

Accessibility to Local Public Transport in Cagliari with Focus on the Elderly

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Abstract. The principle that inspired the authors in the preparation of this study is the concept of "*expanded accessibility*" in terms of usability of spaces, places and services, for their users. From here, in the face of the periodic survey work carried out on local public transport vehicles managed by the transport company of the Municipality of Cagliari, the characteristics of the overall sample have been designated. The data sample is analyzed with focus on elderly people. Some statements are reported to show how much and how these passenger use public transport and related technological services. Finally this segment of demand is compared with the complementary one (under 65 years). The outcomes show that the key elements that distinguish the two segments concern multimodality and technological services.

Keywords: Elderly · Public transport · Travel behavior · Accessibility

1 Introduction

Accessible transport and the guarantee of movement are the passport for a daily life characterized by independence for all age groups. Mobility means having transport services, or the set of network infrastructures, means and operating procedures (e.g. ticket offices, information etc.), both in spatial and temporal scale as well as information; knowing how to use them, being able to do it and having the means to pay for them are the attributes that distinguish its accessibility [1].

Accessible transport practices are promoted through the series of International Conferences on Mobility and Transport for the Elderly and Disabled (COMOTRED), supported by the US Research Board since 1978. This initiative is recognized as the world's leading forum for the exchange of results of policy research and approaches [2].

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The growing progress in medicine and the improvement of the standard of living have had a positive impact on people's life expectancy, which has increased worldwide. The natural aging process is accompanied by physiological and customary changes that are reflected in the mobility choices [3]. With age, older people tend to make shorter and fewer trips than other age groups [4].

They begin to walk more and use public transport. In 2008 a survey claimed that after 55 years of age, the use of the car constantly decreases, while for those 75 years old and more, walking and public transport become a valid alternatives [5]. In support of this, the authors believe that in addition to the physiological changes typical of age, there is also a social reason: the end of full-time work, i.e. one of the main reasons for systematic moves.

However, due to the same dynamics, the improvement in health and income levels also had as a downside a more active, more independent and more "*mobile*" population [6] also in terms of car ownership and use [7, 8]. While studies highlight the importance of mobility of older people for their social inclusion [9] and for a good quality of life [10, 11], there is no lack of concerns about the implications that such mobility can have on society both in terms of congestion [12, 13], safety and environment.

In fact, in order to maintain their active lifestyle it is necessary to guarantee them access to public transport. This would allow elderly to continue using goods and services when they are no longer able to drive or simply as an alternative to using a private vehicle [3]. In this regard, it is therefore essential that public transport structures are functional to provide acceptable levels of mobility specific to their needs [14].

A concrete answer in this sense is given by the new Intelligent Transportation Systems applied to the public transport system. ITS play a leading role in that they characterize transport in an innovative and sustainable way, for a better use of urban space and time, optimizing transport network, both in terms of capacity and travel time reliability [15, 16], with inevitable positive externalities on the quality of life of people [17].

These are the premises of the study conducted by the authors who sees the city of Cagliari as a reference scenario and its public transport system as a setting in which the users of the service move. Thanks to the new strategic plan of 2011, developed in partnership between the Municipality of Cagliari, the University of Cagliari and the CTM (i.e. the Public Transport Company), the public transport system has undergone important interventions aimed at improving its efficiency in terms of travel times, punctuality and its service quality [17–19].

The investments on the local public transport network and digital infrastructures in 5 years (2010 ÷ 2015) generated an increase in the flow of passengers by 23%. Among these interventions the creation of friendly applications and devices, attracted new users, especially among the younger ones. Coni et al. [17], concluded that all the interventions implemented by the public administration through ITS and urban policies towards sustainable mobility, have improved the quality of the environment and, consequently, in the quality of life of their citizens. The citizens, in fact, manages part of the movements, some systematic, using more sustainable modes like public transport, walking and cycling. It is in this context that the study conducted by the authors fits.

This paper investigates some characteristics on travel behavior of the 65 years old segment using data collected by an intercept on-board survey of passengers of CTM.

