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How to improve public transport usage in a medium-sized city: key factors for a successful bus system

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Abstract

In recent years, the promotion and use of public transport (PT) has become key to overcoming the negative impacts of mobility, such as traffic congestion, high pollution (GHG), and traffic accidents. Improving users' satisfaction and increasing the attractiveness of buses play an essential role in increasing PT patronage. Whilst most of the literature concentrates on large and complex bus systems, less attention has been paid to European medium-sized cities, the region's most common urban configuration, where public transport mainly depends on bus services. To this end, a survey campaign was conducted on passengers of urban buses in Oviedo, Spain, a representative medium-sized city. An Exploratory Factor Analysis (EFA) was used to identify key user satisfaction factors. In this case, three factors were the most important: comfort and information, service performance, and integration. That was complemented by the overall satisfaction (OS) with services, which was used for ranking the importance of the factors using an ordinal logistic regression model; comfort and information appear as the most important. These findings can serve bus operators to identify service-related attributes that need more attention or investment to increase users' satisfaction and to make the service attractive to potential users.

Keywords Users' satisfaction, Urban buses, European medium-sized cities.

1 Introduction

Urban growth is a global phenomenon with several side effects. In 2018, 55.3% of the world's population resided in cities, expected to rise to 60.4% by 2030 [1]. Consequently, negative impacts related to mobility, like traffic congestion, GHG emissions and pollutants, and traffic accidents, are growing. All these represent the new challenges that must be faced by authorities, transport planners, and public transport operators. Different policies and measures are being deployed to overcome them. Among these, increasing the use of public transport and improving user satisfaction plays a fundamental role.

Buses can be considered as the cornerstone of public transport since they are available in most cities. Moreover, buses are the most accessible and sustainable mode of transportation for all types of citizens. Increasing bus use means reducing car dependency, therefore reducing urban traffic congestion. Since public transport, specifically buses is a clear alternative to reduce mobility's negative impacts, scholars and practitioners have focused on assessing users´ satisfaction and its relationship with their loyalty.

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According to Allen and Allen [2] and Lierop and El-Geneidy [3], satisfied PT users intend to continue using and recommending the service, showing their emotional and behavioural loyalty towards the service. On the other hand, Oliver [4], Minser and Webb [5], and Lai and Chen [6] affirm that customer satisfaction has a significant impact on loyalty rather than being part of the construct. Zhao et al. [7] propose a vision, defining customer loyalty as the combination of two aspects at the same time: the behaviour to continue using a product/service and customers´ attitude towards the service. Additionally, de Oña et al. [8] have demonstrated that satisfaction and perceived quality are the most common determinants of customer loyalty, supporting the need to assess bus users´ satisfaction with the service.

Medium-sized European cities, typically home to populations ranging from 200,000 to 500,000 people [1], strike a balance between simplified transportation networks and diverse industries. They attract approximately 22% of the urban population in the Organisation for Economic Co-operation and Development (OECD) countries, with nations like Germany, Netherlands, and Spain hosting up to one-third of their residents [9], where bus services often serve as the primary and sometimes the only public transportation option. Evaluating bus user satisfaction is crucial for attracting and retaining passengers and boosting ridership. While there is a substantial body of literature on assessing bus user satisfaction, most studies have centred around larger cities or complex bus systems like Bus Rapid Transit (BRT) in Minnesota, United States [10], New York City [11], and Barranquilla (Colombia) [12]. Relatively less attention has been paid to understanding the unique features and requirements of medium-sized European cities and their specific transportation needs. These cities differ significantly from their larger counterparts regarding transportation infrastructure and traffic conditions, making it essential to tailor strategies and research to their particularities. This paper aims to fill this gap by identifying the factors affecting urban bus user satisfaction, taking Oviedo as a case study. Oviedo is a good example of a medium-sized European city due to the high share of sustainable modes, like Karlsruhe (Germany), Bari (Italy), Nice (France), and Malmö (Sweden) [13], which are characterized by the combination of active modes with an attractive bus system. The results provide interesting insights for developing policy recommendations that could be applied in any medium-sized city, with the added value of high transferability.

The objective of this paper is to identify implicitly and not previously measured factors in a representative medium-sized European city; this paper applies an Exploratory Factor Analysis (EFA), which is a widespread methodology in transport studies [14–16]. Then, the impact of these factors on the Overall Satisfaction (OS) is evaluated by conducting an Ordinal Logistic Regression Model [17]. The results rank the factors with the highest impact on users´ satisfaction through new indicators and outputs, providing bus operators with useful insights on where to allocate resources. Focusing on a medium-sized European city makes these results easily transferable to other cities with similar characteristics.

This paper is organised as follows. Section 2 presents the scientific literature relevant to this study. Section 3 describes the case study. The survey conducted and the methodology adopted are presented in Sect. 4. Section 5 describes the results, while Sect. 6 discusses the main findings. Finally, Sect. 7 presents the main conclusions and proposes future research.

1.1 Factors affecting public transport users´ satisfaction

Several research focused on identifying service attributes influencing user satisfaction with public transport. The following sections present scientific literature relevant to our study related to different attributes grouped considering: (1) comfort and service performance and (2) time-related factors, cleanliness, and information availability.

