta=-0.010$, $p<0.001$). This suggests that while the presence of staff and frequent ticket inspections individually enhance perceived safety, their combined effect is less than additive. One interpretation is that excessive ticket inspections, when staff are already present, may lead passengers to feel overly monitored or distrusted, slightly diminishing the positive impact of staff presence on safety perceptions.

The negative interaction suggests a need for balance in ticket inspection frequency to maintain the positive influence of visible staff without causing discomfort to passengers. This moderation effect highlights the complexity of operational measures and the importance of aligning them with passengers' comfort and perceptions of safety.

4.3.2 Updated conceptual model

The updated conceptual model, as shown in Figure 10, shows the relationships identified in the regression analyses between the key variables influencing passengers' perceived safety. This model incorporates the beta coefficients obtained from the regression results to illustrate the strength and direction of these relationships.

***Figure 10**: Updated conceptual model*



NS: Not significant

4.4 Model diagnostics

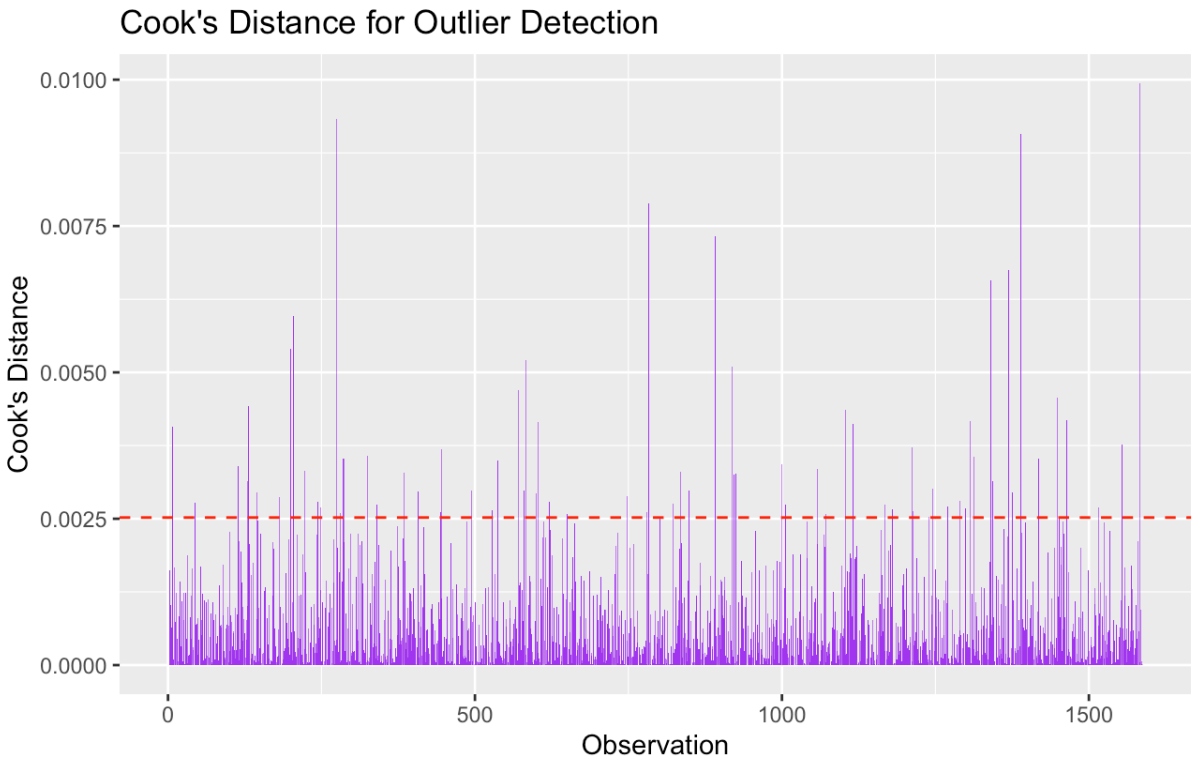
To validate the robustness of the regression model, several diagnostic checks were conducted, including checks for outliers, multicollinearity, and a residual analysis.

4.4.1 Detection of outliers

An outlier analysis was conducted using Cook's distance to identify data points that may disproportionately impact the regression results. Observations with Cook's distance values exceeding 4/n (where n is the sample size) were classified as potential outliers. This threshold is commonly applied to assess the influence of individual data points on the overall model stability.