First, the authors examined some characteristics of users in general. Subsequently, the analysis focused on weak users, meaning the over 65 years segment, with the aim of discover their characteristics. Their travel behavior and the rate of use of technological services are examined in order to highlight, impediments to accessing the service in its complexity, if any The latter could be brought to the attention of the service operator that could convey them in order to make the service more efficient. Once the data were acquired, they are analyzed using by descriptive statistics.

The remainder of this paper is organized as follows. Section 2 presents the context analysis with the nature of the investigation carried out, with particular reference to the section of the questionnaire. The section dedicated to the methodology concludes this section. Section 3 shows the results of the analysis of the general characteristics and travel behavior for both the whole sample and the segment of the elderly. Finally, Sect. 4 provides conclusions and draw future perspectives.

2 Data and Method

The study was conducted on CTM, the public transport company of Cagliari. Cagliari is the most important and densely populated town in Sardinia (Italy). It has 154.108 inhabitants, and it is the 26th town more populous of Italy. Its metropolitan area counts 431.038 inhabitants. Starting from 2011, Cagliari and its 17 municipalities adopted a new strategic plan to improve local public transport network. This plan was developed with the University of Cagliari and provided using of ITS, improving lines 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, car-pooling bike sharing, electric mobility and completing and integrating tramway network [17]. Currently, CTM operates public transportation by 271 vehicles (i.e., buses and trolleys) and serves approximately 40.8 million trips a year. Moreover, these vehicles travel over 12.4 million km per year along 34 routes [20]. Its routes operate in a heterogeneous context including residential areas, large industrial sites, shopping centers, entertainment activities and service companies. Moreover, since 2011, CTM makes a bi-annual intercept survey, designed to elicit socio-demographic, travel behavior and customer satisfaction information [21].

CTM has a control room which coordinates and monitors all buses on the road in real time and the information points. Users can download an App where they can buy tickets, check the real time of bus arrivals, find the path to reach a destination or the routes list as well as other information about specific services or about changes in the services. On CTM Website, it is possible to find information about the company, routes, tickets and transport pass, the path to reach a destination, statistics, traffic and other information about specific services. Every bus stop is equipped with intelligent bus-stop sign which provides the time of bus arrivals in real time [17, 18].

2.1 The Survey

The survey was conducted in July 2019. The sampling was carried out by 8 total observers, four out of these observers were surveyors of CTM and 4 were technicians

from the DICAAr (Department of Civil Engineering, Environment and Architecture). They who carried out the surveys during the weekdays in three consecutive weeks, for a total of 10 days.

CTM collected data for this experimentation on a pool of 26 routes, which are representative of the general bus network regarding passengers, lengths (6 ÷ 18 km), vehicle types (7 ÷ 18 m) and capacities (24 ÷ 170 passengers). A total of 198 trips was investigated.

The questionnaire administered to passengers is organized into four sections, only the first two contain the data useful for the purposes of the current study:

- The first section is general and reports on contextual information, including the date, time, route investigated and a question regarding the passengers' agreement to participate in the survey;
- The second section deals with socio-demographic attributes, including gender, age, educational qualifications, employment, car availability and reason for using the bus and trip-related attributes, including trip purpose, in-vehicle time, other transit systems used, and bus use frequency;
- The third and fourth sections deal respectively with the quality of the service and the fare evasion.

All questions were formulated in closed form (i.e. see Fig. 2). This solution allows, during the processing phase, to be able to analyze the collected data, appropriately aggregating the responses of passengers. Therefore, the type of closed response enforces the dual need to clarity responses and simplify the process. Furthermore, this type of question structure does not worry the interlocutor since he/she does not have to think about how to formulate the answer, since the latter is contained among the proposed options [22].

2.2 Methodology

The method of analysis is represented in Fig. 1.