1.2 Comfort and service performance attributes

The importance of comfort and service performance on public transport users´ satisfaction was studied by Fellesson and Friman [18] who evaluated the satisfaction of PT users in nine European cities concluding that it mainly depends on comfort, staff, and safety. Dell'Olio et al. [19] also found that comfort together with waiting time, and cleanliness are the most significant attributes for PT users in Santander (Spain), whereas bus occupancy, trip duration, and driver behaviour were found to be the less important ones. They also have observed that the influence of these elements varies depending on the socio-economic characteristics of the users. According to Eboli and Mazzulla [20], customer satisfaction is affected by four latent constructs: service planning and reliability, comfort and other factors, safety and cleanliness, and network design. These four variables are explained by 16 service quality attributes measured throughout a survey. Nevertheless, the results cannot be generalised since the survey was addressed only to University of Calabria, Italy students. Charbatzadeh et al. [14] also conducted a study focused on university campuses to assess determinants of satisfaction with campus transportation services. According to the authors, there are four main factors related to users´ overall satisfaction: driver, planning & reliability, service, and routes. de Oña et al. [8] developed a structural equation model (SEM) to assess bus riders' satisfaction with service. They identified three latent variables representing the main characteristics of the service. The performance factor had the highest effect on

overall service quality, while the other factors (comfort and personnel) had a weaker effect. Hansson et al. [21] have analysed different quality attributes of regional public transport to assess their influence on modal choice, demand, and customer satisfaction through a literature review. The authors have observed that comfort is a priority for regional travellers and becomes more important with longer travel periods.

Other studies have analysed users´ satisfaction under specific and contextual conditions like economic crisis periods [15]. Lierop and El-Geneidy [3] used results from three user satisfaction surveys conducted in Athens between 2008 and 2014. Three prevalent factors were identified through a Factor Analysis: quality of service, service production & transfer quality, and ticket services. The impact of other specific conditions, like a major change in the network, was studied by Allen et al. [22]. The authors evaluated the impact of a radical reform of Barcelona bus network on users´ satisfaction, reducing travel time but increasing the number of transfers. Their results showed that users value reliability over other latent constructs.

1.3 Time-information-related factors

Further research focused on other time-information-related factors like the availability of information, integration of services provided, and timelines. Friman et al. [23] studied satisfaction with public transport services in Sweden. Results showed that attribute-specific satisfaction is related to treatment by employees, service reliability, and information simplicity.

Dell'Olio et al. [24] modelled user perception of bus transit quality in Santander (Spain) and found that consumer satisfaction was based mostly on service reliability and waiting time at the stop; moreover, the importance of these attributes reduced when passengers were asked to consider other service attributes like driver kindness. In their research, Calvo and Ferrer [12] assessed the quality of the services offered by the Bus Rapid Transit (BRT) system in the city of Barranquilla (Colombia), finding that information availability is one of the four most influential factors in user´s overall satisfaction.

Romero [25] obtained some behavioural insights related to the perceived quality of PT information and service of metropolitan bus passengers within the Madrid – Alcobendas North corridor (Spain). He assessed the value of real-time information attributes such as waiting time and total travel time-saving. He found that improving the information passengers receive through transit apps could ease their trips and help materialise some potential bus demand in metropolitan areas.

Regarding regional public transport, Hansson et al. [26] studied the importance of peak and off-peak frequencies, confirming the importance of frequency for passengers. The results obtained by the authors suggest that improved time coverage may improve user satisfaction in regional public transport. Eboli and Mazzulla [27] studied passengers' perceptions of railway services in northern Italy. They concluded that service characteristics like punctuality, regularity and frequency, and cleanliness positively affect service quality. In a later study, Eboli and Mazzulla [28] studied the relationship between rail passengers´ satisfaction and service quality. They found that information and service characteristics, like punctuality and frequency, have the highest positive effect on perceived quality. In addition, they built a Customer Satisfaction Index (CSI), which assesses the overall service quality by combining importance and satisfaction rates. de Oña et al. [29] also observed that regularity and timeliness are some of the most important factors influencing users´ satisfaction among diverse groups of railway passengers in northern Italy.

This paper introduces a novel perspective on public transport user satisfaction by focusing on medium-sized European cities, exemplified by Oviedo. Unlike prior studies primarily centred on larger urban areas or complex transit systems, this research examines the dynamics of medium-sized European cities, where bus services often play a pivotal role in sustainable mobility. One of the main advantages of the data collection methodology was that face-to-face interviews were carried out with an online connection that allowed the evolution of the responses to be seen in real-time. That allowed the campaign to be readjusted to search for specific user profiles on specific lines to ensure the sample's representativeness. Additionally, employing a well-known and commonly used methodology in the transport field, it conducts an Exploratory Factor Analysis (EFA) to unveil implicit and previously unmeasured factors shaping user satisfaction. The results not only shed light on the specific attributes that drive passenger contentment but also offer high transferability to similar cities facing similar challenges. Combining EFA with an Ordinal Logistic Regression Model, this study's methodological rigour enhances our understanding of urban bus user satisfaction. In sum, the paper's singularity lies in its contextual focus, implicit factor exploration, transferability of findings, and practical policy implications learned from a successful bus system, collectively contributing to a more comprehensive understanding of public transport user satisfaction in medium-sized European cities.

2 Case study

This study focuses on Spanish urban bus services, specifically in Oviedo. The municipality of Oviedo, with a population of 220,000 inhabitants [30], is the region's capital of Asturias (1,022,800 inhabitants) and its second most populated city after Gijon. It is an inland city located

in the geographical centre of Asturias, in the North of Spain. It functions as a regional service centre, providing essential services and as a hub for its region's economy, culture, and administrative activities. Oviedo´s metropolitan area comprises the city centre and other 14 parishes located between 4 and 12 km. Sustainable mobility modes account for almost 80% of total trips. 66.4% correspond to walking and cycling, and 8.5% to bus trips. Cars and motorcycles represent 24.1% of trips [31]. Oviedo's lower dependence on private cars and public transport matches the simpler transportation networks of medium-sized cities. This emphasis on walking, cycling, and other active transportation options suggests a city that prioritizes sustainable and active mobility. Such a focus aligns with contemporary urban planning goals and positions Oviedo as a forward-thinking city in terms of promoting healthier and more eco-friendly transportation choices.

