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Research Article

Multivariate analysis of public transport quality: a case study in a medium-sized Brazilian city

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Abstract

Paper aims: This study aimed to analyze how the satisfaction level of public transport (PT) users is influenced by their socioeconomic characteristics.

Originality: The analysis of how socioeconomic variables influence the satisfaction level through the association between MANOVA and exploratory analysis is still not explored, especially in Brazil and in medium-sized cities, which represent the majority of Brazilian cities.

Research method: Data collection was carried out by questionnaire in a Brazilian city. The 330 users of PT evaluated their satisfaction level concerning 12 quality indicators. Statistical analyses were performed using Pearson's correlation and MANOVA.

Main findings: Most socioeconomic variables influenced user satisfaction in at least one indicator, gender and schooling being the most prominent. The results showed that women's mean level of satisfaction is lower than men's concerning indicators affected by gender. Fare was the indicator with the worst score, being influenced by users' occupation.

Implications for theory and practice: The study presents practical and methodological contributions. The results provides technical and scientific subsidies for public policies and service improvement. It possible to improve each indicator according to the users' socioeconomic characteristics, encouraging the use of PT and contributing to the urban environment sustainability.

Keywords

Bus service. Satisfaction level. Socioeconomic characteristics. Quality Indicators. Multivariate analysis of variance.

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1. Introduction

The urban mobility theme is a central issue nowadays and several challenges are involved in the process of moving people safely and comfortably to their desired destinations (Brunoro et al., 2015). The increase in on-demand transport and new trends in micromobility, such as e-bikes and e-scooters, have become, along with walking and cycling, means of transport that promote sustainable urban mobility (Vij et al., 2013; Lima & Machado, 2019). They are cleaner transportation options used for short distances (Davies et al., 2020) which are important, mainly, for first/last mile travel, making necessary their integration with public transport (PT) (Meng et al., 2020).

Public transportation provides an accessible and sustainable mobility service, essential for the economic vitality and well-being of society, especially for the promotion of social equity (Zuo et al., 2020). It is a priority due to continuous urban growth, environmental issues, competition for limited spaces, and long travel distances

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(Abenoza et al., 2017). However, there has been a decrease in the demand for PT in several countries (Chakrabarti, 2017; Shaheen & Cohen 2018; Tembe et al., 2019). In Brazil, the demand for buses, according to the Brazilian National Association of Urban Transportation (National Association of Urban Transport Companies, 2018), has been falling for the past 20 years, having lost approximately 35.6% of paying passengers. The worst scenario being from 2014 to 2018, years which presented an accumulated mean decrease of 25.9% in users.

The decrease in demand for PT was even more pronounced due to the COVID-19 pandemic, which changed the behavior of the population in relation to the choice of mode of transport. This fall may be because habitual users have resorted to using taxis, hitchhiking services, or even private vehicles (De Vos, 2020). The drop in demand impacts not only the sustainability of the urban environment, by increasing the use of individual motor vehicles, but also the economic sustainability of the companies operating the service, which in many cases are having to reduce the level of service provided to remain in the Marketplace.

Despite the current pandemic scenario, PT is still one of the main alternatives for mass displacement of people over long distances. Maintaining the demand for PT and attracting new users is a challenge that can be overcome by offering quality service (Fatima & Kumar, 2014; Batty et al., 2015; Diez-Mesa et al., 2016; Guirao et al., 2016; Abenoza et al., 2017). Barcelos et al. (2017) pointed out that investments in the sector should be focused on the satisfaction of the users, who evaluate the quality of the service based on their perceptions and expectations (Diez-Mesa et al., 2016).

Due to the importance of considering the user's perception and expectation, the main way to evaluate the quality of the PT service is a satisfaction survey, which is an evaluation process that involves subjective judgments (De Oña & De Oña 2015; Soltanpour et al., 2020). The authors state that the users' opinions are varied and dependent on several factors. Stratifying the sample, through the identification of the factors that actually influence users' perceptions, is a good strategy to reduce heterogeneity.

One of the techniques used for this purpose is the multivariate analysis of variance (MANOVA). In the literature, there are few studies that have proposed to identify how a set of socioeconomic variables influence users' perceptions regarding to different quality indicators. The application of the MANOVA technique aimed at evaluating the quality of PT is found in the works of Mahmoud & Hine (2013), Currie et al. (2013), and Weng et al. (2018). Mahmoud & Hine (2013) considered a wide set of indicators; however, only the difference in the perception of current and potential users was analyzed. The work of Currie et al. (2013) evaluated factors that influence the perception of safety of PT. Finally, Weng et al. (2018) used the technique in a wide set of indicators, but they did not investigate the relationship between the individual characteristics of passengers and the perception of service quality. Understanding how the main socioeconomic factors influence the level of satisfaction is paramount since service companies have scarce resources and the analysis helps to identify priority indicators for improving the quality of users' perceptions.

The present work proposes to fill this research gap, using the MANOVA technique together with an exploratory analysis, with the objective of not only identifying the socioeconomic variables that influence the level of satisfaction of PT users, but also analyzing how these variables exert this influence in a medium-sized Brazilian city. The relevance of the work is also due to the scarcity of similar studies applied in medium-sized Brazilian cities, which represent the majority of cities in the country. These cities, for the most part, have only the bus as a form of PT, being an important element for the population that has no other form of locomotion. For data collection, a satisfaction survey was carried out with 330 users of the public bus service. Then, the level of satisfaction of the selected indicators was analyzed using MANOVA to see how these are influenced by the users' characteristics. The results have practical and policy implications and can be used as technical support in decision-making processes for the establishment and implementation of business strategies and public policies to promote the use of PT.