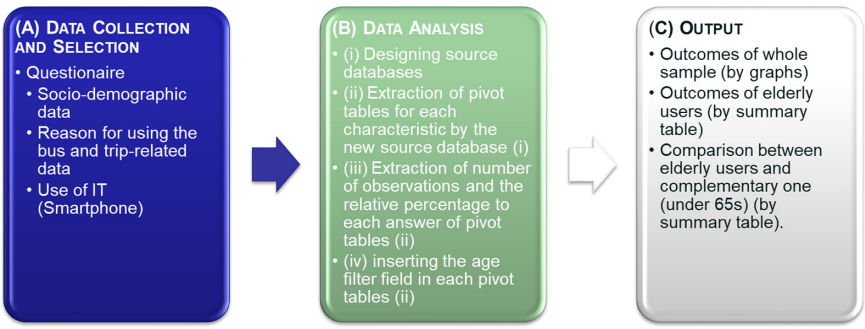

Fig. 1. Method of analysis

(A) Data Collection and Selection

During the survey campaign, 754 questionnaires were administered and acquired. Collected data were loaded into a database. According to the purpose of the work, the data analyzed concern:

- Socio-demographic characteristics: gender, age, residence, education and profession;
- Travel behavior: travel purpose, frequency of use, how he/she traveled (sitting or standing) and in what position of the bus, travel ticket, use and type of other transport operators, ownership of private vehicle and why to choose of bus for the trip (Fig. 2);
- Info mobility use: smartphone ownership, the utilization rate of the App, the travel ticket purchase via App and the info-channel (Fig. 2).

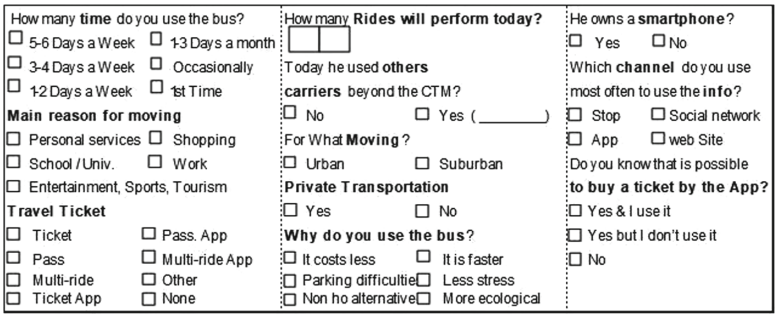

Fig. 2. Travel behavior data and info mobility use

(B) Data Analysis

The method used to process the data is as follows. The questionnaire responses were uploaded into a database with dimensions $i \times j$ (755×94). Columns j contain the characteristics, rows i contain the answers of the sample.

It should be noted that the questionnaire had sections that were not taken into consideration in the present study, as they are not necessary for our current analysis. The sections rejected regard the quality and fare evasion. Therefore, (*i*) the source database for our processing has $i \times y$ dimensions (with $y < j$), where y indicates the number of characteristics analyzed. The latter are those described in section (A).

The data analysis (*ii*) was done by extracting a pivot table for each characteristic y from the new source database. For each pivot table (iii) and for each answer the number of observations b and the relative percentage p were extracted. Each pivot report was sorted in descending order of the number of observations b. The comparison between the elderly and the remaining segment was made (*iv*) using the pivots created, by inserting the age filter field in each of them. Proceeding in this way the value fields of number of observations b and percentage p were automatically updated.

The data were analyzed through descriptive statistics.

(C) Output
The results of the analysis are shown first for the whole sample. For these, it was preferred to analyze each attribute by a graph that contained the answers given. The results on the elderly were reported in a summary sheet, where for each characteristic the results of this segment and of its complementary (under 65 years) were reported. For the main characteristics that had comparable answers, the two samples (over and under 65 years) were examined through a statistical significance analysis of the proportions at a significance level of 95%, which corresponds to a value critical (Z_c) of 1,96.

3 Results and Discussion

This section reports the results of the analysis. It is divided into two parts: the first discusses the results related to the overall sample; the second one comments the results related to the elderly, both individually but also comparing them with the complementary segment.

3.1 Overall Users

General Data
The first 7 queries of the questionnaire asked for general user information. The analysis of the answers has given following results.

The gender distribution of the interviewees shows that female sex is the most frequent class (63% of the sample). Looking at the age, most of the users are young people aged between 18 and 25 (39%) and younger (21%). The 17% is between 26 and 35 years old and the 12% among 36 and 50 years old. The remaining 12% is over 51 years old (Fig. 3 – left side).