Oviedo's public transportation system primarily relies on its bus services, which offer convenient and accessible options for commuters within the city. Furthermore, Oviedo has a regional rail network comprising six lines that efficiently connect the city with the surrounding parishes. There are three stations in the city, including the central one, well integrated with urban bus services. While public transportation is a key component of the city's mobility, the city does have two taxi cooperatives for those seeking more personalized travel. Oviedo currently lacks other on-demand services like Uber or Cabify.

This city was chosen as a case study due to its successful bus system. The bus services in Oviedo are operated by TUA, a private company that belongs to ALSA Group. Oviedo's urban bus network has fifteen daytime lines and one night-time line with a fleet of 67 buses to cover the service. For analysis purposes, these sixteen lines were classified into urban (see Fig. 1) and suburban lines (see Fig. 2), depending on their routes.

2.1 Methodology

A four steps methodology (see Fig. 3) was applied to identify the key factors to improve bus user satisfaction in Oviedo as a medium-sized city: (1) Selection of lines, (2) Survey design and data collection, (3) Analysis and Modelling, (4) Policy recommendations.

2.2 Selection of lines

The sixteen lines were grouped into urban and suburban, as previously described in section 3. The urban lines´ average ridership of 126,000 passengers/ is more than ten times higher than that of the suburban lines, 16,000 passengers/month, as shown in Fig. 4. For this study, six representative urban lines were chosen (C-D-E-F-H-J) based on their high ridership. Among suburban lines, two were selected (G and L) because of their long and transversal itineraries covering many suburban boroughs. The selection of surveyed bus lines aimed at resource efficiency and was based on both ridership (representing nearly 78.7% of total ridership of 12 million in 2019) [32] and potential impact. Focusing on heavily used lines allows for quicker and broader improvements in urban mobility, serving a larger population segment. This approach also aligns with public transport policies that prioritize addressing the needs of most commuters, making