2. Perceived quality of public transport

Behavioral issues and the choice of different means of transport are influenced by many factors, such as economic, geographic, or sociological (Arana et al., 2014), as well as personal characteristics, as gender, education, employment status, and income (Chiou et al., 2015; Han et al., 2018). A practical study by Tembe et al. (2019) verified that vehicle ownership, income, and employment status influenced the likelihood of bus use in two African cities.

Choice decisions may also depend on individuals' preferences concerning latent variables such as flexibility, comfort, safety, convenience, and reliability, in addition to quantifiable variables such as travel time and transport costs (Sarkar & Mallikarjuna, 2017). The study of latent variables can be done using a stated or revealed preference method and indicators observation to assess users' perceptions of aspects that could not be measured otherwise

(Lobato & Lima, 2010; Han et al., 2018). Maraglino et al. (2014) and Guirao et al. (2016) called attention to the large number of indicators found in the literature and to the importance of selecting the most relevant ones. Table 1 summarizes studies evaluating the quality of PT and their indicators.

Table 1. Indicators used in studies on the quality of public transport. Adapted from (Santos & Lima, 2021).

	Ngoc et al. (2017)	Diez-Mesa et al. (2016)	Efthymiou et al. (2018)	Guirao et al. (2016)	Abenoza et al. (2017)	Diana et al. (2016)	Grisé & El-Geneidy (2017)	Mouwen (2015)	Maraglino et al. (2014)	Noor et al. (2014)	Tsami & Nathanail (2017)	Birago et al. (2017)	Suman et al. (2017)	Barcelos et al. (2017)	Antunes & Simões (2013)	De Oña & De Oña (2013)	Maha et al. (2014)	Azmi et al. (2018)	Bajčetić et al. (2018)	De Oña et al. (2018)	Güner (2018)	Lombardo et al. (2018)	Silver (2018)	Aquino et al (2018)	Leitão et al. (2018)	Freitas et al. (2018)
Accessibility	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x
Information	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x			x	x	x
Punctuality	x		x	x	x	x	x	x			x	x	x	x	x	x		x	x	x		x		x	x	x
Safety	x	x	x			x	x	x	x	x	x		x	x	x	x	x	x	x	x		x		x		x
Frequence	x		x		x		x	x	x	x	x	x				x	x	x	x	x	x	x	x			x
Fare	x		x		x	x		x	x	x	x	x	x	x		x	x		x	x			x			x
Travel Time	x			x	x		x	x	x			x	x	x	x	x			x	x	x		x		x	x
Crowding		x		x			x	x	x	x	x	x	x		x	x	x		x	x	x		x			x
Stations characteristics	x		x	x	x	x	x			x	x	x		x	x				x			x		x	x	x
Employee behavior			x		x	x		x	x		x			x	x	x	x		x	x		x		x	x	x
Comfort				x	x		x	x	x	x		x		x		x	x	x		x		x		x		x
Vehicles cleanliness	x		x	x			x		x	x	x	x				x	x		x	x		x		x	x	
Security	x			x	x				x	x		x	x	x	x		x	x				x		x		x
Connections			x	x	x	x			x	x	x	x		x			x		x			x		x		x
Vehicles characteristics	x	x			x		x	x	x	x		x			x		x		x		x			x		
Driver behavior	x		x	x			x	x	x	x	x	x					x		x						x	
Network coverage	x		x	x	x				x	x	x								x		x					
Span of service	x	x	x						x		x							x	x	x	x					
Accessibility for disabled person	x		x						x	x												x		x	x	
Customer interface		x			x				x		x							x				x		x		
Environmental impact		x	x						x					x								x				

The indicators accessibility, information, punctuality, public security, and frequency were used in more than 70% of the analyzed studies. Moreover, the indicators fare, travel time, crowding, stations characteristics, employee behavior, and comfort were also widely seen, in more than 40% of the articles. These findings are in agreement with De Oña & De Oña (2015), who demonstrated that there is no consensus about which quality indicators should be used and emphasized that this choice is highly dependent on the context. Despite this, the authors emphasize that the indicators frequency, punctuality, comfort, cleanliness of vehicles, safety, availability of information, courtesy of employees and fare are the most used. In this study, after evaluating the indicators that appeared in more than 40% of the articles reviewed, 12 most important indicators for the city under study were selected, according to previous research (Santos & Lima, 2021).

Although most studies use satisfaction surveys as a form of data collection, they differ in terms of objectives and applied techniques. Investigations that seek to assess the relationship between user characteristics and their perceptions of service quality of PT analyze, in their majority, specific characteristics of the users or groups of users with similar characteristics to verify the differences in their level of satisfaction. Grisé & El-Geneidy (2017) found differences in the evaluation of the service quality of London buses among people who lived in neighborhoods with different socioeconomic statuses. Gender, frequent and occasional users, non-users, age, and monthly income interfered with the perception of quality in studies carried out by De Onã & De Oña (2013), Diez-Mesa et al. (2016), Birago et al. (2017), and Abenoza et al. (2017).

All these works have contributed to the evaluation of the quality of PT; however, further studies to understand the determinants of demand and behavior of PT users are still needed since each case has different settings and characteristics in terms of environment, security, and infrastructure.