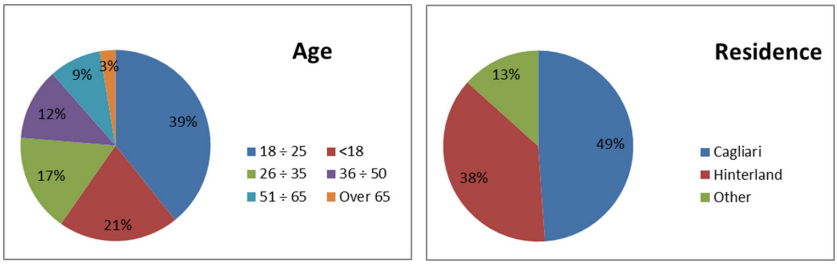

Fig. 3. Age and residence

About 49% of the sample resides in the city center, 38% in the hinterland and 13% in the neighboring municipalities (Fig. 3 – right side).

The whole sample (∼99%) has a middle school certificate (Fig. 4 – left side). Out of these, 45% have a diploma and 16% have a degree. Half of sample that has a middle school license (53%) is still in a school age (<18) or are students undergraduate (Fig. 4 – right side).

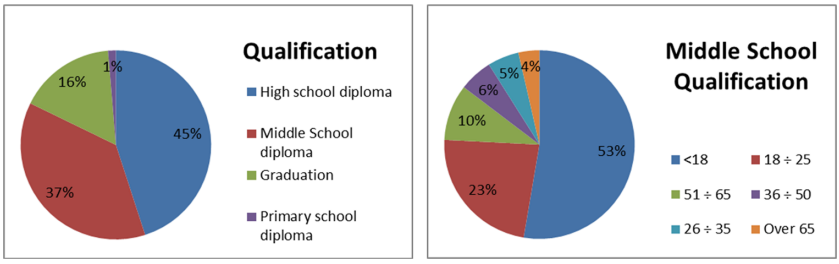

Fig. 4. Qualification and middle school qualification by age

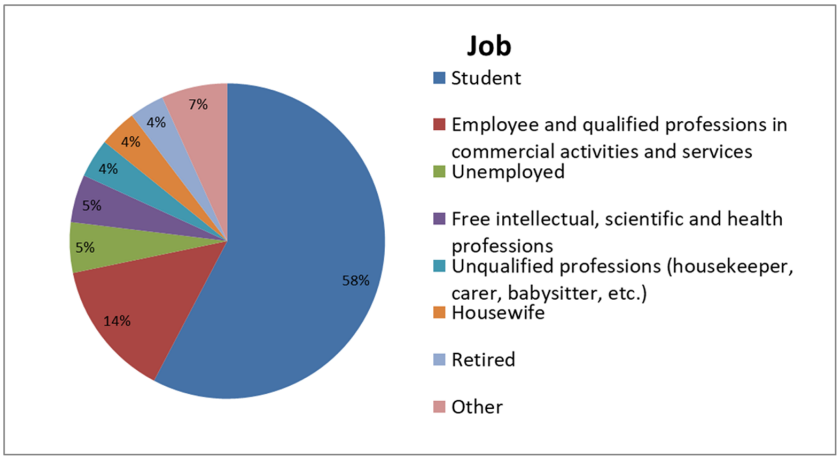

Fig. 5. Job

Confirming the above, Fig. 5 shows that students are the category most represented (58%), percentage that rises to 88% if the analysis is restricted to the age group under 25 years of age. Then there are employees (14%) followed by the unemployed and freelancers, with the same percentage (5%) and unqualified professions, housewives and retirees (4%). The remaining categories were merged into a single class called Other (7%).

The 91% of the sample interviewed was seated and the remaining 8% was standing. The major part of the sample (56%) stayed in the rear area of the bus while 29% was in the front. Only 14% was in the center of the bus.

Travel Behavior

The 80% of the sample uses public transport respectively for leisure and sport (35%), for work (23%) and to reach high schools and universities (22%). The remaining 20% uses public transport for personal services (18%) and for shopping (2%) (Fig. 6).