Detection of outliers: A total of 70 outliers were identified, as shown in Figure 11, where each observation above the red dashed line represents a potential outlier. These outliers were primarily characterized by extreme values across various predictors, such as staff checks and seat availability rates.

***Figure 11**: Cook's distance for outlier detection*



Impact on model: Outliers can significantly influence parameter estimates, potentially distorting the regression results. To ensure the robustness of the analysis, each outlier was carefully examined. Given that these observations reflect genuine data variations rather than errors, they were retained in the final model to preserve dataset integrity.

4.4.2 Multicollinearity assessment

To ensure the reliability of the regression analysis, a multicollinearity assessment was conducted using the Variance Inflation Factor (VIF) for each independent variable. A VIF threshold of 5 was applied; values above this threshold may indicate multicollinearity issues that could distort the regression results.

As shown in Table 6, all VIF values for the variables under consideration are well below 5, suggesting that multicollinearity is not a concern in this model. This confirms that each predictor contributes independently to explaining the variance in perceived safety, thereby supporting the robustness of the subsequent regression analysis.

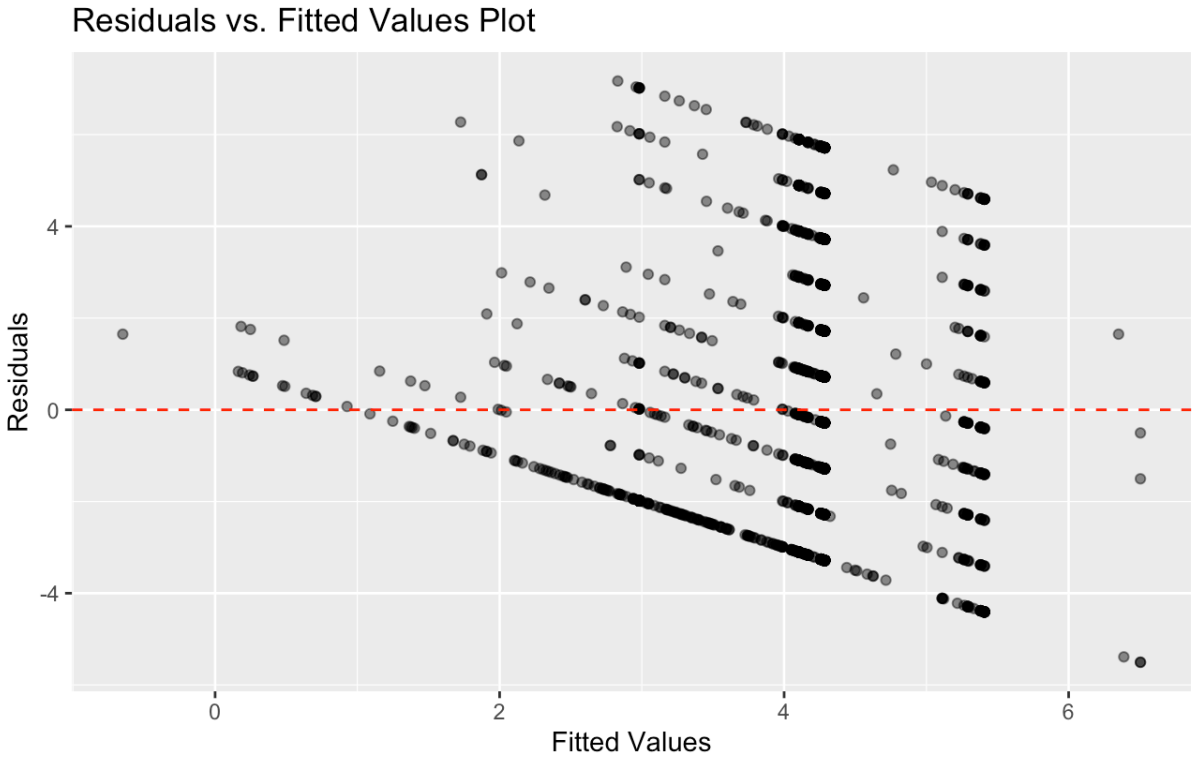
Table 6: *Variance inflation factors*

Variable	VIF
Presence of staff	1.65
Staff check	1.41
Seat availability	1.33
Urban	1.34
Security cameras	1.15
Late travel times	1.18

4.4.3 Residual analysis

The residuals were examined for patterns to confirm the assumptions of linearity and independence. Figure 12 displays the plot of residuals versus fitted values. The random distribution of residuals around the zero line suggests that the linearity assumption holds, with no indication of systematic error in the model. Additionally, visual inspection of the residual plot confirms homoscedasticity, as the spread of residuals appears consistent across all fitted values. This uniform spread indicates that the variance of the error terms is constant, supporting the model's validity.

