Public transport use and health status in later life: which relationship?

Abstract

In many developed countries, ageing trends have called for mobility policies oriented to active travels for older adults, preventing some diseases. As a result, in the transport and health literature, the elderly's psycho-physical health is growingly recognized as linked to the accessibility to local public transport (LPT) and its usage frequency. Using data drawn from a survey by the National Institute of Statistics (ISTAT) on the Italian citizens' daily life, this paper investigates the relationship between health dimensions of the sub-sample of people aged over 60 years in Italy and their use of LPT, considered as a more active and sustainable means with respect to car. By applying a recursive mixed-process approach and controlling for LPT service availability and parking issues, the findings highlight that (i) taking public transport services or driving cars more frequently is associated with higher levels of psychological and self-perceived health; (ii) especially for people over 65 years old, the use of LPT at least once a week is linked to better physical conditions. From a policy perspective, the insights of this study are two-fold. First, improving the accessibility to welfare and activity spaces by using LPT is likely to increase ageing people's mental health and their social inclusion. Second, stimulating the LPT usage might be a primary way to effectively promote physical health, to prevent ageing-related diseases, and to help reducing healthcare expenditures connected to the lack of active mobility in later life.

Keywords: Aging; Local public transport; Car; Seniors health; Transport policies; Mixed-process models

1. Introduction

The increase of the ageing population has raised some concerns in modern societies for the excess burden that the governments will face to their healthcare and pension systems (Abdullah et al., 2018). Among the list of aside outcomes that will inevitably come up two are of key importance: the provision of specific ageing-oriented products or/and services, and society transformations, i.e. the changes of the daily life of the people surrounding the elderly (Metz, 2000). Notably, in 2019 Italy was the second country in the world (after Japan) in terms of old-age dependency ratio (United Nations et al., 2020). As confirmed by recent estimations of the Italian National Institute of Statistics (ISTAT) (http://dati-anziani.istat.it), the segment of the population aged over 65 years old was 22.8% and the average age of the total population 45.4 years old. The same estimations for the next twenty years project an increasing trend both for the percentage of the over 65s (32.2%) and the average age (50.2 years old) of the total population.

As described in section 2, it has been stressed by various scholars that ageing mobility affects various health-related issues and influences the health-related quality of life that the elderly enjoy (among the others, Sugai et al., 2019; Musich et al., 2018; Sunderaraman et al. 2019; Yu et al., 2019). Even if there is no consensus between international experts about the suggested levels of physical activity in order to maintain sufficient health condition, it is proposed at least half an hour of moderate intensity exercise most days of the week (WHO, 2006). To obtain this aim, among the key priorities of the World Health Organization (WHO, 2018) in living actively and achieving healthy ageing is the provision of appropriate transport services

that respond indeed to the mobility needs of the older people, enhancing not only the physical health but also the psychological one. The transport system therefore become a necessary condition to facilitate the accessibility to the destinations of the "welfare-space" (Johnson et al., 2017), such as accessibility to goods, services, employment and other activities (Hounsell et al., 2016). Furthermore, it can assist in maintaining social connectedness and community participation (Wong et al., 2018; Brown et al., 2018; Green et al., 2014). Through the satisfaction of utilitarian, affective and aesthetic needs, it has the potential to promote the levels of quality of life of the older people (Kim et al., 2020; Musselwhite and Haddad, 2010; Banister and Bowling, 2004).

Considering the Italian demographic changes and the crucial role of mobility for satisfactory health performance and quality of life, it is needed sufficient preparation of the scientists and policymakers in order to overcome the great challenges that will appear in the near future.