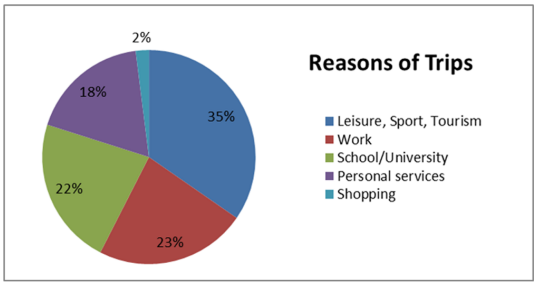

Fig. 6. Reasons of trips

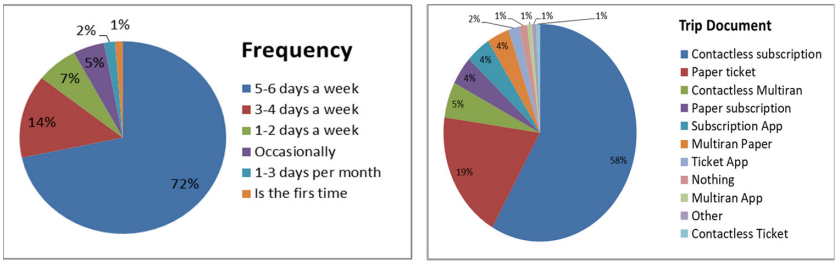

Fig. 7. Frequency and trip document

The analysis showed that the sample is highly represented by regular passenger who use the service regularly during the week and the day (Fig. 7). Specifically, left side of Fig. 7 shows that 86% of sampled passengers travel from 3 to 6 days during the week, respectively 72% between 5–6 days and 14% between 3–4 days and from 1 to 4 daily journeys. Analyzing trip document (Fig. 7 right side), it can be noticed an attitude to the use of a travel pass in various forms: 58% of passengers uses the contactless subscription and 8% uses the other solutions, both on paper and via the app, both in the same percentages (4% each one). The 19% use paper ticket (single) and 5% use the contactless multi-ride. The remaining solutions are shown in Fig. 7.

Another interesting aspect is the result on intermodality with other public transport operators (Fig. 8). Only the 16% of sample uses other operators. Out of these: 72% of passengers use the regional transport operator (ARST) both in Bus mode (46%) and in Metro - Tramway mode (27%) and 24% use FdS. 76% of passengers use other operators to suburban journeys and the 24% for urban journeys.

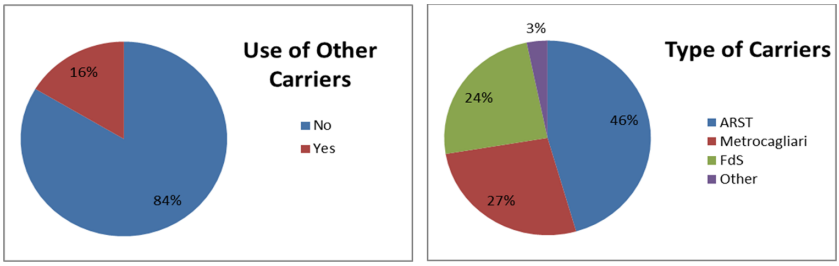

Fig. 8. Use and type of other carriers

The motivation for the modal choice of collective transport was examined in relation to the possession of the private car, in order to detect the motivation of the choice. This is shown in Fig. 9.

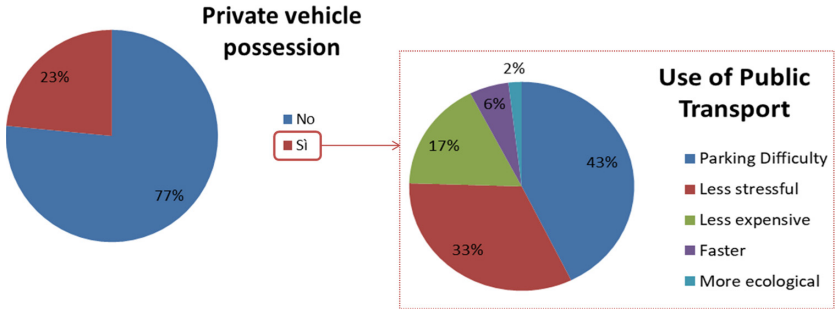

Fig. 9. Reasons of using public transport

As shown in Fig. 9, 77% of the sample does not have a private vehicle, therefore, it is clear that for these users the choice of public transport is a real necessity. For the remaining part of the sample, the public transport is preferred to private car for reasons related to: the traffic component, which is manifested by the difficulty in finding parking, especially in the city center, and with the greater speed of movement compared to the private vehicle (48%). Furthermore 33% of user find it less stressful 17% of the sample chooses it because it is less expensive and finally a minority (2%) motivates the choice in an ecological way.

