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Computational Science and Its Applications – ICCSA 2020

20th International Conference
Cagliari, Italy, July 1–4, 2020
Proceedings, Part VII

7 Part VII

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Preface

These seven volumes (LNCS volumes 12249–12255) consist of the peer-reviewed papers from the International Conference on Computational Science and Its Applications (ICCSA 2020) which took place from July 1–4, 2020. Initially the conference was planned to be held in Cagliari, Italy, in collaboration with the University of Cagliari, but due to the COVID-19 pandemic it was organized as an online event.

ICCSA 2020 was a successful event in the conference series, previously held in Saint Petersburg, Russia (2019), Melbourne, Australia (2018), Trieste, Italy (2017), Beijing, China (2016), Banff, Canada (2015), Guimaraes, Portugal (2014), Ho Chi Minh City, Vietnam (2013), Salvador, Brazil (2012), Santander, Spain (2011), Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

Computational science is the main pillar of most of the present research, industrial and commercial applications, and plays a unique role in exploiting ICT innovative technologies. The ICCSA conference series has provided a venue for researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in computational science.

Apart from the general track, ICCSA 2020 also included 52 workshops in various areas of computational science, ranging from computational science technologies to specific areas of computational science, such as software engineering, security, machine learning and artificial intelligence, blockchain technologies, and of applications in many fields. We accepted 498 papers, distributed among 6 conference main tracks, which included 52 in workshops and 32 short papers. We would like to express our appreciation to the workshops chairs and co-chairs for their hard work and dedication.

The success of the ICCSA conference series in general, and of ICCSA 2020 in particular, vitaly depends on the support from many people: authors, presenters, participants, keynote speakers, workshop chairs, session chairs, Organizing Committee members, student volunteers, Program Committee members, Advisory Committee members, international liaison chairs, reviewers, and others in various roles. We take this opportunity to wholeheartedly thank them all.

We also wish to thank our publisher, Springer, for their acceptance to publish the proceedings, for sponsoring part of the Best Papers Awards, and for their kind assistance and cooperation during the editing process.

We cordially invite you to visit the ICCSA website http://www.iccsa.org where you can find all the relevant information about this interesting and exciting event.

July 2020

Osvaldo Gervasi
Beniamino Murgante
Sanjay Misra

Welcome to the Online Conference

The COVID-19 pandemic disrupted our plans for ICCSA 2020, as was the case for the scientific community around the world. Hence, we had to promptly regroup and rush to set in place the organization and the underlying infrastructure of the online event.

We chose to build the technological infrastructure using only open source software. In particular, we used Jitsi (`jitsi.org`) for the videoconferencing, Riot (`riot.im`) together with Matrix (`matrix.org`) for chat and asynchronous communication, and Jibri (`github.com/jitsi/jibri`) for live streaming sessions on YouTube.

Six Jitsi servers were set up, one for each parallel session. The participants of the sessions were helped and assisted by eight volunteer students (from the Universities of Cagliari, Florence, Perugia, and Bari), who assured technical support and smooth running of the conference proceedings.

The implementation of the software infrastructure and the technical coordination of the volunteers was carried out by Damiano Perri and Marco Simonetti.

Our warmest thanks go to all the volunteering students, to the technical coordinators, and to the development communities of Jitsi, Jibri, Riot, and Matrix, who made their terrific platforms available as open source software.

Our heartfelt thanks go to the keynote speakers: Yaneer Bar-Yam, Cecilia Ceccarelli, and Vincenzo Piuri and to the guests of the closing keynote panel: Mike Batty, Denise Pumain, and Alexis Tsoukiàs.

A big thank you goes to all the 454 speakers, many of whom showed an enormous collaborative spirit, sometimes participating and presenting in almost prohibitive times of the day, given that the participants of this year's conference come from 52 countries scattered over many time zones of the globe.

Finally, we would like to thank Google for letting us livestream all the events via YouTube. In addition to lightening the load of our Jitsi servers, that will allow us to keep memory and to be able to review the most exciting moments of the conference.

We all hope to meet in our beautiful Cagliari next year, safe from COVID-19, and finally free to meet in person and enjoy the beauty of the ICCSA community in the enchanting Sardinia.

July 2020

Ivan Blečić
Chiara Garau

Organization

ICCSA 2020 was organized by the University of Cagliari (Italy), University of Perugia (Italy), University of Basilicata (Italy), Monash University (Australia), Kyushu Sangyo University (Japan), and University of Minho (Portugal).

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Vulnerable Users and Public Transport Service: Analysis on Expected and Perceived Quality Data

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Abstract. Today's cities are meeting places, economic and social development centers, where all citizens should have the opportunity to live and move, according to adequate quality of life standards. However, this does not always correspond to reality in particular for the most vulnerable categories of the population. So, UN's 2030 Agenda underlines the need to make cities inclusive and accessible by means, for instance, a suitable transport system for all, and in particular for vulnerable people as older people.