3. Methodological procedure

This study adopted the mathematical modeling procedure, using the multivariate analysis of variance (MANOVA). This technique is used to investigate whether the mean vectors of a population are the same (Johnson & Wichern, 2002). MANOVA has been used in similar studies to analyze behavioral factors and user characteristics that can affect their level of satisfaction (Currie et al., 2013; Mahmoud & Hine, 2013; Weng et al., 2018). Furthermore, it is the most used multivariate statistical technique in social and behavioral studies, as it assesses the differences between latent variables that are not directly observed (Warne, 2014).

The statistical analyses of the indicators were performed using the Minitab® Statistical Software (State College, Pennsylvania, USA). Initially, the correlation between the levels of user satisfaction regarding the indicators was verified using Pearson's correlation test. Subsequently, MANOVA was applied, using p-value to verify the significance of the variation between the mean values of satisfaction levels for each socioeconomic variable. The level of significance adopted was 0.05. Finally, individual analyzes of the mean satisfaction levels were carried out for the socioeconomic variables which were found to be significantly different by MANOVA.

This research was carried out in Itajubá, a medium-sized Brazilian city in the south of the state of Minas Gerais (MG) with an estimated population of 97,782 (Brazilian Institute of Geography and Statistics, 2021). Figure 1 shows the bus service coverage in Itajubá, bus lines, and location of the bus stops.

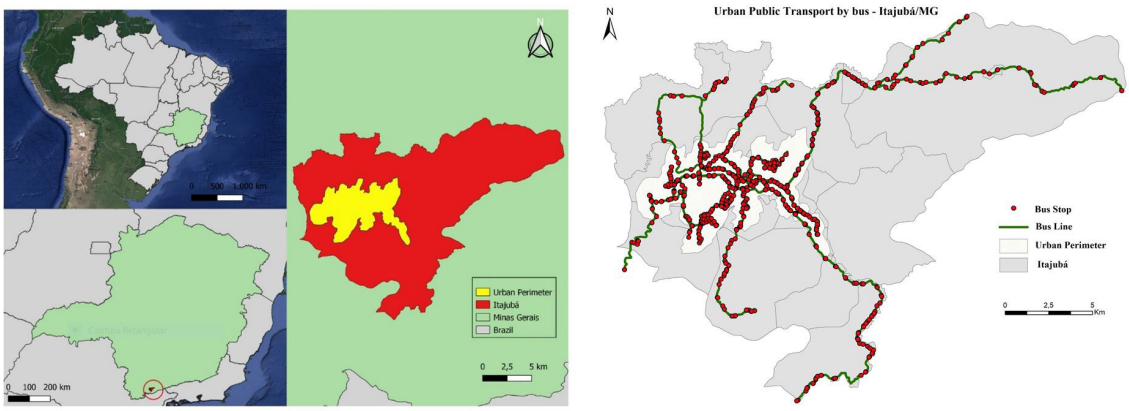

Figure 1. Location and coverage of the public bus transport service.

3.1. Data collection

Data collection was performed using a questionnaire divided into two parts. In the first, socioeconomic information about the user was collected: gender; age group; schooling; occupation; type of payment; household income; frequency of use of PT; ownership of other means of transport; and reasons for using PT. In the second part, the level of user satisfaction was evaluated, referring to 12 relevant quality indicators found in the literature and considered important for the city under study (Santos & Lima, 2021), as presented in Table 2. These indicators were evaluated using a 5-point Likert scale (1 – very poor to 5 – very good), one of the most adopted in satisfaction surveys to assess the quality of PT services (Guirao et al., 2016).

The questionnaire was applied through face-to-face interviews, in the second semester of 2018, with users at random, on different days of the week, times, and locations in the city, such as public schools, universities, supermarkets, stores, more remote neighborhoods, some public bodies, and a housing complex. The questionnaires were not applied at bus stops due to the time required for their application, which, in general, exceeded the bus waiting time.

Sample calculation was performed considering 6% of sampling error and the size of the population equal to the mean daily demand of 9.411 users in 16 months, resulting in a minimum necessary sample of 270 questionnaires. The formulas used to calculate the sample are demonstrated by Equations 1 and 2, and were applied in similar works (Antunes & Simões, 2013; Barcelos et al., 2017).

$$N0 = 1/\varepsilon^2 \quad (1)$$

Table 2. Indicators used in this research.

ID	Indicators	Definition
I01	Shelter	Availability of shelter at bus stops
I02	Information	Availability of information at bus stops
I03	Travel time	Time taken to reach final destination
I04	Frequency	Time interval between buses
I05	Punctuality	Compliance with the public transport timetable
I06	Crowding	Number of passengers inside vehicles
I07	Public security	Security level for crimes while traveling
I08	Road safety	Safety level for traffic accidents
I09	Staff courtesy	Staff attitude during service
I10	Driving ability	Driver performance in driving
I11	Fare	Monetary value of one bus trip
I12	Fare integration	Possibility to pay only one fare for more than one bus trip over a given period

$$n = N0.N / N0 + N \quad (2)$$

Where: N0 - first approximation of the minimum sample size; ε - tolerable sampling error; N - population size; n - sample size.

Three hundred thirty questionnaires were applied and the Cronbach's Alpha test with a value of 0.754 confirmed their internal reliability (the α coefficient must have a value between 0 and 1, 0.70 being the minimum acceptable) (Weng et al., 2018).