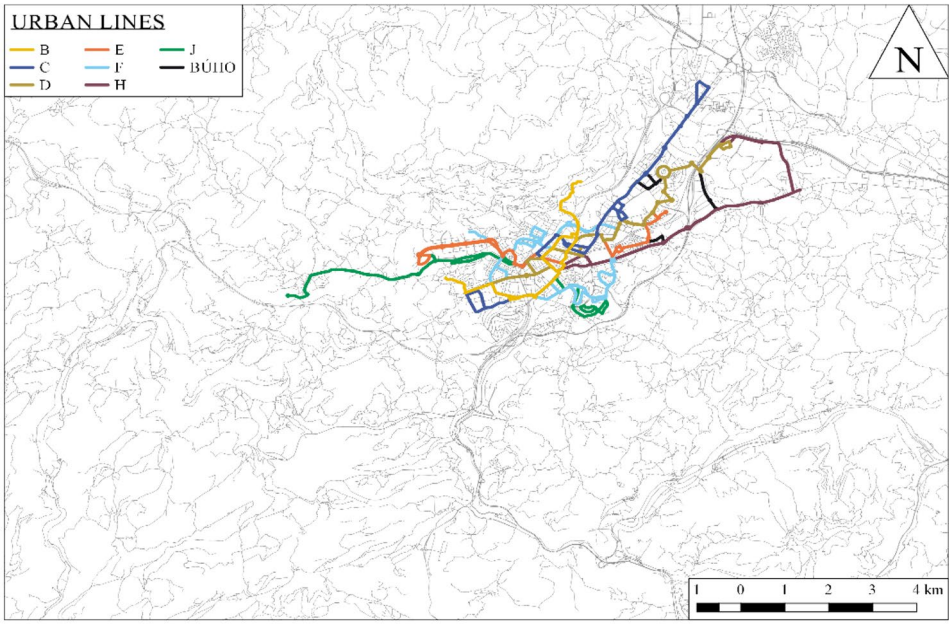

Fig. 1 Oviedo´s urban lines

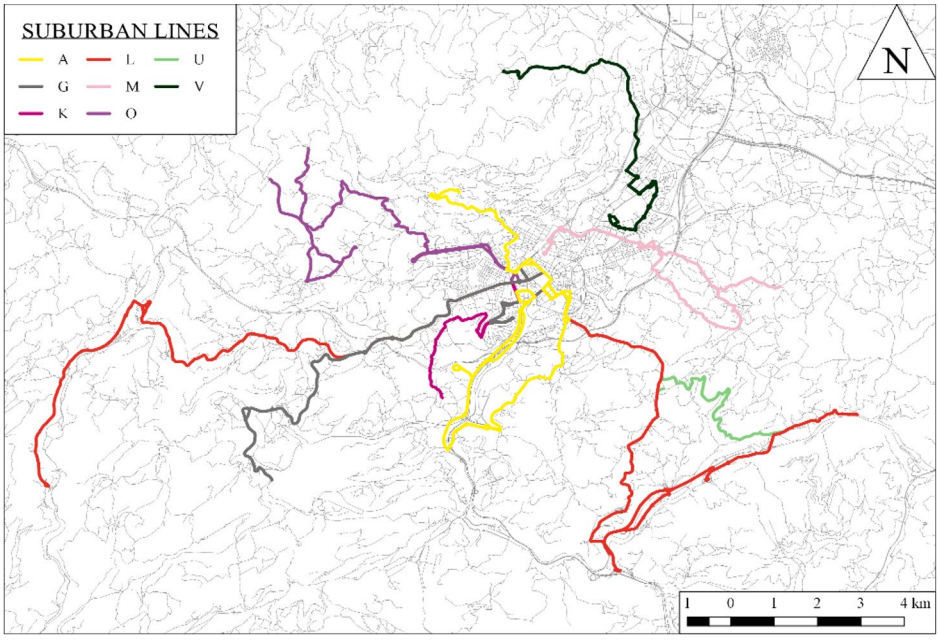

Fig. 2 Oviedo´s suburban lines

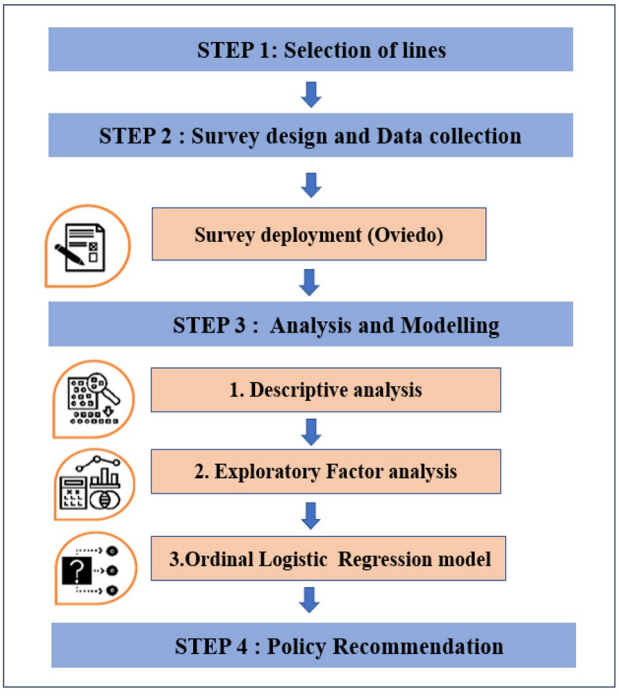

Fig. 3 Methodology Outline

research outcomes highly relevant to decision-makers and urban planners.

2.3 Survey design and data collection

The survey design was based on two inputs, a previous survey conducted in 2018 by the operator ALSA and the review of previous studies with a similar scope. All the service attributes from the survey of 2018 were included in the new survey to evaluate their performance over the years. Additionally, complementary questions were included to evaluate new service attributes that were not previously measured. Furthermore, the impact of COVID-19 on users' perception of security was also included.

As a second input, findings from previous studies like the ones of Dell'Olio et al. [19], Eboli and Mazzulla [33], de Oña et al. [8] and de Oña et al. [16] were taken into account for the design of the survey. The combination of both is derived by selecting the thirteen attributes presented in Table 1. The content of the survey and its questions were validated on a pilot test carried out on different lines and stops on 16 June 2021.

The questionnaire had a total of 21 questions grouped into three sections with the following objectives (see Tables 2 and 1):

- Section 1 - Socioeconomic characteristics. This section aimed to identify the sociodemographic profile of bus users. It also included travel-related variables such as car/motorcycle ownership, car availability for frequent personal use, possession of a driving license, and public transport pass.
- Section 2 - Trip characteristics. This section addressed passengers' mobility patterns, including frequency of bus use, trip purpose, the line used, trip duration, and the type of ticket used.
- Section 3 - Satisfaction with different service-related attributes such as service availability, accessibility, information, time, comfort, and safety. In this section, users were asked to rate 13 different service-

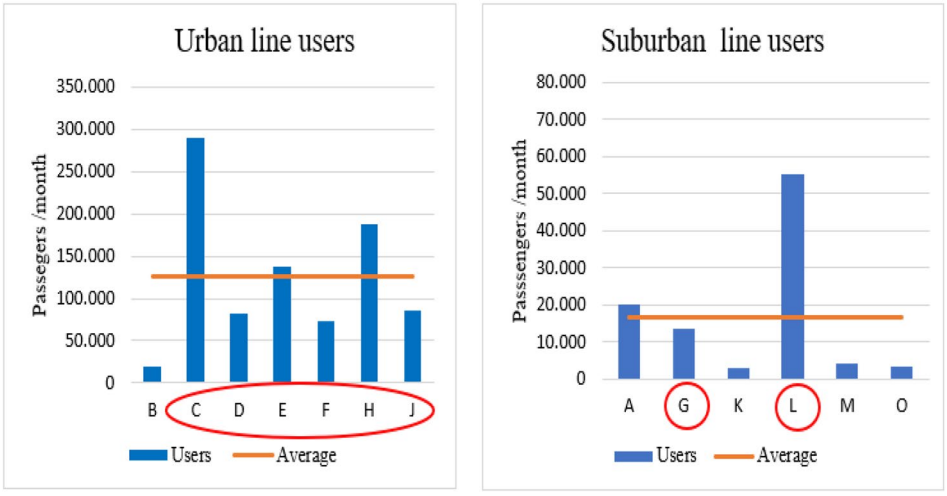

Fig. 4 Average monthly ridership in Oviedo 2019

Table 1 User´s satisfaction with the 13 service attributes

Items	Mean	SD.
I-1. Information on schedules and frequencies at the stops	**4.04**	0.902
I-2. Information inside the bus	3.96	0.943
I-3. Connection with other modes and between lines	3.40	1.501
I-4. Extent of the bus network	3.79	1.142
I-5. Ticket Price	3.24	1.173
I-6. Ease of purchasing passes/cards	3.74	1.257
I-7. Travel comfort (bus occupation)	3.84	0.911
I-8. Smooth driving (curving, braking)	3.78	0.985
I-9. Frequency and schedule on working days	3.87	0.962
I-10. Frequency and schedule on holidays and weekends	2.81	1.226
I-11. Compliance with schedules and frequencies	3.73	1.136
I-12. Service start/end time on business days	3.31	1.439
I-13. Service start/end time on holidays	2.68	1.388

(Source: Authors)

related attributes on a *Likert scale* from 1 to 5 (1= "totally dissatisfied" and 5= "totally satisfied"). Additionally, they were asked to rate their overall satisfaction with the service.