A lot of studies presented interesting contributes on how older people choose to move and initiatives taken to address their public transport requirements, but no attention has been given to evaluate expected and perceived quality of public transport system, particularly referring to older people. So, the aim of this study is to highlight which should be the most important attributes of a public transport service (PTS) for over 65 years old passengers and if the local PTS satisfy their desires. By an intercept on board survey in the metropolitan area of Cagliari, it has been shown that, for all users, PTS appears qualitatively adequate with respect to each attribute analysed and vulnerable customers are more satisfied than all.

Keywords: Accessibility · Public transport service · Older people · Cagliari

1 Introduction

Today's cities are meeting places, economic and social development centers, where all citizens should have the opportunity to live and move, according to adequate quality of life standards in line with the current smart paradigm cities. However, this does not always correspond to reality not only because cities continue to develop in a chaotic and differentiated way, with large development gaps and services offered between the

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city center and the periphery, but also because the most vulnerable categories of the population are often excluded from this development (such as people with disabilities, the elderly people who risk being marginalized with the consequent worsening of their condition of disadvantage and exclusion).

In addition, as evidenced by UN's 2030 Agenda[1], by 2030 it is expected that almost 60% of the world population will live in urban areas and, in particular the goal n.11 underlines the need to "make cities and human settlements inclusive, safe, resilient and sustainable" [1].

Specifically, this means that States and in particular local governments will have to face important challenges and propose appropriate policies to "provide access to safe, affordable, accessible and sustainable transport systems for all, […] by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons" [1].

The proposal of this paper fits into this framework, aimed at reorganizing the city in a smart way, by analyzing the quality expected and perceived of a public transportation system to make urban environments more sustainable, more inclusive and more accessible for all. Indeed, today, public transport plays a key role in urban space accessibility and provides the opportunity to access to several urban services to all categories of users, including the most disadvantaged such as elderly people.

In Europe, life expectancy is increasing as a result of improved quality of life and medical discoveries and it is known that aging is accompanied by changes of physiological performances as reduced flexibility and strength, impairment of visual and auditive perception, increased vulnerability to bone fracture, etc. which can influence mobility of older people [2]. Mollenkopf and Flaschenträger [3] find that "older persons suffer from the tighter and more aggressive traffic".

Other studies conducted in America [4–7], Canada [8–10], Australia [11], the Netherlands [12] and United Kingdom [13], observe that private car is the most preferred elderly transport mode, but in these last two Countries the percentage of car use decreases with increasing age. However, transport facilities represent a very important opportunity for elderly to avoid dependency on private transport and to travel to do shopping, to reach health care center, retirement recreation [14] or to visit retail services as food shops, banks, post office, chemists, etc. Also, older people, who are usually retired, can maintain social bonds thanks to public transport which allows independence, freedom of movement and choice [15] and [16].

But, what does older people think about public transport? What they need?

Metz [17] draws elderly's perfect journey using public transport: it should involve a short and safe walk to the bus stop, a brief and sheltered wait, punctuality, a safe and comfortable journey and a bus stop near to the final destination.

Fatima and Moridpour [18] examine the situation in Melbourne and the reason because elderly don't use public transportation and prefer private car. Often, older

[1] The UN's 2030 Agenda for Sustainable Development has 17 Sustainable Development Goals (SDGs) at its core, is about making people's lives better (https://ec.europa.eu/sustainable-development/about_en).

adults may be not able to walk to the bus stop or to climb the stairs, or to pay for transportation services and, also, they did not feel confident in crowded interchanges.

Borges [19] estimates that 10–20% of European citizens still find barriers and reduced accessibility on public transport, nevertheless Marsden et al. [20] and Koffman et al. [21] observe that road crossing and bus stop facilities represent the main aspects which can dissuading older people from using public transport. Shrestha et al. [22] find that various initiatives have been carried out or are underway to address older people's public transport requirements in many national and international policies.

All previous studies presented interesting contributes on how older people choose to move and initiatives taken to address their public transport requirements. However, to the best of our knowledge, no attention has been given to evaluate expected and perceived quality of public transport system, particularly referring to older people.

This paper covers this gap by analyzing data collected during a survey campaign carried out in July 2019 on board of the buses of CTM, that is the name of the public transport company of Cagliari. The aim of this study is to highlight which are the most important attributes of a public transport service (PTS) for over 65 years old passengers and if the local PTS satisfy their expectations.

The paper is structured in six sections including this introduction. Section 2 describes public transport service of Cagliari metropolitan area. Section 3 presents the questionnaire submitted to do the survey. Section 4 describes the methodology adopted to build a gradual evaluation on quality of public transport service from elderly viewpoint. Results are reported in Sect. 5. Finally, Sect. 6 provides the conclusions and research perspectives.