4. Characterization of the sample and level of user satisfaction

Once the questionnaire was applied, the characterization of the sample showed that the proportion of women and men interviewed was 73.3:26.7. It portrays the difficulty in approaching men to answer the questionnaire, as they reported, in most cases, preferring to travel on foot or by bicycle. Most respondents (71%) were from 20 to 59 years of age and had finished high school or higher education. Most bus trips were work- or study-related. Almost 80% of the interviewees have a household income of up to three times the minimum wage. This result confirms what is presented in the literature, which states that low-income people are the ones who most use the PT service (Chakrabarti, 2017; Yang & Wang, 2018). In this sense, improving the quality of service brings benefits to society as a whole and, in particular, to disadvantaged people (Borchardt et al., 2007). It also demonstrates the need for subsidies by the competent authorities in order to make this service more accessible to people with lower incomes. Table 3 shows the sample distribution of this study (categories, quantities and percentage).

Table 3. Sample distribution.

Variable	Categories	Qty	Percentage	Variable	Categories	Qty	Percentage
Gender	Female	242	73.3%	Means of payment	Regular ticket	150	45.5%
	Male	88	26.7%		Student ticket	65	19.7%
Age group	15 - 19	72	21.8%		Free ticket	17	5.2%
	20 - 35	122	37.0%		PT voucher	98	29.7%
	36 - 59	112	33.9%	Household monthly income in dollar	Up to $178	60	18.2%
	> 60	24	7.3%		$178 - $535	191	57.9%
Schooling	Elementary school	22	6.7%		$535 - $1070	60	18.2%
	Middle school	32	9.7%		> $1070	19	5.8%
	High school	139	42.1%	Frequency of use	Frequently	210	63.6%
	Higher education	137	41.5%		Occasionally	58	17.6%
Occupation	Employed	180	54.5%		Rarely	62	18.8%
	Student	111	33.6%	Ownership of vehicles*	Yes	266	80.6%
	Retired	17	5.2%		No	64	19.4%
	Unemployed	22	6.7%				

*car, motorcycle, and/or bicycle in the household.

Regarding the ownership of other means of transport, only 19.4% of the interviewees stated that they did not have any other means at home. Among those who had, 22% owned a car, 21% a bicycle, and 6% a motorcycle. Another question asked in the questionnaire was the user's motives for choosing PT. It was possible to select more than one answer, as shown in Figure 2.

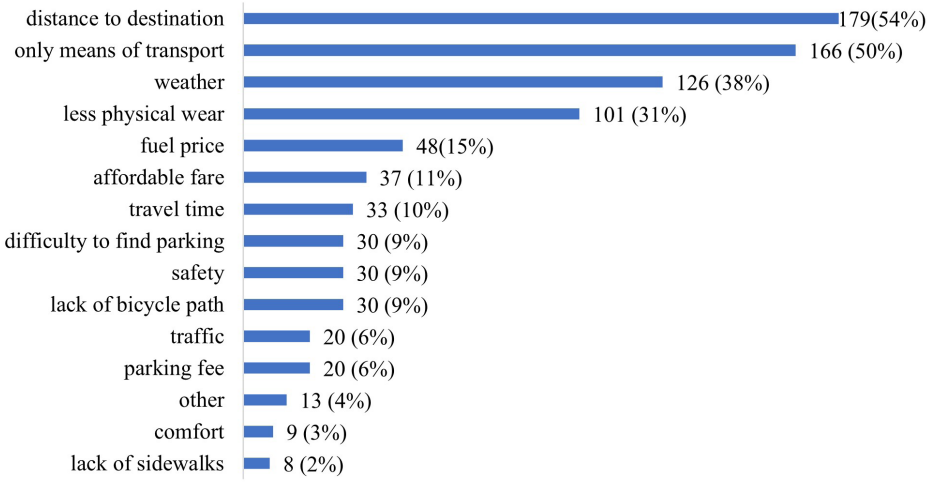

Figure 2. Motives for choosing PT

The most relevant reasons for choosing PT were the ones related to distance to destination (54%), to it being the only available means (50%), weather (38%), and the interviewee's search for less physical wear (31%). Figure 3 shows the interviewees' perception of the quality of PT in the evaluated city concerning the indicators used in this study.

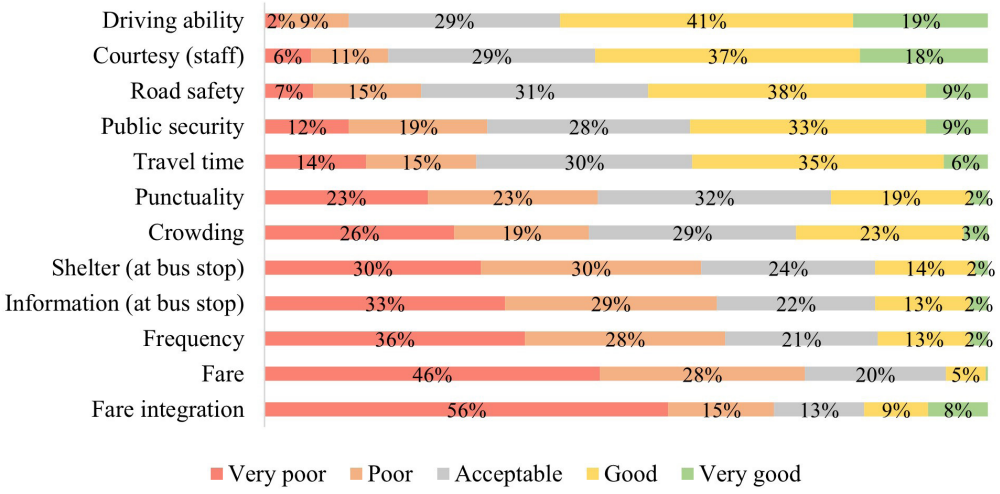

Figure 3. Level of satisfaction of quality indicators.