The survey campaign was conducted between 15th and 19th November 2021. This period was chosen since no alterations were caused by external factors such as holidays or others. Additionally, there were no mobility restrictions during that period due to COVID-19. The face-to-face interview method was used since it was considered the most adequate method for reaching a relatively high response rate in a short period, following the experience of previous studies [16, 34, 35]. As surveyors conducted face-to-face surveys, they had to wear face masks, maintain a safe distance, and exhibit utmost respect, especially for older individuals.

Eight surveyors worked in pairs for 3.5 h during the five days of the campaign. Data was collected between 7:30 a.m. and 9:30 p.m. Passengers were interviewed inside the buses and at certain bus stops by surveyors using tablets with an internet connection to the online questionnaire. SurveyMonkey software was used to collect the responses. The answers recorded by the tool were directly exported to an Excel database, avoiding any input errors and illegible responses.

2.4 Analysis and modelling

The analysis of the survey outputs comprised three steps: (i) a descriptive analysis of the data collected through the survey, (ii) an exploratory factor analysis to identify key factors on user satisfaction, and (iii) the application of an ordered logistic regression model (Ologit).

(i) The descriptive analysis of the satisfaction level with the thirteen service-related attributes (Table 1) was done to identify the best and worst-rated ones.

(ii) Methods based on component analysis, such as Exploratory Factor Analysis (EFA), are commonly used to analyse user satisfaction since they serve to identify the latent constructs underlying a set of measured variables in a situation without prior hypotheses. Factor analysis finds the interrelationships between several variables and explains them in their common underlying dimensions [36].

(iii) Finally, an ordinal logistic regression was used to assess to what extent each identified factor contributes to explaining users 'overall satisfaction (OS). Ordinal logistic regression is a statistical model used for analysing and modelling relationships between one or more independent variables (predictors) and an ordinal dependent variable (outcome), which has more than two ordered categories or levels. In ordinal logistic regression, the goal is to understand how the independent variables

Table 2 Distribution of the complete sample (n = 970)

Survey	Category	Variable	%
Section 1 Socioeconomic characteristics	**Gender**	Male	40
		Female	**60**
	Age	< 21	19
		22–30	20
		31–45	22
		46–65	27
		> 65	12
	Employment situation	Student	**33**
		Employee	**34**
		Self-employed worker	8
		Unemployed	9
		Pensioner	15
		Other	1
	Level of studies completed	Primary	6
		Secondary school	15
		Sixth form/professional education	46
		University degree	32
		Other	1
Section 2 Characteristics of the trip	**Availability of**	Driving license	58
		Own car	40
		Own motorcycle	7
		Own bicycle	18
		Public Transport Card	**73**
		None of them	7
	Trip purpose	Work	**36**
		Study	29
		Leisure	30
		Other	5
	Frequency of use	Daily	**51**
		3 or 4 times a week	18
		1 or 2 times a week	16
		A few times a month	8
		Occasionally	7
	Type of ticket	Single-trip ticket	27
		10-trip ticket	16
		Monthly Pass	33
		Young Pass	19
		Disabilities bonuses	0
		Pensioner Pass	4
		Other	1

(Source: Authors)

are associated with the likelihood of an outcome falling into one of several ordered categories. The dependent variable is categorical and ordered; it could represent responses on a Likert scale where the categories are ordered from "totally dissatisfied " to "totally satisfied ". That is consistent with this study, where service attributes are the independent variables, and overall satisfaction is the dependent variable, which is categorical and ordered on a Likert scale. Therefore, using this statistical model is most appropriate in our case.

Ordered Logit models (Ologit) are based on the following specification of a latent regression:

$$q_i^* = \beta' X_i + {}_i, i = 1 \ldots n. \tag{1}$$

In which the latent continuous preference variable q_i^* is only observed in discrete form q_i through a censoring mechanism:

$$\begin{aligned} &q_i = 0 \, if \; q_i^* \leqslant \mu_0 \\ &q_i = 1 \, if \, \mu_0 < q_i^* \leqslant \mu_1 \\ &\ldots \\ &q_i = J \, if \, \mu_{j-1} < q_i^* \leqslant \mu_j \end{aligned} \tag{2}$$

Where q_i^* represents the non-observable overall satisfaction with the service, while q_i is the observable overall satisfaction obtained from the rating question of the survey.

J represents the 5-point Likert scale options of the rating. The dependent variable assumed for the model is the overall satisfaction with the service (OS), while the independent variables are the factors identified in the EFA. The model was obtained using the software STATA.

2.5 Policy recommendation

The qualitative and quantitative analysis of the survey provides a better understanding of bus users´ perceptions of different service attributes [27]. Moreover, identifying latent variables and the causal relationship between them and the overall satisfaction (OS) is of great interest for both the operator and transport planners to identify certain attributes to which special attention should be paid to achieve higher satisfaction levels and ensure users 'fidelity.

The model results allow us to identify the importance of each of these factors for bus services, guiding operators to design effective strategies and investment plans to meet users´ expectations. These results are expected to serve as insights to develop adequate policy recommendations to increase public transport usage in medium-sized cities with similar characteristics.

3 Results

3.1 Sample characteristics

A total of 384 valid responses were needed to ensure a representative sample with a 95% confidence level. Additionally, the number of responses required for each line according to gender and age range was calculated using the population pyramid of the municipality of Oviedo in 2019 [37]. During the data collection campaign, the representativity of each line was checked at the end of every

shift to restructure the data collection plan if needed to ensure the sample's representativeness. 982 responses were obtained, of which 970 were valid, representing a global representativeness of 97% for all the system. Moreover, the representativity of lines was also assessed separately, with all of them being over 80%.

The general characteristics of the collected sample are shown in Table 2. There is a higher percentage of women (60%) than men (40%). Most respondents were aged 46–65 (27%), and the following groups were 31–45 (22%) and 22–30 (20%). People younger than 21 represent (19%) of the sample, while passengers older than 65 are (12%). Regarding the employment situation, employees account for around (34%) of the sample, and a considerable part are students (33%). About (8%) of the respondents were self-employed workers, while (9%) were unemployed, (15%) were pensioners, and only 1% had "other" employment situations, such as housewives.