2 Public Transport Service in Cagliari Metropolitan Area

Fig. 1. Metropolitan city of Cagliari

The Metropolitan City of Cagliari (consisting of 17 municipalities including the city of Cagliari) in 2017 counts 431,038 inhabitants (see Fig. 1). Starting from 2011, the Metropolitan City of Cagliari assumed a new strategic plan to improve local public transport network, which led the CTM to become the 2nd public transport in Italy in 2013 [23]. This plan was developed with the University of Cagliari and provided using of Intelligent Transportation Systems (ITSs)'s technologies, improving routes and fleet buses, forbidding traffic cars in the historical center and promoting places and pedestrian areas, developing a network of cycle paths, supporting the use of car-sharing, carpooling, bike sharing, electric mobility and completing and integrating tramway network. These actions produced different and important improvements in the area. First of all, citizen started to modify their behavior walking, running, cycling, using the public transport service, so living the city in a completely different way. But it is not all. Coni et al. [24] identify and analyze further benefits for private traffic, for public traffic, for safety and for users. They find a reduction in inter-municipal private traffic (of 8,2%) and in intra-municipal private traffic (of 9,1%), in reducing of travel time (an average of 20%) and an increase of commercial speed on the main roads of the city. Passengers on public transport increased of 23% in 5 years and traffic safety also improved: accident rate decreased by 32% in 7 years. Also, the Automatic Vehicle Location system on buses produced an improvement of punctuality and information of the public transport service for users [25]. Thanks to these efforts, all CTM's routes have the service quality certified according to European Norms [26].

Currently, CTM manages 30 Bus lines, 1 electric bus line, a fleet of 276 buses and a network of 432 km long by the support of ITSs.

CTM is adapting the stops to allow and facilitate access on busses to people with disabilities. Several stops are equipped with a manual platform for getting on and off the bus. All buses are equipped with low floor, handrails, priority seating facilities, wheelchairs space and real time audible and visual information.

Another CTM service that meets the difficulties of disadvantaged passengers is the Amico Bus: it is a "door to door" and on-call bus service, funded by the Autonomous Region of Sardinia, and it integrates the ordinary public transport offer [27].

3 The Survey

The data examined in this paper were collected during a survey conducted in July 2019 on CTM fleet. Sampling was carried out by 8 observers, who carried out surveys during weekdays in three consecutive weeks. The survey campaign was conducted on 26 outward and return routes for a total of 198 rides.

The questionnaire administered to users was organized into four sections but for quality analysis the authors examined just two:

1. General data;
2. Data related to the quality of service in turn divided into Expected and Perceived.

The questions were formulated in closed mode. This solution allows, during the processing phase, to analyze the collected data appropriately aggregating the responses obtained by passengers. The type of closed response guarantees clarity in the answers and simplify analysis process. In addition, with this type of survey, the interlocutor is facilitated in filling in the questionnaire since he does not have to think about how to write the answers.

Section General Data reported information on observers (identification code, date and time), line (name, number of vehicle, direction, stop of getting on) interviewed (gender, age, educational qualification, residence, profession and position during the interview).

This paper reports the analysis on data related to the quality of service, referred to quality expected (or desired) and quality perceived.

More precisely, the part dealing with the quality included 2 sets of 23 questions each (see Fig. 2), evaluated on a 1 to 10 scale (1 = the worst; 10 = the best). The first set was designed to show the importance given to the attributes investigated. The questions, referred to the urban public transport in general, were formulated as follows: “On a scale from 1 to 10, how important would you consider to be the (name the attribute) within the urban public transport system as a whole?” The second set of questions was aimed at discovering the degree of perceived satisfaction toward the attributes analyzed at bus line level. The questions were formulated as follows: “On a scale from 1 to 10, how satisfied are you of the (name the attribute) with reference to the (name the urban bus route where the interview was held)?” The difference between importance and perceived satisfaction provided the gap score, that is, the degree of criticality as perceived by the average rider using the system within the Cagliari’s metropolitan area. As already mentioned, our scale ranged from 1 to 10 (10 points scale), despite the majority of applications adopting a 5 or 7 Likert scale. The motivating reason to adopt a 1 to 10 scale is its adoption in the Italian scholastic evaluation method. Thus, the authors assume that, for the interviewed passengers, it is easier to provide ratings from 1 to 10, rather than the 1 to 5 or 1 to 7. Nevertheless, Dawes [28] pointed out the similar reliability of different scales from a statistical viewpoint, even if more options tend to lead to somewhat lower scores. However, the choice of a 1–10 scale does not influence the generality of the method, which is effective using any scale range.

During the investigation campaign, 754 questionnaires were administered and acquired.