Considering these reflections, enhancing transport aspects in later life, i.e. prolonged driving capability, car availability and accessibility of destinations through well-served public transport systems, need to be considered seriously by the policy makers when seeking ways of improving health in later life (Nordbakke and Schwanen, 2015). Designing age-friendly transport systems and facilities will require efficient allocation of the public funds and sufficient research could best justify this decision. However, despite the role of transport mobility in later age, the mobility of the elderly people in Italy is in general an ignored topic in the scientific literature (Mariotti et al., 2018). Within this framework, the objective of the current analysis is to stress a topic that has been neglected by the literature (see section 2): the relationship between health dimensions of ageing people and their public transport use compared to car. In terms of policy implications, the findings would give indications to policymakers about how to increase the use of local public transport (including bus, tram, subway and local trains), that should be promoted as it implies an *active* way to travel and satisfy own mobility demand in a sustainable way. In other words, our intention is to give an answer to the following research question:

What is the link between the health status of the Italian elderly (as measured by mental, physical and self-perceived health indicators) and the frequency of the local public transport (LPT) use with respect to private car?

The paper is organized as follows. Next section presents the literature review on the transport habits of the elderly population and the links of public transport usage with health dimensions. Section 3 describes the dataset and the methodology and section 4 presents the estimation results. Section 5 includes the discussion of the results and some key policy implications, and lastly, section 6 draws the conclusions, the limitations of the study and future research directions.

2. Literature Review

Nowadays, the elderly people live more active and mobile compared to their peers in the previous decades (Klein-Hitpaß and Lenz, 2011). The human needs for mobility and social interactions do not decrease when people get older (Shrestha, 2017), but what actually change are the mobility patterns, e.g. health issues could cause a decreased percentage of people moving outside of their homes on an average day, fewer trips and kilometres travelled per person (Ryan et al., 2015; Sikder and Pinjari, 2012). The mechanisms of transport mode selection are not a simple task to be analysed by the researchers. From a trans-disciplinary perspective, it reflects habits, personal norms, perceived mobility necessity, occupation,

social norms, life stage, structural environment, income, symbolic and affective meanings (Nakanishi and Black, 2015). Several studies indicate that even within the group of the elderly people there are observed heterogeneous transport behaviours. For instance, the younger seniors are more likely to travel compared to the older elderly (Yang 2018) and the male elderly travel usually longer distances than females on a daily basis (Shrestha, 2017; Siren and Haustein, 2013).

The selection of the transport mode for the satisfaction of the transport needs in later age can be determined by various parameters. First, the age is an obvious one. A study conducted in Sweden (Levin and Berg, 2009) found that between 65-84 years old 60% of travels are made by car, while after the age of 84 years old the public transport services become more popular. In another study conducted in the city of Milan (ISFORT, 2016, as cited in Mariotti et al., 2018), it has been found that the willingness to decrease car use or increase LPT use is higher for the people aged 60-69 years old than the over 70's. Second, the gender plays its own role. Older men more frequently use the private car than women, nevertheless, as women are getting involved in driving the gap with males will gradually shorten (Klein-Hitpaß and Lenz, 2011). Potential reasons for gender heterogeneities are proposed by some researchers (Legendre et al., 2014; Klein-Hitpaß and Lenz, 2011): (a) the absence of mobility alternatives, (b) the personal characteristics and constraints e.g. income, time budget, individual abilities, (c) the car availability and (d) the possession of a driving license.

In the literature, there is a general consensus that the private car is considered by the elderly people the synonym of independence (Ziegler and Schwanen, 2011). When the elderly face driving cessation, they have to reorganize their daily routine. Beyond feelings of discomfort in asking for informal support from others (Murray and Musselwhite, 2019), additional undesirable effects of driving cessation are described by the researchers, for example depressive symptoms (Marottoli et al., 1997), limitations to out-of-home and social activity participation (Spinney et al., 2020) and social isolation (Dabelko-Schoeny et al. 2020), an issue aggravated in the rural areas of residence (Hansen et al. 2020). Evidently, providing alternative means of transport such as tailor-based transport services or well-organized public transport systems can support the elderly mobility and, thus, their life satisfaction (Lee and Choi, 2019). Beimborn et al. (2003) outline that the elderly might be "trapped" in using public transport because of disabilities, economic hardship or family reasons. Indeed, according to Shrestha (2017) the public transport is one of the transport choices during the period of driving cessation. Under a more holistic point of view, as sustainability has become an urgent challenge in the transport research the public transit has the advantage to be more environmentally friendly than the private car (Rojas-Rueda et al. 2012).