Looking at data on the possession of a smartphone and the use of the App (Fig. 10), almost all the sample interviewed owns a smartphone.

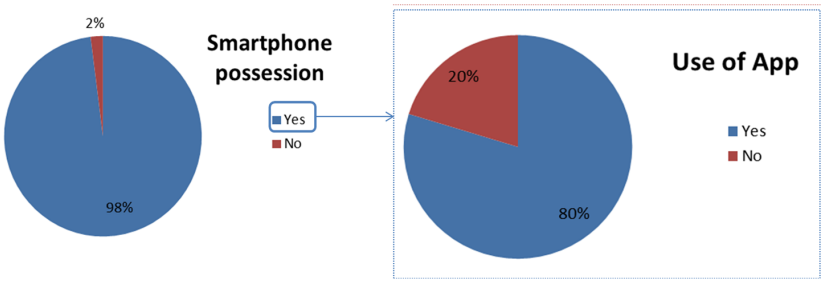

Fig. 10. Media possession and usage

Out of these, 80% have downloaded and use the CTM application and must of them use it primarily as an information channel (94%). For those who do not use it, the information on the transport service is taken in order: by the website and by information panel at the stop. Furthermore, as regards the knowledge of the possibility to purchasing the travel pass through the application, 71% of users who have downloaded the app, knows the service but do not use it, 21% use it and 8% does not know this possibility. The percentages change slightly if the field extends to the whole sample.

3.2 Elderly Users

This part shows the results on the sampled demand of elderly. In order to highlight any impediments and/or limits to the use of public transport in terms of accessibility and/or technological services, the results of the analysis on this demand segment are compared to those of the complementary segment.

The outcomes are shown in Table 1 in which for each attribute (first column) the results of weak users (Over 65s) and complementary users are reported respectively. The results of statistical test are reported in column 4 (Z_{calc})[1].

Table 1. Typical traveler form - elderly and complementary users

Characteristic	Type Traveler (>65 years)	Type Traveler (<65 years)	Z_{calc}
Gender	*Females (80%)* *Males (20%)*	*Females (63%)* *Males (37%)*	1,58
Residence	*Cagliari (55%)* *Hinterland (35%)* *Other (10%)*	*Cagliari (49%)* *Hinterland (38%)* *Other (13%)*	*n.c.*
Profession	*Retired (70%)* *Housewife (25%)* *Education, training and research specialist (5%)*	*Student (59%)* *Employee and qualified professions in commercial activities and services (14%)* *Unemployed (5%)* *Freelance professional of intellectual, scientific and health professions (5%)* *Other (16%)*	*n.c.*

(*continued*)

[1] "*n.c.*": "not calculated" refers to the characteristics where Z_{calc} is not been calculated.

Table 1. (*continued*)