Figure 12: Residuals versus fitted values for regression models



In summary, the diagnostic checks support the assumptions required for linear regression, indicating that the model reliably estimates the relationships among variables without significant bias.

5 Discussion

5.1 Overview

This study aimed to investigate the factors influencing passengers' perceived safety in public transportation systems. Grounded in theories such as the Guardianship theory and the Social Presence theory, there are several hypotheses formulated to examine the impact of staff presence, ticket inspections, urban environments, overcrowding, late travel times, and security cameras on passengers' sense of safety. The primary research question was: “What factors directly or indirectly influence passengers' perceived safety within public transportation in a European context?”

The analysis incorporated variables such as the number of staff, ticket inspections, urban areas, seat availability, and the presence of security cameras. This chapter discusses the findings in relation to each hypothesis, integrates the theoretical framework provided, and explores practical implications.

5.2 Discussion of the findings

5.2.1 Presence of staff and perceived safety

Hypothesis 1 (H1): ***The presence of sufficient staff positively affects the perceived safety of passengers.***

The findings indicate that the number of staff has a significant positive effect on passengers' perceived safety, as reflected by the variable perceived safety. The regression analysis showed a positive coefficient for the presence of staff (β^=1.123, $p < 0.001$), supporting H1.

According to the Guardianship Theory (Cohen & Felson, 1979), the presence of capable guardians reduces the likelihood of crime and increases individuals' sense of safety. In the context of public transportation, staff serve as protectors who can deter potential offenders and assist passengers in case of emergencies or conflicts. This aligns with previous studies suggesting that the presence of staff reduces feelings of anxiety and stress among passengers (Newton, 2004; Welsh & Farrington, 2009).

The Social Presence theory also supports this finding, positing that the visible presence of staff enhances passengers' sense of safety (Biocca et al., 2003). Staff members not only provide assistance but also reinforce social norms, contributing to a safer environment. Therefore, the results confirm that sufficient staff presence positively influences passengers' perceived safety.

5.2.2 Ticket inspections and moderation effect

Hypothesis 2 (H2): ***Ticket inspections by public transportation staff moderate the relationship between the presence of sufficient staff and the perceived safety of passengers positively.***

The results showed that contrary to H2, there was a significant negative interaction between the number of staff (the presence of staff) and the number of ticket inspections (the number of staff checks) (β^=−0.010, $p < 0.001$). While both variables individually contribute positively to perceived safety, as shown in the correlation matrix, their combined effect reduces it.

This finding suggests that excessive ticket inspections may offset the positive impact of staff presence on perceived safety. While Smith and Clarke (2000) indicated that ticket inspections contribute to crime prevention and could enhance perceived safety, the results imply that too many inspections might lead to discomfort or annoyance among passengers. This could be due to passengers feeling over-monitored or distrusted, which may increase stress and reduce their sense of safety.

Therefore, the frequency of ticket inspections negatively moderates the relationship between staff presence and perceived safety, leading to the rejection of H2. A balance must be struck between ensuring security and maintaining passenger comfort.

This finding supports Innes' (2004) theory that people may interpret security interventions like ticket inspections as signals of a potentially dangerous environment. Despite the presence of staff, this signaling effect can heighten passengers' feelings of insecurity.

Fare evasion is the huge trigger of aggression on public transportation. Although increased checks aim to reduce the number of fare evaders, they may inadvertently contribute to a sense of insecurity among passengers. When a fare evader is confronted, there is a heightened risk of aggressive behavior. When passengers witness such incidents, the fare evader's aggression can significantly impact their perception of safety.

This highlights that, while increased inspections can reduce fare evasion, they may also unintentionally undermine passengers' sense of security. It is therefore essential to find a balanced approach to such checks, such as minimizing confrontational situations and deploying staff who are well-trained in conflict de-escalation.