	On a scale from 1 to 10, how important would you consider to be the following attributes within the urban public transport system as a whole?			On a scale from 1 to 10, how satisfied are you of the following attributes with reference to this urban bus route?	
Quality EXPECTED	NI	Low noise levels produced by vehicles	Quality PERCEIVED	NI	Low noise levels produced by vehicles
	Cv	Cleaning of vehicles		Cv	Cleaning of vehicles
	Pb	Ease to find a seat on board		Pb	Ease to find a seat on board
	Ss	Stop status (cleaning, seats, bus shelter)		Ss	Stop status (cleaning, seats, bus shelter)
	P	Punctuality and regularity of service		P	Punctuality and regularity of service
	Gi	General information presence		Gi	General information presence
	Ut	Update on timetable and frequency during stops		Ut	Update on timetable and frequency during stops
	UtA	Update on timetable and frequency by App		UtA	Update on timetable and frequency by App
	Ur	Update on ride during stops		Ur	Update on ride during stops
	UrA	Update on ride by App		UrA	Update on ride by App
	Fi	Information on fares		Fi	Information on fares
	S	Presence of safety information		S	Presence of safety information
	F	Frequency		F	Frequency
	Tt	Travel time		Tt	Travel time
	Eb	Ease of buying tickets / passes		Eb	Ease of buying tickets / passes
	Ev	Ease of validating ticket		Ev	Ease of validating ticket
	Dsa	Driver's driving style (acceleration and braking)		Dsa	Driver's driving style (acceleration and braking)
	Dsc	Driver's driving style (Left and right curves)		Dsc	Driver's driving style (Left and right curves)
	Dsj	Driving style of the drivers (jerks along the route)		Dsj	Driving style of the drivers (jerks along the route)
	C	Courtesy of employees (drivers, call centers, administrative staff)		C	Courtesy of employees (drivers, call centers, administrative staff)
	A	Appearance of staff (uniform, identification card)		A	Appearance of staff (uniform, identification card)
	Cs	Conditions of supports to stand		Cs	Conditions of supports to stand
	H	Hazard prevention (fire extinguisher, hammer, interior lighting)		H	Hazard prevention (fire extinguisher, hammer, interior lighting)

Fig. 2. Full list of quality characteristics

4 Methodology

In this section, a simple framework for analyzing quality of transport service is presented. Figure 3 shows the four levels on which the quality of transport service analysis was organized: 1. Data collection; 2. Selection of significant attribute for over 65 years old users; 3. Analysis on expected and perceived data for all users and for over 65 years old users; 4. Comparison of results.

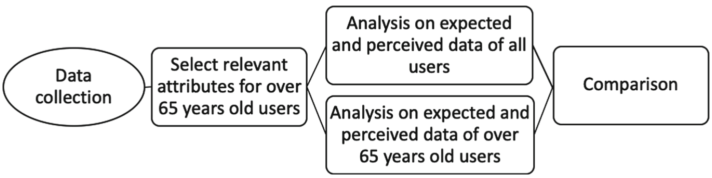

Fig. 3. The proposed framework for analyzing quality of transport service

Data were collected by the questionnaire described in Sect. 3. It was administered to passengers on board. Users had to express a judgment on 23 transport service characteristics assessing them on the basis of the importance they gave to each of them and referring on the specific line they were using. Their evaluations have been collected and reordered in a spreadsheet, separating Expected/Desired data from Perceived data.

In literature, there is a lack of methodologies to objectively determining a set of key significant quality indicators for monitoring the public transport quality. Just Barabino et al. [29] propose a robust methodology for identifying and selecting key quality indicators using both data collected through international surveys and Monte Carlo simulation methods. The attributes reported in the questionnaire correspond to these indicators.

For this study, the authors selected only 18 of the 23 transport service characteristics: 1. Low noise levels produced by vehicles (Nl), 2. Cleaning of vehicles (Cv), 3. Ease to find a seat on board (Pb), 4. Stop status (cleaning, seats, bus shelter) (Ss), 5. Punctuality and regularity of service (P), 6. General information presence (Gi), 7. Update on timetable and frequency during stops (Ut), 8. Update on ride during stops (Ur), 9. Information on fares (Fi), 10. Presence of safety information (S), 11. Frequency (F), 12. Travel time (Tt), 13. Ease of buying tickets/passes (Eb), 14. Ease of validating ticket (Ev), 15. Courtesy of employees (drivers, call centers, administrative staff) (C), 16. Appearance of staff (uniform, identification card) (A), 17. Conditions of supports to stand (Cs) and 18. Hazard prevention (fire extinguisher, hammer, interior lighting) (H).

Elderly's answers on the *Update on timetable and frequency by App* and *Update on ride by App* attributes were less than 30%, so these items were excluded from the study because they were irrelevant.

While *Driver's driving style (acceleration and braking)*, *Driver's driving style (Left and right curves)* and *Driving style of the drivers (jerks along the route)* attributes were not considered because they were analyzed in another work.

First of all, expected data of all users were examined to highlight if the chosen attributes were fundamental requirements for passengers. The number of answers for each score and each attribute were counted; the higher the number of responses on the highest ratings, for a given characteristic, the greater the importance the user gives to that characteristic.

Then to establish an order of priority among characteristics, weights of every characteristics have been determined, on the basis of users' responses and the degree of preference.

Let

Nc_{ji} be the number of times that the characteristic j has received i-th judgment; the score of preference of the j-th travel characteristic Sc_j is given by the following expression:

$$Sc_j = \sum\nolimits_i \left[Nc_{j,i} * (i) \right] \quad (1)$$

So, the weight of the j-th characteristic is given by the incidence that the score of preference of the j-th travel characteristic has on the total:

$$W_j = \frac{Sc_j}{\sum_j Sc_j} \quad (2)$$

The same analysis was conducted on perceived data of all users and results were compared with expected data, in order to understand whether the offer of the transport service corresponds to user expectations or not. The authors applied SERVQUAL methodology to investigate the difference between qualitative perceptions and expectations. The SERVQUAL methodology was introduced by Parasuraman et al. [30–32] and represents the most widely applied methodology to measure customers' perceived quality across the service industry. Moreover, it was recently applied in public transport [33]. The gap between perceived (P) and expected (E) quality was calculated for each attribute. This allows assessing the qualitative difference between what is actually observed and what would represent an "ideal" of service. The vast majority of studies adopting this methodology have produced negative gaps (P < E), because of the general inadequacy in meeting customers' expectations or the less than satisfactory degree of perceived quality. Such outcome is not surprising, given the high expectations normally held by the final users of a service and the not always linear relation between satisfaction and service performance [34].