Fare and fare integration were the indicators with the lowest levels of satisfaction, with 74% and 71% of respondents' disapproval, respectively, considering the poor and very poor scores. Such factors portray the real situation of the object of study in which buses are the only PT available, being provided by a single company and with no fare integration.

Bus frequency was the third-worst indicator assessed, followed by the characteristics of bus stops such as the availability of information and shelter, which are seen only at the bus stops in the city center. Suburban bus stops do not have information or the physical aspects necessary for greater comfort during the waiting period.

Regarding information, the routes and timetables of the bus lines can be found on an application; however, users indicated that it is not up to date. Batty et al. (2015) found that the availability of information on the functioning of the PT system may help attract new users. Moreover, Outwater et al. (2011) showed that, in Salt Lake City (UT, USA), the provision of information in real-time was one of the attributes most valued by PT users.

Human aspects, such as the drivers' driving abilities and the staff courtesy, stood out as the best-evaluated indicators. Considering the good and very good scores, 60% and 55% of respondents were satisfied with the driving ability and the staff courtesy indicators, respectively. Indicators related to employees are widely used to assess PT and have an influence on the overall satisfaction of the service provided. This can be seen in the works of Guirao et al. (2016), Mouwen (2015), Maraglino et al. (2014), and Bajčetić et al. (2018) who found the importance of these aspects for PT users.

Moreover, Figure 2 shows the heterogeneity in the perception of users regarding the quality of PT. This was also evidenced by De Oña & De Oña (2013), Diez-Mesa et al. (2016), Abenoza et al. (2017), and Grisé & El-Geneidy (2017). These authors pointed out the need to understand how different variables affects the user's perception; thus, in the present work, MANOVA was used for these analyses.

5. Results

Initially, the correlation between the indicators in relation to the level of satisfaction of public bus service users was assessed by Pearson's correlation test. As presented in Table 4, most pairs of variables have a significant correlation with each other, with a p-value lower than 0.05, which demonstrates the need to address the problem using multivariate statistical analysis.

Table 4. Pearson's correlation of the level of satisfaction of quality indicators.

	I01	I02	I03	I04	I05	I06	I07	I08	I09	I10	I11
I02	0.338										
p-value	0.000										
I03	0.347	0.227									
p-value	0.000	0.000									
I04	0.282	0.241	0.342								
p-value	0.000	0.000	0.000								
I05	0.181	0.161	0.216	0.439							
p-value	0.001	0.003	0.000	0.000							
I06	0.151	0.086	0.210	0.178	0.278						
p-value	0.006	0.118	0.000	0.001	0.000						
I07	0.163	0.029	0.220	0.115	0.319	0.389					
p-value	0.003	0.594	0.000	0.038	0.000	0.000					
I08	0.098	-0.016	0.244	0.120	0.315	0.338	0.463				
p-value	0.075	0.768	0.000	0.030	0.000	0.000	0.000				
I09	0.156	0.082	0.236	0.289	0.445	0.364	0.323	0.311			
p-value	0.005	0.139	0.000	0.000	0.000	0.000	0.000	0.000			
I10	0.068	0.016	0.160	0.198	0.283	0.274	0.289	0.366	0.537		
p-value	0.215	0.766	0.004	0.000	0.000	0.000	0.000	0.000	0.000		
I11	0.214	0.205	0.313	0.333	0.314	0.290	0.214	0.178	0.237	0.225	
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	
I12	0.028	0.015	0.048	0.199	0.078	0.097	-0.065	0.025	0.087	0.081	0.156
p-value	0.608	0.784	0.387	0.000	0.157	0.077	0.242	0.647	0.114	0.141	0.004

MANOVA was carried out to find which socioeconomic variables influenced the level of user satisfaction. In order to verify which indicators were influenced by those variables, the univariate variance analysis result presented in MANOVA was used. The significant results, with a p-value lower than 0.05, are presented in Table 5 and these relationships are graphed in Figure 4.

The MANOVA results can be described as follows:

a. The level of satisfaction regarding the existence of shelter (I01) was significantly influenced by the users' education level;

Table 5. MANOVA results (only significant results).