For the level of studies completed, around (46%) of the respondents have finished sixth form/professional education, about (32%) obtained a university degree, (15%) from secondary school, only (6%) from primary school, and (1%) from others. It is interesting to see the high percentage of passengers with a public transport card (73%). Almost two-thirds of the users have a driving license (58%), (40%) own a car, (18%) own a bicycle, and only (7%) own a motorcycle. Most users travel daily (51%), while (18%) travel 3–4 times per week, and (16%) travel 1–2 times per week. Only (8%) of the respondents travel a few times each week, while (7%) use the bus only occasionally.

The main reasons for travelling are work (36%), leisure (30%), and studies (29%). Finally, most of the respondents (33%) purchase a monthly ticket, followed by users who purchase a single-trip ticket (27%), and (16%) of them use a 10-trip ticket. Around (19%) of the passengers use a young pass, and only (4%) use the pensioner pass, as seen in Table 2.

3.2 User satisfaction with different service-related attributes

This research focuses on evaluating user satisfaction with the 13 service-related attributes presented in Table 1. As mentioned in section 4.2, these attributes were chosen based on previous surveys conducted by the operator and on the review of previous studies with similar scope.

A five-level Likert scale was used to rate users' satisfaction with each item from 1(totally dissatisfied) to 5(totally satisfied), as shown in Fig. 5. The rates for all the attributes considered and for the overall service, as well as their standard deviation, are shown in Table 1. From a preliminary analysis of the responses, users have good overall satisfaction with TUA services. The average overall satisfaction has a rate of 3.99 with a standard deviation of 0.657.

Table 1 shows that most service attributes have a good average satisfaction rate, considering that users are sufficiently satisfied if they score between 3.5 and 5 using the Likert scale. Eight of the thirteen attributes assessed have an average score greater than 3.5. Moreover, the highest-rated attributes are the ones with lower standard deviation. On the other hand, attributes (I-10) and (I-13) have an average satisfaction rate lower than 3, and their high deviation shows the dispersion of perceptions. Both attributes are related to the service start/end time on holidays (I-13) and frequency and schedule on holidays and weekends (I-10), with rates of 2.68 and 2.81, respectively.

3.3 Exploratory Factor Analysis (EFA)

An EFA was used to see if and how the thirteen observable variables (service-related attributes) are connected to unobservable ones. The methodological approach is based on a Principal Component Analysis (PCA) covering the 13 items collected through the survey. The step-by-step procedure by Hernandez and Monzon [38] was followed to ensure the appropriate use of this statistical technique.

As a first step, the Spearman correlation matrix shows the existence of correlations without multi-collinearity, which was also verified through the determinant of the matrix. Bartlett's test for sphericity rejected the null hypothesis of an identical correlation matrix. The items assessed in the survey demonstrated good internal consistency (Cronbach's alpha = 0.8 > 0.7) and good sampling adequacy according to the Kaiser-Meyer-Olkin test (KMO = 0.75 > 0.6). These results showed that data met the necessary preliminary conditions for conducting factor analysis and obtaining meaningful results [39].

In the second step, an EFA was applied to extract the existing latent constructs among the different declared variables measured in the questionnaire using the SPSS software. Principal component analysis (PCA) was used to obtain the initial solutions with an orthogonal "varimax" rotation [40] to ensure that the latent factors are uncorrelated. Based on the convergence of the Scree plot [41] and Kaiser´s criterion [42], three principal components were revealed. Table 3 presents the loadings of each observed item.

Item I-4 was deleted following Hair et al. [43] recommendations because it has a low loading (≤0.5). The rest of the items have considerably good loads (|> 0.5).

Information at stops and inside the bus and smooth driving and travel comfort have a similar impact (homogeneous loading) on the ´comfort and information` exogenous latent variable with weights between 0.634 and 0.703. In factor 2, service start and end time on weekends (0.881) and working days (0.821) are the attributes that

Table 3 Service-related factors that influence users´ satisfaction

FACTORS	ITEMS	F1	F2	F3
F1. Comfort and information	**I-1.** Information on schedules and frequencies at the stops	**0.703**	0.069	0.173
	I-8. Smooth driving (braking, cornering)	**0.698**	0.103	-0.012
	I-2. Information inside the bus	**0.665**	0.051	0.141
	I-7. Travel comfort (bus occupation)	**0.634**	0.041	0.281
	I-9. Frequency and schedule on working days	**0.524**	0.393	0.182
F2. Service Performance	**I-13**. Service start/end time on weekends	-0.039	**0.881**	0.160
	I-12. Service start/end time on working days	0.198	**0.821**	-0.026
	I-10. Frequency and schedule on weekends and holidays	0.050	**0.660**	0.300
	I-11. Compliance with schedules and frequencies	0.472	**0.589**	0.024
F3. Integration	**I-6.** Ease of purchasing passes/cards	0.112	0.039	**0.754**
	I-5. Ticket Price	0,062	0.159	**0.721**
	I-3. Connection with other modes (RENFE, FEVE, interurban bus…) and between lines	0.216	0.069	**0.545**
	I-4. Extent of the bus network	0.364	0.234	0.379

(Source: Authors)

Table 4 Ordinal Logistic Regression Model results

Factors	Coeff (β)	Std. Error	P	95% Conf. Interval	
F1. Comfort and information	**1.346905**	0.0867	0.000	1.177042	1.516769
F2. Service performance	0.487227	0.0721	0.000	0.3456888	0.6287659
F3. Integration	0.515476	0.0730	0.000	0.3723748	0.6585791
Log-likelihood	-707.12				
Chi-squared	383.32				
Pseudo R-squared	0.2132				

(Source: Authors)

have a major impact on it. For factor 3, ´integration`, there is a clear difference in the weight of ticket-related factors (ease of purchasing (0.754) and price (0.721)) compared to connection with other modes and lines (0.545).