The same procedure was repeated on expected and perceived data selecting only judgments of over 65 years old people.

Lastly, SERVQUAL gaps obtained considering all users' responses and selecting only over 65 years old users' ones were compared to draw conclusions.

5 Analysis on Expected and Perceived Quality Data

In this section, the authors specifically examine the answers of sample related to expected and perceived quality expressed by the eighteen selected attributes.

These judgments represent the degree of preference and were elaborated in order to determine weights that users assigned to each features of the travel in order to establish a priority scale between them.

5.1 General Users

First, the responses of all users were investigated. The analysis has produced results showed in Fig. 4 where how many users gave that judgment to a specific attribute are reported.

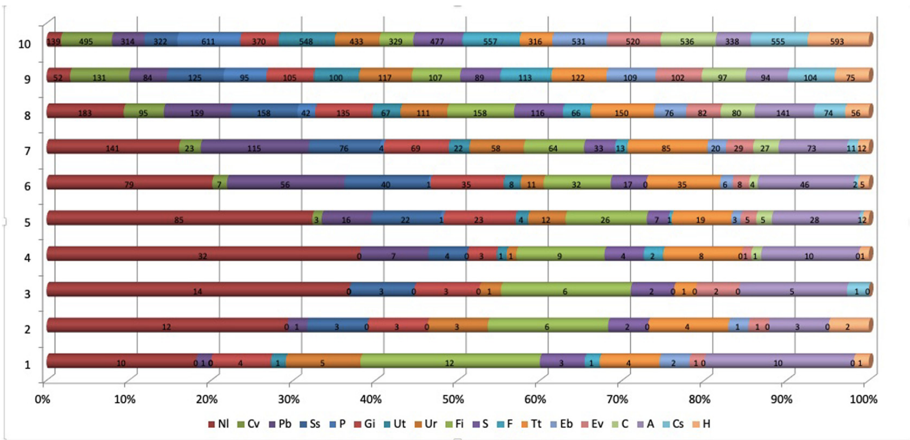

Fig. 4. Users responses on travel characteristics (expected)

Figure 4 shows that users assigned higher scores (between 8 to 10) to all chosen attributes. This result expresses the importance that sample entrusts to those characteristics of the public transport. In other words, this means that all users have a great expectation on public travel service.

On the basis of these responses and the degree of preference, weights of every characteristics have been determined.

Results are shown in Fig. 5. Looking at the obtained results, users assigned a higher weight to Punctuality and regularity of service (P), followed by Frequency (F) and Hazard prevention (H). So, these are more important travel service characteristics for surveyed people. At the last three position, there are Information on fares (Fi), Appearance of staff (A) and Low noise levels (Nl).

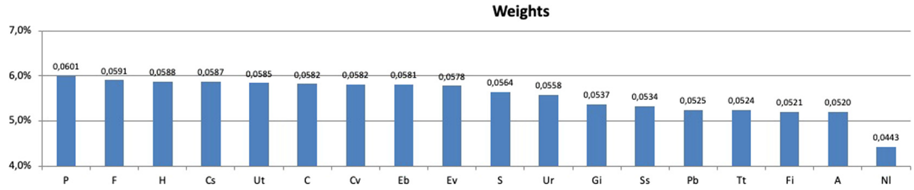

Fig. 5. Weights of characteristics of travel service (expected)

The same analysis was conducted on perceived data, that is on users' judgments related to the ride where they were. Findings are shown in Fig. 6.

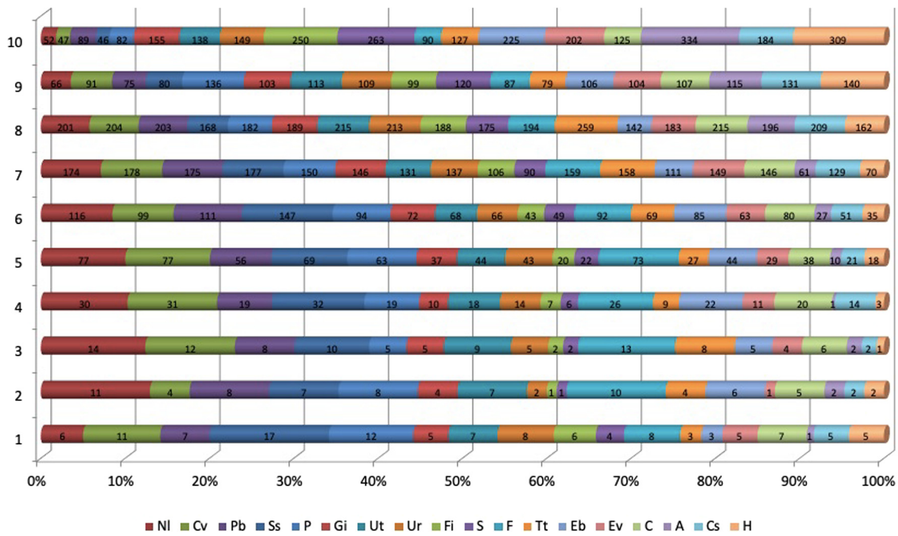

Fig. 6. Users responses on travel characteristics (perceived)