Characteristic	Type Traveler (>65 years)	Type Traveler (<65 years)	Z_{calc}
Location on board and where	*Sitting (95%)* *Standing (5%)* *Rear (45%)* *Central (30%)* *Front (25%)*	*Sitting 90%* *Standing (10%)* *Rear (56%)* *Front (30%)* *Central (14%)*	*n.c.*
Reason	*Personal Services (88%)* *Leisure, Sport, Tourism (6%)* *Shopping (6%)*	*Leisure, Sport, Tourism (35%)* *Job and School/University (each one 23%)* *Personal Services (16%)* *Shopping (2%)*	*n.c.*
Frequency of use	*5–6 days a week (72%)* *3–4 days a week (11%)* *Occasionally (11%)* *It's the first time (6%)*	*5–6 days a week (72%)* *3–4 days a week (14%)* *1–2 days a week (7%)* *Other (7%)*	*n.c.*
Rides	*2 (39%)* *4 (22%)* *6/8/3 (11%)* *1 (6%)*	*2 (40%)* *4 (24%)* *3/1 (11%)* *6/5 (5%)* *Other (4%)*	*n.c.*
Travel ticket	*Contactless subscription (66%)* *Multi-rides Contactless (17%)* *Paper ticket (17%)*	*Contactless subscription (58%)* *Paper ticket (19%)* *Multi-rides Contactless (5%)* *Other (18%)*	*n.c.*
Use of other carriers	*No 100%*	*No 83%* *Yes 17%*	*1.90*
Type of carriers	–	Composition of the 17% of users that using other carriers: *ARST (46%)* *Metrocagliari (27%)* *FdS (24%)* *Other (4%)*	*n.c.*
Moving with another mode	–	*Suburban (76%)* *Urban (24%)*	*n.c.*
Private vehicle ownership	*No (89%)* *Yes (11%)*	*No (76%)* *Yes (24%)*	*1.25*
Use of the bus	For car owners only: *Parking Difficulty (50%)* *Less stressful (50%)*	For car owners only: *Parking Difficulty (43%)* *Less stressful (32%)* *Less expensive (17%)* *(Other 8%)*	*n.c.*
Smartphone possession	*Yes (79%)* *No (21%)*	*Yes (99%)* *No (1%)*	*6.01*
Use of app	*No (87%)* *Yes (13%)*	*Yes (81%)* *No (19%)*	– *7.31*
Info channel	For those who DO NOT use the APP: *Bus stop (81%)* *WEB site (19%)*	For those who DO NOT use the APP: *Bus stop (65%)* *WEB site (32%)* *Other (3%)*	*n.c.*
Purchase with app	For the users of the APP: *Yes but I don't use it (100%)*	For the users of the APP: *Yes but I don't use it (71%)* *Yes and I use it (21%)* *No (8%)*	0.91

The results on the gender of users over 65 confirmed a dominance of women over the male component, to a greater extent than the complementary demand (80% vs. 63%). This is in line with the Dutch study [6] in which there is a greater propensity by older women to use public transport and to walk compared to the male gender who instead uses the car more often.

The 55% lives in Cagliari and 35% in the Hinterland. Considering the age group, it is natural that it is represented by retired with whom housewives stand out (25%). The 95% of the sample interviewed occupied a seat, preferring the rear and central area of the vehicle.

The 89% use the bus for personal services and the rest for leisure and shopping to the same extent. These reasons are in line with those found in a survey conducted in Germany [5] in which it emerged that the main purposes of the movements of the elderly were shopping and leisure. The study cited further states that in favor of these results: access to healthcare facilities, grocery stores, post offices and other cultural, social and leisure facilities (including libraries, leisure centers, non-food stores, city centers and places of worship) were considered as elements of relevance in a review of the accessibility planning of local transport [23, 24].

To sum up, most of the sample uses the public transport service almost daily: between 3–6 days/week (83%). Of these, most make multiple trips per day (2/4).

Turning to the travel pass, 83% use a contactless travel pass both in the subscription form (66%) and in the multi-journey (17%).

Nobody uses other operators. This aspect confirms the aptitude of older people to travel for shorter distances [6]. The authors believe that the shortness of the journey is closely connected with the main reasons for the trip given by the elderly population. In fact, it is assumed that the trips for leisure and purchases have destinations that do not require a long journey in the sense of plurality of carriers.

The use of travel by public transport is the only alternative available for 89% of passengers without a private car. Conversely, it is worth noting that the owners of a private vehicle use the bus owing to the difficulty in finding a parking space or stress due to traffic congestion in the same percentages (50%).

Lastly, regarding the technology available to users and on the information channels, it has been ascertained that the 79% of the sample owns a smartphone. Only 13% use the CTM app and no one makes the purchase through the app despite knowing the service. The information channel for the majority who do not use the app is the bus stop and the website.

The results of the statistical test, reported in the fourth column, show the Z_{calc} values lower than the critical value for four observed characteristics. These are: gender, use of other operators, private vehicle ownership and knowledge and use of the purchase service via app. This allows us to conclude that the two samples have no statistical significance with respect to the observed characteristics. Conversely, for the possession of the smartphone and the use of the app, the test result returned Z_{calc} values higher than the critical value. In this case it is concluded that the two samples have a high statistical significance.