5.2.3 Urban areas and perceived safety

Hypothesis 3 (H3): ***Urban areas negatively affect the perceived safety of public transportation passengers.***

The variable urban was not a significant predictor of perceived safety in the regression models (p=0.316), leading to rejecting H3.

While prior literature suggests that urban areas, with higher crime rates and increased anonymity, can negatively impact perceived safety (Farrall et al., 2009; Mari, 2007), the findings do not support this hypothesis. One possible explanation is that passengers in urban areas may be accustomed to their surroundings and thus do not perceive them as inherently less safe. Additionally, as Ditton et al. (2004) point out, perceptions of safety can be influenced by familiarization and regular exposure to specific environments. Passengers who regularly travel through urban areas may become less sensitive to the environmental risks that might concern infrequent visitors.

5.2.4 Overcrowding and perceived safety

Hypothesis 4 (H4): ***Overcrowding in public transportation negatively affects the perceived safety of passengers.***

This study used seat availability as a proxy for overcrowding. The regression analysis showed that seat availability has a significant positive effect on perceived safety (β^=5.072, $p < 0.001$), supporting H4.

Overcrowding can induce feelings of claustrophobia, anxiety, and heightened vulnerability (Evans & Wener, 2021). Wener et al. (2006) found that crowded environments increase stress and discomfort, diminishing passengers' sense of safety. The findings align with this, suggesting that greater seat availability (indicating less overcrowding) positively influences perceived safety by providing passengers with a more comfortable and less confined environment. This effect underscores the importance of managing passenger density to promote a safer and more pleasant travel experience.

The first data in this study was collected in 2022, shortly after the end of the COVID-19 crisis. This timing is relevant because the pandemic fundamentally reshaped public attitudes toward crowded

spaces, including public transportation. Having experienced prolonged periods of social distancing, passengers may have developed a sensitivity to crowded environments, potentially feeling more unsafe when vehicles are full. This contextual factor could have amplified the association between overcrowding and perceived safety in the findings. It would be worthwhile in future research to examine whether this sensitivity remains consistent across subsequent years as passengers readjust to pre-pandemic travel conditions. Comparing data over multiple years could provide insight into whether the influence of overcrowding on perceived safety a persistent concern or a temporary response shaped by the pandemic's legacy.

5.2.5 Late travel times and perceived safety

Hypothesis 5 (H5): Traveling at late hours negatively affects perceived safety.

The regression analysis did not support H5, as there was no significant effect of late travel times on perceived safety (β=−0.117, p=0.603). This finding suggests that passengers' perceptions of safety do not vary significantly between daytime and nighttime travel.

According to existing literature, late-hour travel can lead to decreased feelings of safety due to factors like reduced social control, lower lighting levels, and an increased perception of crime risk. Ellis and Newman (1974) note that a higher presence of people contributes to social control and a sense of security, so when fewer passengers are present, feelings of vulnerability and isolation may increase. Additionally, Cozens et al. (2004) and routine activity theory (Cohen & Felson, 1979) propose that individuals traveling alone at night face a higher risk of victimization due to fewer potential helpers nearby. Furthermore, inadequate lighting at night can reduce visibility, creating shadowed areas where threats could be perceived (Farrington & Welsh, 2004; Painter, 1996).

However, the findings suggest that these effects may be mitigated by other factors. Passengers may feel safer at night than anticipated due to enhanced lighting and increased staff presence on vehicles, which were likely expanded in recent years. Regular use of public transportation at night may foster a sense of familiarity and reduce fear as passengers adjust to their surroundings.

5.2.6 Security cameras and perceived safety

Hypothesis 6 (H6): ***The presence of security cameras positively affects the perceived safety of passengers.***

The variable security cameras (presence of security cameras) was not a significant predictor of perceived safety (p=0.886), leading to rejecting H6.

This finding contrasts with previous studies indicating that security cameras increase the sense of safety (Gill & Spriggs, 2005; Welsh & Farrington, 2009). One possible explanation is that passengers may be unaware of the presence of security cameras or doubt their effectiveness. Alternatively, the mere presence of cameras without visible monitoring or prompt responses to incidents may not impact perceived safety.