In this case, most of responses are concentrated in high ratings (between 6 and 10) for all attributes, but it is also true that all attributes received low degree of preference (between 1 and 5).

Starting from these responses and calculating weights of every characteristics, results are shown in Fig. 7:

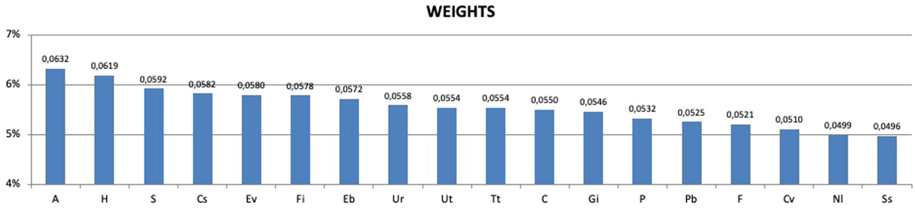

Fig. 7. Weights of characteristics of travel service (perceived)

Looking at the obtained results, users assigned a higher weight to Appearance of staff (A), Hazard prevention (H) and Presence of safety information (S). At the last three position, there are: Cleaning of vehicles (Cv), Low noise levels (Nl), Stop status (Ss).

5.2 Vulnerable Users

The authors applied the same analysis to expected and perceived data related to vulnerable users, considering passengers over 65 years old.

The analysis on expected data has produced results showed in following Fig. 8: the majority of users over 65 years old assigned highest score to all chosen attributes, so they express a great expectation on public travel service.

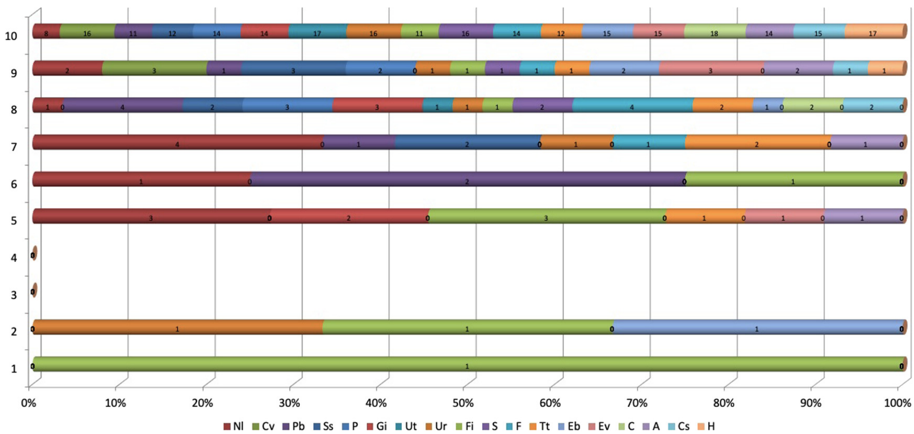

Fig. 8. Vulnerable users' responses on travel characteristics (expected)

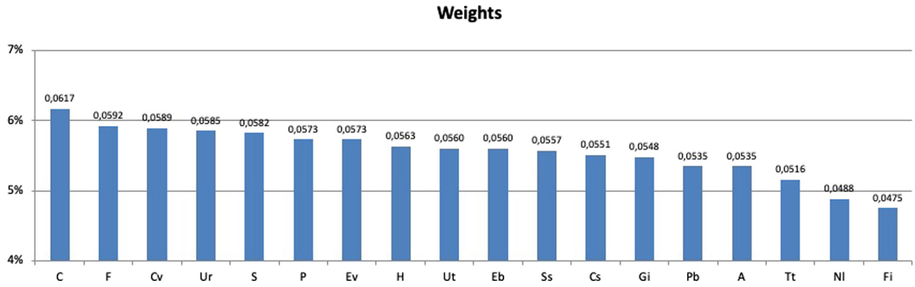

Fig. 9. Weights of characteristics of travel service for vulnerable users (expected)

Looking at weights (Fig. 9) vulnerable users gave a great importance to Courtesy (C) and to Frequency (F), followed by Cleaning of vehicles (Cv). The least important attribute is Information on fares (Fi) preceded by Low noise levels (Nl) and Travel time (Tt).

While, the analysis on perceived data has produced results showed in Fig. 10.