3.4 Ordinal logistic regression model

After preliminary data analysis, we applied an ordinal logistic regression model to assess the influence of the identified latent factors on users´ overall satisfaction with the service, recording Echaniz et al. [44]. It is important to mention that the five possible responses included in the questionnaire were grouped together due to the low number of responses obtained in some of them. We considered three categories for the dependent variable ("overall satisfaction with the service"): Low satisfaction = 1 (merging rates 1 and 2 from the questionnaire), Moderate satisfaction = 2 (3 from the questionnaire), and High satisfaction = 3 (merging 4 and 5 responses).

The modelling results of an Ologit model are presented in Table 4. All the signs of the regression coefficients in the model and their statistical significance show that higher satisfaction in each latent factor means higher overall satisfaction. We can see that the coefficient of "F1. comfort and information factor" (1.35) is the most important, with a considerable difference from the other two factors. Factors "F2. Service performance" and "F3. Integration" have similar importance (0.487 and 0.515) on users´ overall satisfaction with the service.

4 Discussion

This work aimed to identify key parameters to improve PT usage mainly focused on urban buses in medium-sized cities. Results showed that women use buses more than men. Around 70% of bus users are between 22 and 64 years old, with a uniform distribution between the three ranges considered in this research (see Table 2). Moreover, around 65% is either a student or worker, which means commuter trips, as reflected in the high percentage of daily usage, 51%. Regarding mobility trends, 58% of the passengers have a driving licence, while only 40% own a car. Finally, 73% of the passengers have a public transport card using either monthly, including young or pensioner passes. That means that bus services are attractive and good value for money. Figure 5 presents users´ satisfaction rates with the service and its different attributes.

Figure 5 shows that EFA grouped items in 3 Factors with similar satisfaction rates, with only one exception, ´Compliance with schedules and frequencies`. **Factor 1** has the best-rated items, **Factor 2** the worst-rated ones, while **Factor 3** includes the average-rated service attributes.

The first factor (**F1**), called **"Comfort and information"**, is aligned with previous studies [8, 19, 20] that identified comfort as one of the most important factors influencing users 'satisfaction. Moreover, it is interesting to see how information appears as a significant attribute of this factor. That could be attributed to the fact that access to information plays a fundamental role in making the trip easy and reducing anxiety, which is related to ´comfort` according to Hill and Garner [45] and Simmons [46]. Moreover, Simmon's [46] definition of comfort as "feeling at ease" also explains why ´frequency and schedule on working days` belong to F1 since the daily