Variable	Indicators	DF	SEQ SS	ADJ SS	ADJ MS	F-test	P-value
	I08	1	7.008	6.975	6.975	6.82	0.009
	I11	1	6.7041	3.7953	3.7953	4.89	0.028
Gender	I09	1	5.361	5.417	5.417	4.90	0.028
	I10	1	4.2017	3.7200	3.7200	4.03	0.046
	I06	1	9.893	6.072	6.072	4.74	0.030
Age group	I06	3	20.800	20.864	6.955	5.43	0.001
	I01	3	8.900	9.960	3.320	2.89	0.036
	I04	3	10.465	11.343	3.781	3.03	0.030
Schooling	I12	3	17.525	18.186	6.062	3.82	0.010
	I03	3	12.947	12.583	4.194	3.28	0.021
	I06	3	15.162	11.102	3.701	2.89	0.036
Occupation	I11	3	13.2526	10.6316	3.5439	4.57	0.004
Payment	I05	3	11.381	11.664	3.888	3.26	0.022
	I12	3	45.916	19.232	6.411	4.04	0.008
Frequency of use	I06	2	13.400	12.100	6.050	4.72	0.010
Bicycle ownership	I04	1	1.512	5.585	5.585	4.48	0.035
	I04	1	5.145	5.145	5.145	4.12	0.043
Vehicles ownership	I05	1	4.720	4.720	4.720	3.96	0.048
	I09	1	5.376	5.376	5.376	4.86	0.028

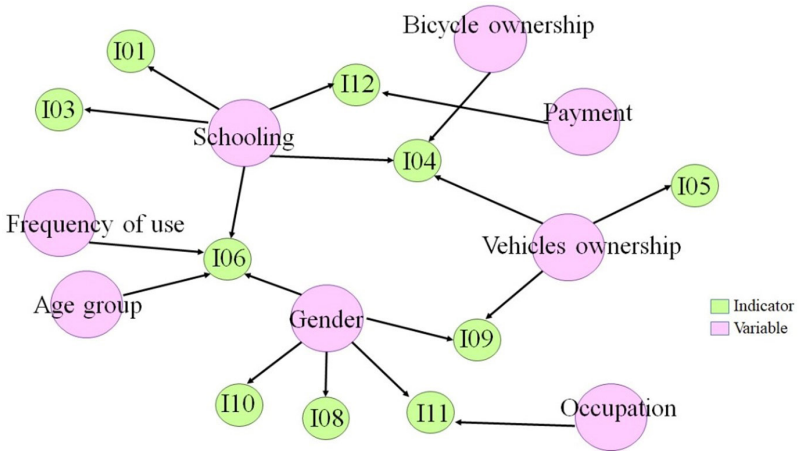

Figure 4. Socioeconomic variables and indicators relationships.

b. The level of satisfaction regarding the frequency (I04) was influenced by the users' level of education and ownership of bicycles and vehicles;

c. The level of satisfaction regarding punctuality (I05) was influenced by the users' means of payment and vehicles ownership;

d. The level of satisfaction regarding road safety (I08) was significantly influenced by the users' gender;

e. The level of satisfaction regarding bus fare (I11) was influenced by the users' gender and occupation;

f. The level of satisfaction regarding fare integration (I12) was influenced by the users' occupation, education level, and means of payment;

g. The level of satisfaction regarding staff courtesy (I09) was influenced by the users' gender and vehicles ownership;

h. The level of satisfaction regarding the driver's driving ability (I10) was influenced by the users' gender;

i. The level of satisfaction regarding travel time (I03) was influenced by the users' education level;

j. The level of satisfaction regarding in-vehicle crowding (I06) was influenced by the users' gender, age group, education level, and their frequency of use of PT;

k. The level of satisfaction regarding the information (I02) and public security (I07) indicators was not significantly influenced by any of the users' characteristics.

The users' gender and education level were the characteristics that significantly influenced a greater number of indicators, followed by vehicles ownership and means of payment.

The Figure 5(a-h) shows in detail the association of the significant variables identified by MANOVA with the mean level of satisfaction of the related indicators.

As seen in Figure 5a, women had a mean level of satisfaction lower than men in relation to all indicators affected by the users' gender. De Oña & De Oña (2013) also verified that women were more critical of the general quality of the PT service, being influenced by a higher number of indicators than men.

Considering the age group (Figure 5b), the older the users, the greater the satisfaction with the frequency of buses, especially for those over 60 years of age. Part of this behavior may be because older people, in general, perform less daily activities, while more active users who study and work need to make more bus trips, which makes them realize that the frequency of buses does not satisfactorily attend to their needs. For Weng et al. (2018), age played a significant role in the satisfaction level of users regarding the punctuality of PT.

As shown in Figure 5d, the fare indicator (I11) was rated as more satisfactory by retired users, who, in general, are exempt from payment. Working users, on the other hand, had the lowest mean satisfaction level concerning the fare. These users pay the fare price in full or use transportation vouchers, with a percentage being deducted from their salary, which may influence their level of satisfaction with the price paid. Furthermore, if they use PT as a means of getting to work, the frequency of use is high, implying a high amount of money spent on PT.

According to Figure 5f, the more frequent the use of PT, the more dissatisfied users were with in-vehicle crowding. For Birago et al. (2017), the performance of PT concerning agglomeration and cost was also unsatisfactory for users who used it in different frequencies.

Figures 5g and 5h demonstrated that people who do not own bicycles or vehicles had a lower level of satisfaction regarding the frequency indicator (I04). Users who do not own vehicles also showed lower satisfaction in relation to punctuality (I05) and staff courtesy (I09). This may be because users who depend more on PT tend to pay more attention to the service provided.

6. Discussion

Providing a quality service is an essential requirement for transport system operators, since the increase in customer satisfaction leads to user retention, greater use of the system and new customers (De Oña & De Oña, 2013). This fact is even more relevant due to the impact that the COVID-19 pandemic has had on the PT system. In Brazil, at the beginning of the pandemic, the average reduction in demand for buses was around 80% (National Association of Urban Transport Companies, 2020). In this context, the need for intervention and adaptation of the service has been highlighted, aiming to make it safer and more attractive to users (Bucsky, 2020; Dong et al., 2021). However, considering the moment when resources are even more scarce, investments must be made in priority aspects and, mainly, considering the users' vision.