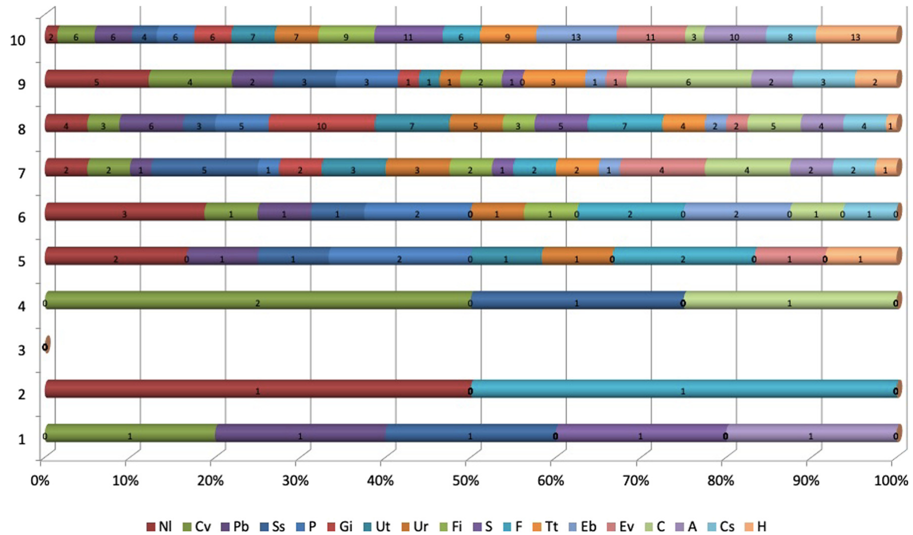

Fig. 10. Vulnerable users' responses on travel characteristics (perceived)

Vulnerable users assign higher scores (between 7 to 10) to all chosen attributes. So, it means that they are satisfied by transport service. Looking at weights (Fig. 11) it can be notice that Ease of buying and validation tickets/passes (Eb, Ev) and Hazard prevention (H) are the characteristics which obtain higher scores. Conversely, Ease to find a seat on board (Pb), Stop status (Ss) and Low noise levels produced by vehicles (Nl) are at the end of the ranking.

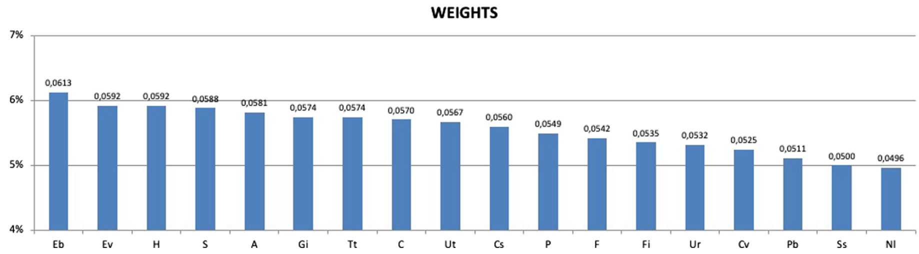

Fig. 11. Weights of characteristics of travel service for vulnerable users (perceived)

5.3 Comparison

Results on data analysis are summarized in Table 1. First four columns of data report average scores for each attribute. It can be notice that the overall average result indicates a substantial lack of inefficiencies, with an average perceived quality along rides investigated of 7,76 for general users and of 8,42 for over 65 years old users (up against expectations as high as 9,04 for general users and 9,31 for vulnerable users). Elderly customer's evaluations, both on perceived and expected quality, are always higher than those of the rest of all users. These outcomes show the particularly high qualitative standards demanded by public transport users in Cagliari, a feature which might imply increased difficulties in the provision of a service able to duly accommodate needs and requirements. Surprisingly enough, no single attribute registers particular criticism, as testified by average scores consistently higher than 6.5.

Next the gaps were computed to investigate the difference between qualitative perceptions and expectations. Results for each attribute are illustrated in the sixth and seventh column of Table 1.

Table 1. Average and SERVQUAL gap scores of attributes

	Quality perceived (P)		Quality expected (E)		General users	Vulnerable users	Zcal P-E
Attributes	General users	Vulnerable users	General users	Vulnerable users	P-E	P-E	
Nl	6,96	7,05	7,22	7,45	−0,25	−0,44	0,19
Cv	7,04	7,84	9,41	9,84	−2,37	−1,90	−0,82
Pb	7,28	8,06	8,51	8,95	−1,24	−1,25	0,01
Ss	6,86	7,47	8,64	9,32	−1,78	−1,75	−0,06
P	7,37	8,21	9,74	9,58	−2,40	−1,30	−2,82
Gi	7,83	8,58	8,74	9,16	−1,17	−0,55	−1,64
Ut	7,69	8,47	9,50	9,89	−1,83	−0,85	−1,52
Ur	7,80	8,39	9,06	9,30	−1,30	−1,75	1,09
Fi	8,35	8,94	8,51	7,95	−0,45	0,05	−1,03

(*continued*)

Table 1. (*continued*)