5.3 Practical implications

5.3.1 Enhancing staff presence

Staff presence has a positive impact on passengers' perceived safety. Public transportation companies can implement measures to optimize staffing strategies and improve the overall passenger experience:

- **Ensure adequate staffing**: Maintain a minimum of one staff per unit to ensure that staff are always available when the vehicle is in operation. This constant presence ensures a safe and

comfortable environment, deterring potential offenders and reassuring passengers, especially during late hours or in crowded situations. When insufficient staff is available to man all units, priority should be given to routes where higher levels of insecurity are reported. By strategically allocating staff to areas with greater perceived risk, transportation companies can maximize the impact of their personnel on passenger safety perceptions.

- **Promote visibility and approachability**: Encourage staff to understand that their visibility is crucial to passengers' sense of safety. Staff should regularly move through the vehicle and make themselves approachable to passengers. Wearing easily identifiable uniforms and proactively interacting with passengers can reinforce their presence as guardians.

5.3.2 Balancing ticket inspections

Ticket inspections can negatively impact the relationship between staff presence and passengers' perceived safety. Public transportation providers should consider strategies that balance effective ticket validation with maintaining a positive passenger experience. The following actions can help achieve this balance:

- **Implement ticket validation gates at stations**: Introducing ticket validation gates at stations can streamline the ticket-checking process and reduce the need for frequent onboard inspections. Their use can enhance fare enforcement efficiency. It is crucial to ensure these gates are monitored effectively to prevent individuals from bypassing them without a valid ticket, such as by attempting to jump over or slip through. Strengthening control measures at these entry points can minimize fare evasion and allow for a reduction in ticket inspections aboard vehicles.
- **Conduct random checks at ungated stations**: At stations without ticket validation gates, random inspections can be performed as passengers exit the platforms. This method targets fare evaders while minimizing disruptions for compliant passengers. By implementing occasional checks rather than constant monitoring, transportation providers can maintain oversight without imposing on the overall passenger experience.
- **Optimize inspection frequency based on fare evasion risk**: Adopting a data-driven approach to inspections can enhance efficiency. By focusing on times, routes, or areas with a higher probability of fare evasion, transportation companies can reduce the overall number of inspections while effectively addressing fare evaders. Targeted inspections allow for resources to be allocated where they are most needed, improving fare compliance without negatively impacting passengers' perceived safety.

5.3.3 Reducing overcrowding

Overcrowding in public transportation significantly negatively influences passengers' perceived safety. Implementing strategies to manage capacity, provide real-time information, and enhance infrastructure can mitigate these effects and improve the travel experience.

- **Capacity management:** Adjusting service frequency and increasing carriage capacity during peak hours are essential steps to alleviate overcrowding. By deploying additional vehicles when demand is highest, transportation providers can reduce congestion and create a more comfortable environment. Capacity management strategies may also include scheduling staggered services to better distribute passenger flow across multiple vehicles, reducing the discomfort associated with overcrowding.
- **Real-time updates on seat availability:** Offering passengers access to real-time information on seat availability allows them to make more informed travel decisions. Through displays, passengers can view vehicle occupancy levels before boarding and choose less crowded vehicles or carriages when possible.

5.4 Limitations and future research

5.4.1 Limitations

The primary limitation of this study is the lack of precise location data for each safety review. While the movement number of each journey was available, the exact point along the route where the rating was recorded is unknown. For example, a vehicle traveling from A to B may be in operation for several hours, during which various factors, such as the number of staff and passenger density, can change multiple times. Due to this constraint, the maximum number of staff and the average seat availability for each journey are used as proxies for these variables.

This approach may not fully capture the dynamic conditions throughout the trip. Future research would benefit from linking each perceived safety assessment to more specific situational data, allowing for a more accurate reflection of how factors like real-time crowding and fluctuating staff presence impact passengers' sense of safety. Improving this contextual alignment could provide more precise insights into the interplay between travel circumstances and perceived safety.

However, determining the exact moment when a passenger's perception of safety changes remains challenging, even with more accurate data. An event or feeling that arises at the beginning of a journey can continue to influence a passenger's sense of safety until the end of the trip. Therefore, capturing the temporal nuances of perceived safety requires careful consideration in future studies to fully understand how initial experiences impact overall safety perceptions throughout the journey.