For the municipality under study, the fare and fare integration indicators were the ones that presented the highest percentage of evaluation considered very poor, evidencing the users' dissatisfaction with these two indicators and the need for measures that make the service more accessible. As in most medium-sized Brazilian cities, in Itajubá, the public transport service is provided by only one company and without fare integration. Currently, the price charged in the city is $0.70 for urban lines and $0.80 for rural lines. The distance traveled also reflects the expensive fare. In cities of similar size, the mean travel distance using PT per person is 2.7 km (Associação Nacional de Transportes Públicos, 2016). According to the same report, in cities with more than one million inhabitants, such as São Paulo and Curitiba, where the fares cost $0.77 and $0.80, respectively, this mean is 8.1 km. Therefore, the price charged in the city studied is high in relation to the area covered. One of the possible measures is the provision of government subsidies that help defray the costs of transport. The operating company can also intervene in this value through more efficient cost planning. It is noteworthy that in some studies found in the literature, the fare is considered a relevant factor (Maraglino et al., 2014; Noor et al., 2014; Barcelos et al., 2017). However, some authors emphasize that the transport fee alone is not sufficient to guarantee the increase in demand (Birago et al., 2017).

The frequency, characteristics of bus stops and the availability of information were also poorly evaluated. More specifically on frequency, during the current pandemic moment, this indicator has gained greater attention. Bucsky (2020) highlights that the drop in demand for PT, due to the COVID-19 pandemic, significantly impacted companies' revenues, forcing operators to reduce the level of service provided and, especially, the frequency,

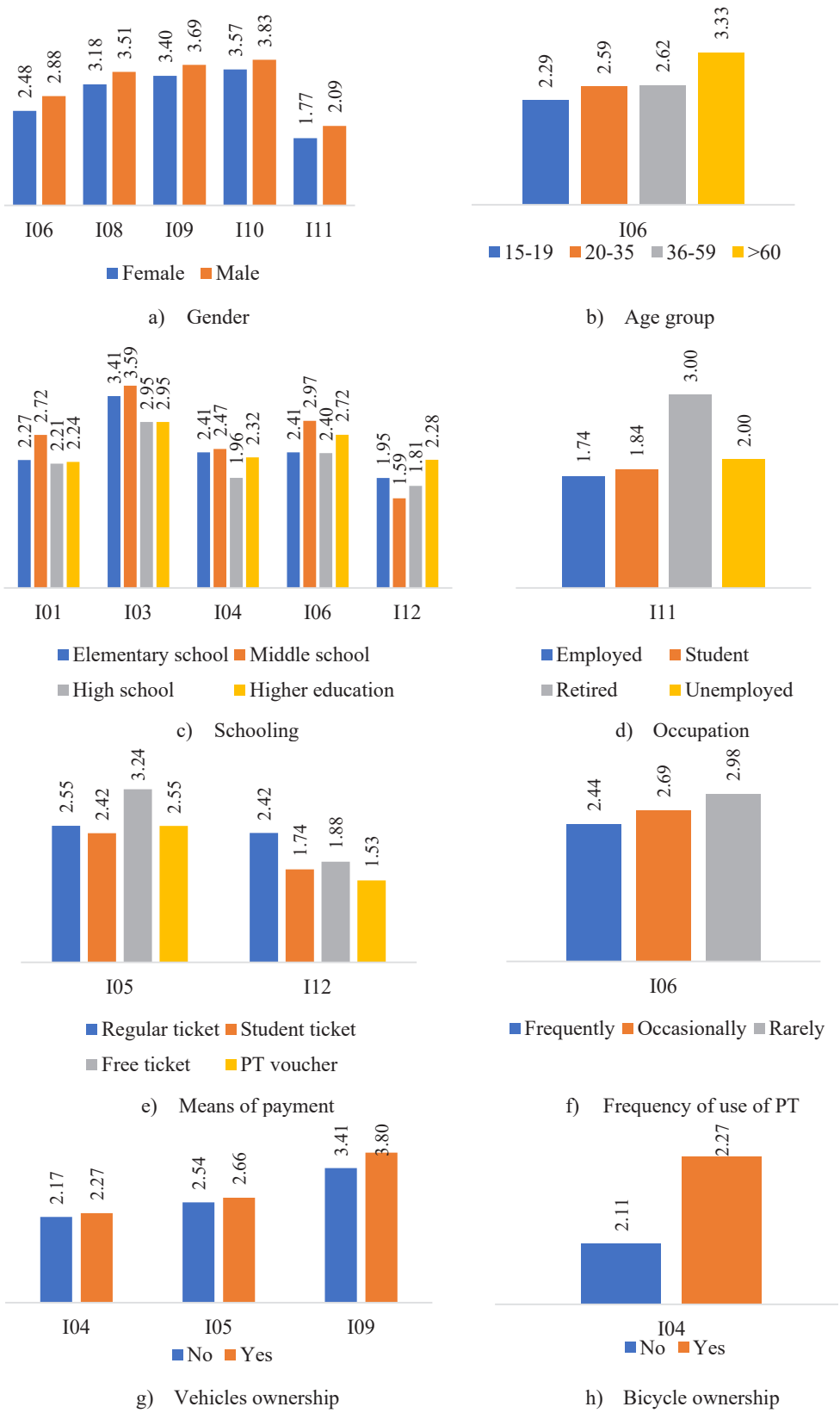

Figure 5. Mean level of satisfaction of the indicators according to different socioeconomic variables.