Continuing the comparison between the two macro demand segments, considering the almost daily frequency, both can be considered as regular users. Given the difference in the age group and socio-demographic differences in employment, differences in travel motivation for the trip are implicit.

In both cases, the percentage of users who do not own a private car is high (89% vs. 76%), greater for those over 65 and less for the rest. Considering that in the latter class there are minors, the percentage drops by 5 percentage points if they are removed from the segment.

However, the key elements that distinguish the two segments concern multimodality and technological services. The difference between the two samples, for the second category, is also supported by a high statistical significance of the test. For the former, instead, the value of $Z_{calc} = 1.90$ is at the limit for a significance level of 95%.

As for the first point, it is stated that elderly passengers use collective transport limited to the CTM network. In fact, since there are no users from suburban areas, there is no recourse to the combined use of other carriers. An element that could justify this result could be due to the fact that for the elderly, given their age, they do not move anymore for work and/or study. Systematic trips home/work-study often requires the use of multiple carriers to reach the destination.

Another substantial element of difference is the ownership of the smartphone and the services connected to it. The 21% of the over 65 category does not have a smartphone against 1% of the complementary category.

Restricting the analysis to the owners of the smartphone only, only 13% of the elderly downloaded the transport operator application's (vs. 81%). The service is used only to acquire information but not to buy the travel ticket despite they know this option.

4 Conclusions

Growing progress in medicine and the improvement in the quality of life have had a positive impact on people's life expectancy, which has increased worldwide. We find ourselves in front of a more active elderly population, who moves more and even in the absence of full-time work commitment, maintains its independence in carrying out its activities that are attributable to leisure and shopping. The natural aging process is accompanied by physiological and customary changes that are reflected in the mobility choices. The elderly walks more and uses public transport. The study proposed by the authors focuses on the behavior of these users.

On the basis of the periodic quality survey carried out by the public transport company of the Municipality of Cagliari (CTM) on its vehicles, 754 questionnaires were collected. From these data, socio-demographic characteristics and travel behavior were investigated. The analysis was done using descriptive statistics.

By the data provided by the CTM, the sample of the elderly is 3%. This result is not surprising as the survey was motivated by business needs and aimed to evaluate the service quality. Hence, despite the limited sample size, the authors wanted to analyze the behavior of over 65 years who, especially for some characteristics, showed specificities that deserve further study.

The results for both the overall sample and the share of demand of elderly showed that the users are systematic. However, the study found that the use of multimodality and technological services are the discriminating elements between the two samples. The difference in this sense is not only qualitative but was also supported by the statistical test of significance. In fact, the test result showed that the difference between the two groups (over and under 65 years) is statistically significant.

As for the intermodality, the elderly do not use other operators but limit themselves to using public transport on the local network. This confirms that the elderly make shorter trips, an option that is probably also due to the reasons for the movement that distinguish this age group. Most elderly have a smartphone, but only 13% use the app as an information channel only.

As regards the actions to be suggested to the Company, nothing can be added about intermodality, as none of the elderly use it. If this aspect will be confirmed by a more detailed investigation, it would confirm their habits on the use of public transport for short and short-term trips. So, in this sense, there is no glimpse of a policy to suggest to the companies involved in order to acquire this demand segment as well.

Conversely, as for technological services, there are some elements that could facilitate the use of the services by increasing its accessibility. In this regard, a distinction must be made between:

- Network consultation services, timetables and route interrogation services;
- The purchase service.

While for the first category it would be enough to enhance advertising, for example on board vehicles, for the second category the purchase service should be facilitated. It is known that the elderly, especially in these latitudes, are rather hostile to credit card purchases. Therefore, a solution to be able to use the subscription service through the app, could be to make it possible to upload credit directly to the sales network (e.g., Tobacconists, newsagents). This would facilitate the purchase service and would probably allow the spread of the use of the app, even for the category of users over 65 years.

To conclude, the authors confirm their interest in deepening the study on this segment of users. In this regard, a new targeted investigation could be set up precisely on the elderly. In fact, it would be interesting to understand, in the context of the Municipality of Cagliari (with a temperate climate, with investments in structures for pedestrian and cycle paths), what their real travel habits are, what their travel behavior is as well as their modal choices. This could be a starting point for future studies.

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