5.4.2 Future research

To build upon the findings of this study, several options for future research exist. The finding that ticket inspections have a negative influence on passengers' perceived safety is unexpected. Further research is necessary to investigate the underlying causes of this phenomenon. One potential area of investigation is whether the act of issuing fines contributes to feelings of insecurity among passengers. Since fines are a direct consequence of ticket inspections, examining their impact could provide valuable insights into why ticket inspections negatively affect perceived safety. Incorporating variables related to fines into the existing model from this study could deepen the understanding of this issue. By investigating the emotional and psychological effects of fines on both fare-compliant passengers and fare evaders, it is possible to gain a more comprehensive understanding of the dynamics that lead to decreased perceived safety during ticket inspections.

Qualitative methods, such as interviews, could be used to gather deeper insights into passengers' perceptions and experiences of safety. Qualitative data can reveal nuanced views on aspects like overcrowding, nighttime travel, and ticket inspections, which may not be fully captured through quantitative measures alone.

Given the limitations of this study, future research could incorporate more granular, location-based data to capture real-time fluctuations in factors such as overcrowding, staff presence, and time of the day. Linking passenger safety assessments to specific points along a route would allow for a more detailed analysis of how changing conditions impact perceived safety throughout a journey.

Lastly, conducting comparative studies across different geographic regions or transportation systems could provide valuable insights into how perceived safety varies. This approach would help determine whether factors such as staff presence or surveillance consistently impact perceived safety or whether cultural and contextual differences play a significant role.

6 Conclusion

Public transportation serves millions of passengers daily in Europe, playing an essential role in urban mobility and contributing to sustainable development goals by reducing traffic congestion and lowering environmental impacts (Berg & Ihlström, 2019; European Commission, 2023). Ensuring passenger satisfaction is therefore crucial for encouraging widespread public transport use. While factors such as reliability, comfort, and safety are known to impact satisfaction (Brons & Rietveld, 2009; Freedman, 1975; Lierop et al., 2017), this study specifically explored the factors that affect passengers' perceived safety, a critical determinant of their willingness to use public transportation.

The research aimed to fill a gap in the literature on passengers' perceptions of safety by investigating operational and environmental factors within European public transportation. Results from the analyses indicated several key findings:

- **Staff presence:** Consistent with prior literature, the findings showed that the visible presence of staff has a significant positive impact on perceived safety. Passengers generally feel more secure when staff or security personnel are readily accessible and visible throughout their journey. This aligns with the concept of social control, where visible authority figures contribute to a sense of safety (Smith and Clarke (2000). The practical implications suggest improving staffing strategies by promoting visibility and implementing priority rules to assign staff to high-risk journeys.
- **Impact of ticket inspections:** Surprisingly, the study found that excessive ticket inspections could negatively moderate the positive effects of staff presence on perceived safety. Frequent inspections may lead to discomfort or feelings of overmonitoring, potentially causing passengers to feel distrusted or unsafe. This finding supports theories of signal crimes where excessive enforcement can signal higher risks (Innes, 2004). Recommendations include optimizing inspection frequency and implementing other ticket validation options like gates.
- **Overcrowding and seat availability:** Overcrowding, measured through seat availability, was found to negatively impact perceived safety, supporting the hypothesis that crowded environments increase stress and discomfort. Passengers felt significantly safer when seats were available, indicating that reducing overcrowding through capacity management and real-time occupancy information could enhance safety perceptions. This is especially relevant in the post-COVID-19 context, where passengers may still be sensitive to crowding due to periods of social distancing.
- **Travel time:** Contrary to expectations, late travel times did not significantly affect perceived safety. Although the literature suggests that reduced social control and lower lighting at night might decrease safety perceptions (Cozens et al., 2004; Ellis & Newman, 1974), passengers did not report a notable difference between day and night travel. This may reflect increased familiarity with nighttime travel or the presence of mitigating safety measures such as lighting and extra staff.

The study's findings highlight several practical implications for public transportation providers, emphasizing the importance of staffing, balanced security measures, and managing passenger density. However, some limitations should be considered. The lack of precise location data limited the ability to capture all nuances of passenger experiences. Overall, this research offers a deeper understanding of the factors influencing perceived safety in public transportation and underscores the importance of targeted interventions to improve passengers' perceived safety. By addressing these factors, transportation providers can create a safer environment, ultimately encouraging greater public transport use and supporting sustainable urban development goals.

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