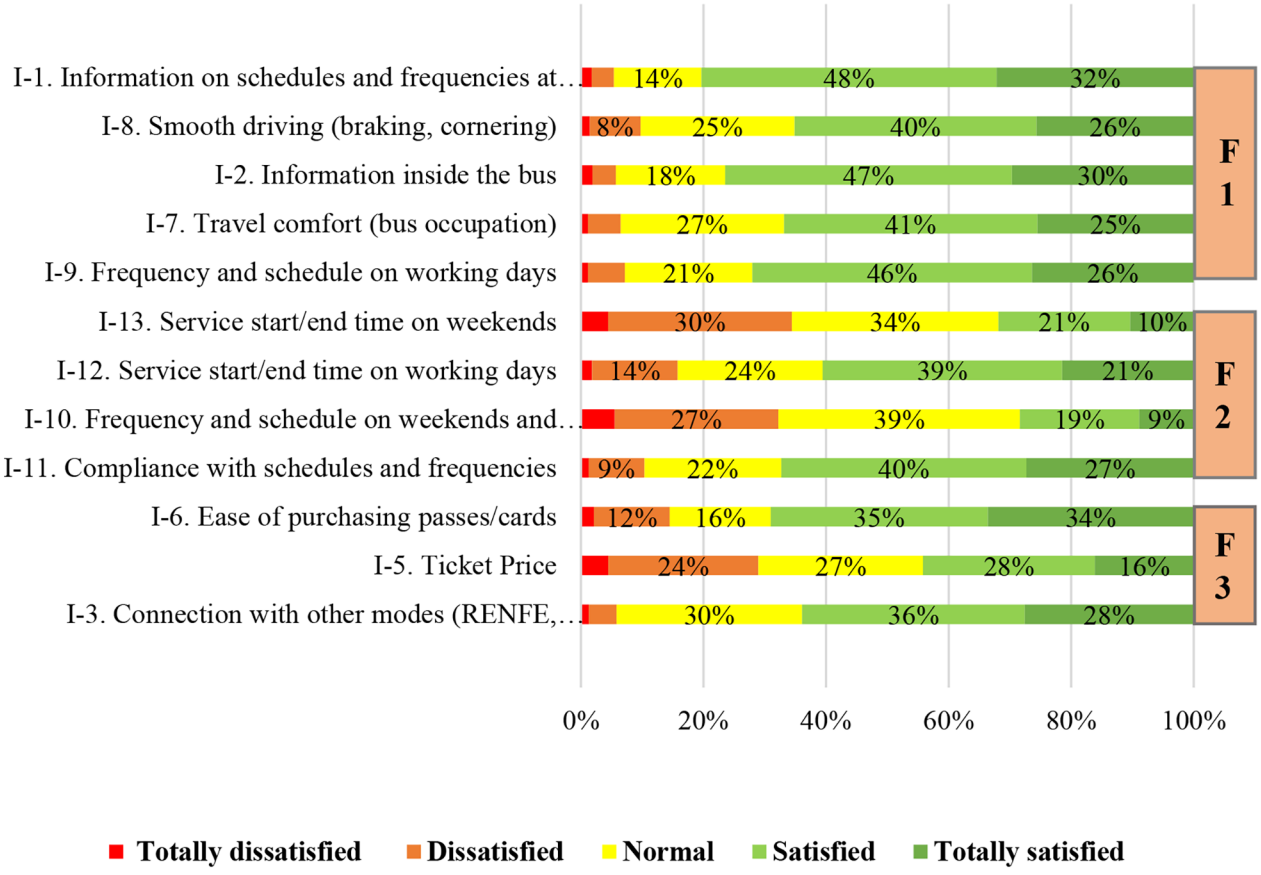

Fig. 5 Satisfaction rates with the different service attributes

usage of buses makes passengers perceive it as a comfort-related attribute rather than a ´service performance` one. The F1 merges the five best-rated attributes. It can be explained by the comfortable occupation of the buses, the smooth driving, and the availability of service information in stations and on the buses, accessible through different sources like the webpage and the mobile application of the operator (TUA).

The second factor (**F2**), called **"Service performance"**, was also previously identified as important by Charbatzadeh et al. [14], who called it "routes service" since it included the same items as our factor plus routes and location. In our case, the factor groups the worst-rated items (with an average grade < 3.5) with exception of ´compliance with schedules and frequencies´. It is linked to time-related services like start/end time, frequency, and compliance with schedules. There is a clear dissatisfaction with service on weekends and holidays, explained by the reduction in the number of services compared to weekdays.

The third factor (**F3**), called **"Integration"**, merges items such as the connection of the bus with different transport means, such as interurban buses and suburban railways, with items related to the integration of the services provided, like the ease of purchasing tickets/cards and their convenience price. All the items included in this factor are rated higher than 3.5.

As mentioned in section 5.3, the item (I-4) ´extent of the bus network` was deleted following Hair et al. [47] recommendations because its load is lower than 0.50 on all common factors.

The model outputs show that F1 "Comfort and information" is the factor that has a major effect on OS, while F3"integration" and F2"Service performance" present lower and similar contributions.

5 Conclusions and policy recommendations

The user-centric approach has gained importance as an urban mobility paradigm. Therefore, understanding users´ perceptions needs and identifying the different target groups is key to ensuring the success of any policy measure that aims to promote behavioural change toward sustainable mobility.

In this frame, the research assessed the key factors of urban bus users´ satisfaction in a medium-sized city (Oviedo-Spain) where public transport mainly relies on bus services, together with the successful performance of the system, make it an interesting case study whose

outputs could serve as insights for developing adequate and replicable policy measures for other cities with similar characteristics.

Survey results showed a generally high overall satisfaction level with the service among users (3.99/5). Eight of the thirteen service attributes evaluated have an average score > 3.5. The remaining five still need some improvements. The EFA applied allowed us to identify three latent factors that were not directly measured from the survey but influenced user satisfaction. Even though these factors were partially identified as important in previous research works, the factors grouped in each of them present new and interesting findings.

The combination of "Comfort and information" in the F1 factor has a major effect on OS, reflecting the growing importance of information availability, as comfort was identified as an important attribute related to users' satisfaction in previous research. Including information in this factor supports the importance of deploying all the efforts needed to provide users with the necessary information to make the service attractive.

Factor 3, "Integration", reflects one of the main challenges of public transport identified by the European Metropolitan Transport Authorities (EMTA), which considers that a threefold integration should be achieved: functional, technical, and physical integration of services. The integration should be applied to payment, travel information, data access and sharing to create "a travel offer that makes for a seamless and comfortable journey" [48]. Moreover, F3 groups all attributes related to the MaaS approach, which, according to Schikofsky et al. [49] and Hoerler et al. [50], is mostly associated with a ´user centricity paradigm`, ´intramodality/multimodality support` and ´integration` and serves as a key lever to reduce negative transportation effects like congestion and pollution.

These findings allowed us to propose interesting policy recommendations that can be summarised as (1) focus on comfort and information, (2) use users´ feedback to understand their needs, and (3) foster integration to ease the sustainable decision.

Focus on the **"F1- Comfort and information"** as it has been identified as the most influential factor in the OS. It has been demonstrated that information and marketing campaigns are cost-effective to boost ridership [51, 52]. The first one focuses on the individual benefits gained from using PT (buses in this case), while the second one is focused on raising awareness among non-PT users in terms of tickets, timetables, transfers, and service characteristics. Special attention must be taken when choosing the channels to provide information. Although the popularity of APPs continues to grow, a considerable percentage of people still do not use them to plan their trips (75.7% in Oviedo).

Use users´ feedback to understand their needs. Regular surveys allow users to identify profiles, understand their mobility patterns, and receive feedback on their satisfaction with the service. In this case, user feedback showed the need to improve the attributes grouped in the **"F2- Service performance"** by exploring the viability of changing service starting and ending times and increasing frequency in some specific routes.

Foster integration to ease the sustainable decision. **"F3- Integration"** shows the importance of functional, technical, and physical integration in OS. Among the different integration solutions being studied, MaaS benefits transport operators and users. The MaaS app provides operators with new sales channels, improved payment processing, and dynamic demand data of potential users. On the other hand, it helps customers to plan single or multimodal journeys by simplifying booking and payment.

The study highlights the key role of comfort and information; however, contextual conditions must be acknowledged as well. Future research might consider evaluating bus users´ satisfaction in other medium-sized European cities where the service is provided by the same operator but with different contexts to assess if it influences users´ perceptions. Based on the possible differences in the results, socioeconomic and demographic characteristics might be included in the model proposed to analyse their influence on overall satisfaction.

Supplementary Information

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Supplementary Material 1

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Authors' contributions

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Data Availability

The data of the study will be made available upon reasonable request.

Declarations

Competing interests

The author declares no competing interests.

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