in order to remain in the market. According to the author, such a measure can generate a vicious circle of continuous decrease in the number of passengers and quality. In addition, the drop in frequency implies an increase in vehicle capacity. The increase in crowding makes the use of TP unsafe for users. This is because, when using PT, people are very close to each other, which can facilitate the spread of the disease (Wang et al., 2020; Dong et al., 2021). The fear of using the PT can make people seek other forms of locomotion, such as individual motorized transport (Bucsky, 2020), which can lead to several negative externalities for the urban environment. . Therefore, despite the data collection having occurred before the pandemic period, the results have implications for the current moment. The frequency, which was already considered a priority factor in the municipality, should receive greater attention nowadays.

Identifying how different groups evaluate and perceive the quality of the service provided is of paramount importance for operators to focus their investments and market strategies on certain aspects, aiming to attract potential users with a specific profile (Diez-Mesa et al., 2016; Abenoza et al., 2017). De Oña & De Oña (2013) also emphasize that the opinion of users is heterogeneous and dependent on several factors. Therefore, stratifying the sample is a good strategy to reduce heterogeneity and to identify which factors really influence the perception of quality. The results obtained by applying MANOVA in the case study showed that, for Itajubá, gender, education level, vehicle ownership and the form of payment were the characteristics that influenced the level of satisfaction in relation to a greater number of indicators. These results are in agreement with the ones found by Sarkar & Mallikarjuna (2017) who demonstrated that gender, education level, and age group are significant in explaining the latent variables for choosing the means of transport. Han et al. (2018) found that gender, monthly income, as well as the purpose and distance of the trip are factors that influence whether users choose public or private transport. In addition, the authors also confirmed that a higher degree of satisfaction regarding buses, especially their safety, comfort, and convenience, tends to be positive when choosing PT.

The exploratory analysis made it possible to identify how socioeconomic variables influence the perception of quality. As in the study by De Oña & De Oña (2013), in Itajubá, women showed a lower level of satisfaction in relation to indicators that were influenced by gender, that is: road safety, fare, courtesy, driving skills and crowding. It is noteworthy that the sample of respondents was composed mostly of women. Therefore, in order to maintain the use of the service by women, the company and the government must pay attention to these factors.

People who own a vehicle showed a higher level of satisfaction for the indicators frequency, punctuality and courtesy. This may be due to the fact that people who own a motor vehicle tend not to use the service as often (Chiou et al., 2015; Yang & Wang, 2018; Tembe et al., 2019). On the other hand, people who are totally dependent on PT are able to have a greater perception of the service provided. In addition, many depend on the service to perform essential activities, such as study and work. Therefore, the punctuality and frequency of the service are extremely relevant factors considering the nature of the activities.

The level of satisfaction with the fare was influenced by gender and occupation. Retirees showed a higher level of satisfaction with this requirement. However, it should be noted that due to age, most retirees are exempt from paying. Maraglino et al. (2014) concluded that frequent and working users of PT give considerable importance to the fare price. As previously highlighted, a possible measure would be the provision of government subsidies to defray part of the value. In Itajubá, a fee is charged for parking motorized vehicles in some central locations in the city. Part of this resource can be used to defray the fare for paying public transport users.

7. Conclusion

This work presented an analysis of the perception of the level of satisfaction of PT users in relation to quality indicators, considering their socioeconomic characteristics. This study is relevant because service providers have scarce resources, thus, being necessary not only to identify priority quality indicators to improve but also to determine how the characteristics of users influence their perception. This type of analysis could provide technical subsidies that favor the improvement of the quality of the PT system, thus, encouraging its use.

Initially, an analysis of the level of satisfaction of PT users in a medium-sized Brazilian city was presented. In general, fare and fare integration indicators had the lowest levels of satisfaction. In contrast, users reported higher satisfaction regarding aspects related to PT employees, such as courtesy and driving ability.

Subsequently, the MANOVA was performed, demonstrating that 10 indicators were significantly influenced by several socioeconomic variables. The variables gender and schooling significantly influenced a greater number of quality indicators. Similar to the results found in the literature, women showed a lower level of satisfaction in relation to all indicators influenced by gender. Moreover, people who depend totally on PT for mobility had a lower mean level of satisfaction concerning frequency, punctuality, and staff courtesy.

The present study presents practical and methodological contributions. Through the joint use of the MANOVA technique and exploratory analysis, it was possible to identify not only the set of variables that influence the level of satisfaction in relation to various quality indicators for PT, but also how these variables exert this influence. The results provide technical support for the development of strategies and policies that encourage the use of this mode of transport. With the preliminary assessment of the level of satisfaction, critical points that deserve greater attention were identified. In addition, the sample was stratified, verifying how different groups, based on socioeconomic characteristics, perceive quality. This is relevant in order to design strategies more efficiently, making it possible to prioritize certain aspects, retain users and also attract potential customers based on a specific profile. Thus, the results can help the operating company to remain in the market and, by encouraging the use of PT, contribute to the sustainability of the urban environment.

This work was limited by some important variables, which may influence the perception of quality and the choice of using PT, not being considered, for instance, those related to users' behavior, origin and destination of the trips, and built environment.

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