	Quality perceived (P)		Quality expected (E)		General users	Vulnerable users	Zcal P-E
Attributes	General users	Vulnerable users	General users	Vulnerable users	P-E	P-E	
S	8,43	8,79	9,18	9,74	−0,95	−0,90	−0,10
F	7,22	7,70	9,59	9,40	−2,38	−1,70	−1,52
Tt	7,75	9,06	8,60	9,11	−0,85	−0,05	−2,12
Eb	7,93	9,16	9,49	9,37	−1,53	−0,20	−2,53
Ev	8,03	8,84	9,40	9,58	−1,36	−0,70	−2,52
C	7,65	8,10	9,48	9,80	−1,82	−1,70	−0,35
A	8,81	8,68	8,47	9,44	0,34	−0,25	1,58
Cs	8,11	8,83	9,59	9,72	−1,47	−0,80	−2,81
H	8,65	9,33	9,61	9,94	−0,97	−0,55	−1,37

As happens in the most SERVQUAL applications, Table 1 emphasizes the negative gaps between perceptions and expectations/importance. However, the presence of negative gaps is heavily influenced by the users' expectations, with different attributes scoring more than 8 in the 1 to 10 scale. Furthermore, the gap P-E, even if negative, derives from the difference of high average scores. The gap is positive for Appearance of staff (A), for general users, and Information on fares (Fi), for elderly users. For these two attributes, perceived quality exceeds desired one. Comparing P-E gaps obtained considering all users' responses and selecting only over 65 years old users' one, it can be noticed that vulnerable customers are more satisfied of public transport service than all. In general, these results let the authors believe that urban public transport within the Cagliari's metropolitan area can be described as qualitatively adequate with respect to each attribute analysed.

Finally, to investigate if the gaps statistically differ between these segments, a statistical significance analysis of a two-sample z-test between their means was also conducted at the 95% significance level, which corresponds a critical value (Zc) of 1,645. The calculated values (Zcal) are shown in the last column of Table 1. It can be noticed that only for six attributes (P, Gi, Tt; Eb, Ev and Cs) the observed value is greater than the critical one. Therefore, only for these six attributes, there is a significant difference between the evaluations of the sample made up only by the elderly and the total sample. Conversely, for the remaining attributes, the evaluations may be indifferently taken from the two segments.

6 Conclusions

The main purpose of this article is to analyze the quality expected and perceived of a public transportation system in particular referring to over 65 years old customers' viewpoint. Indeed, they belong to the category of vulnerable users who more often than others may have difficulty in moving and accessing to urban spaces. The study can be useful to public transport companies to identify what are the expectations and needs of vulnerable users in order to make the service more functioning, efficient and accessible to this category of customers. The purpose fits in the literature and in general objective of UN's 2030 Agenda which both underlines the need to make cities smart [35], sustainable [36], inclusive and accessible by means, for instance, a suitable public transport system for all.

The data examined in this paper were collected during a survey conducted in July 2019 on board of the buses of CTM, the public transport company of Cagliari. The study highlighted which are the most important attributes of a public transport service (PTS) for all users and over 65 years old passengers, and if the local PTS satisfy their expectations. The data analysis showed that, for all users, the most important features that the public transport service should offer are Punctuality and regularity of service (P), followed by Frequency (F) and Hazard prevention (H); while for elderly customers they are Courtesy (C) and Frequency (F), followed by Cleaning of vehicles (Cv).

The investigation on the degree of perceived satisfaction toward the attributes was conducted at bus route level. Appearance of staff (A), Hazard prevention (H) and Presence of safety information (S) attributes obtained higher scores for all users. While over 65 years old customers appreciated a lot Ease of buying and validation tickets/passes (Eb, Ev) and Hazard prevention (H).

The authors applied SERVQUAL methodology to investigate the difference between qualitative perceptions (P) and expectations (E). Gaps P-E are all negative (except for two attributes): as a rule, this means that public transport service doesn't meet users' expectations. But these results are heavily influenced by the users' expectations, with different attributes scoring more than 8. Furthermore, gap is calculated on high average ratings that pass the score of 6.5. Indeed, the overall average result indicates a substantial lack of inefficiencies, with an average perceived quality along rides investigated of 7,76 for general users and of 8,42 for over 65 years old users.

All that said the analysis let the authors believe that urban public transport within the Cagliari's metropolitan area can be described as qualitatively adequate with respect to each attribute analyzed.

Comparing P-E gaps obtained considering all users' responses and selecting only over 65 years old users' one, it can be noticed that vulnerable customers are more satisfied of public transport service than all.

However, if the CTM wanted to further improve, this analysis suggests that its management policy should focus on Punctuality (P), Frequency (F) and Vehicles Cleaning (Cv).

In a future research, safety and security concern could be explored. Older people are more vulnerable to injuries and they take longer to recover than younger people. So, safety on board represent a crucial issue for over 65 years old passengers. Safety on board is strictly correlated to driver behavior, hence expected and perceived safety requirements could be investigated by data on driver's driving style related to accelerations and brakings, right and left curves and vertical jolts. This data could be matched and compared with objective safety requisites measuring longitudinal and transversal accelerations, decelerations and speed, by means of a GPS on bus, to set safety and comfort threshold as in [37].

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