While extensive literature has analysed the modal choice determinants, including age and other socio-economic characteristics, for many years, transport and public health scholars were ignoring the links between health and public transit. In transport research, this has happened partly because transport transfers were conceived as "fatigue" and partly because of the lack of inclusive datasets (Mulley et al., 2016). However, in public health science there is a growing interest to suggest ways of delaying the appearance of comorbidities that come with ageing as they can aggravate substantially the quality of life (Xuan et al., 1999). In that sense, nowadays the links between public transport and health are attracting more attention by transport and health scholars who are searching for stronger evidence (Mulley et al., 2016). The connection of public transport use with health status can be seen through the lens of different perspectives. The frequent public transport usage has some positive impacts both on community and individual level: lower number of traffic accidents and pollution levels (air

and noise), increased physical activity (walking), improvement of mental health (through social participation and reduction of loneliness), facilitation of transport affordability (in economic terms) and promotion of basic mobility, e.g., access to healthcare services and healthy food (Litman, 2010). In the last few years, active travel (as a type of light physical exercise) has been studied by some scholars for its impact on health dimensions, such as cardiovascular diseases and increased physical activity (e.g., see Norwood, 2014; Laverty et al., 2013). Moreover, it has been demonstrated that higher level of mobility in an ageing stage positively affect several diseases (Pantelaki et al., 2020), improve cognition (Sunderaraman et al. 2019), reduce falls (Musich et al., 2018) and even mortality (Yu et al., 2019) and other health-related issues (among others, Sugai et al., 2019; Curcio et al., 2016).

A few studies have been published for the relationship of public transport use with various physical and mental health dimensions in later life, mainly coming from targeted European countries and the majority regarding UK (see Table 1). Any study has been performed in Italy. As regards the contribution to physical health, the use of public transport requires more effort of walking to reach the transport infrastructures (Coronini-Cronberg et al., 2012). Indeed, Rissel et al., 2012 reviewed 27 studies revealing that 8–33 additional minutes of walking are attributed to the public transport use. This additional physical activity might keep lower the levels of *obesity* (Webb et al., 2012) and *adiposity* (Laverty et al., 2018b; Webb et al., 2016); moreover, it is demonstrated that the elderly users could perform better than non-users to *gait* (Webb et al., 2016) and *walking speed tests* (Rouxel et al., 2017). Apart from the physical health implications, some scholars have uncovered mental health associations with public transport use. The public transport facilitates the accessibility to places for socialization with family, friends, and the participation to volunteering activities (Reinhard et al., 2018), thus the elderly will not feel alone (Van den Berg et al., 2016) and their overall cognitive ability (Reinhard et al., 2019) could be maintained for a longer period. Being surrounded by loved people improves life satisfaction and reduces depressive symptoms (Jackson et al., 2019). As such, some scholars have pointed that the proximity to public transport services might be beneficial to mental health (e.g., Chiatti et al., 2017). From a transdisciplinary perspective, other activities different than the physical exercise (such as the use of the transportation means) could play a dual role in the elderly's life, offering the main benefits of physical activity together with their inherent function (Sallis et al., 2006).

Table 1

Summary of studies on public transport use and health outcomes in later life

Study	*Data source*	*Age*	*Country*	*Findings*
Coronini-Cronberg et al. (2012)	National Travel Survey Longitudinal (2005-2008)	≥60	UK	The possession of a free bus pass significantly increases physical activity.
Webb et al. (2012)	ELSA Longitudinal (wave 1: 2002, wave 2: 2004, wave 3: 2006, wave 4: 2008)	≥50	UK	The eligible for bus pass elderly were more likely to use the public transport and less likely to be or become obese than non-users.
Van den Berg et al. (2016)	Cross sectional 2014	>35-75	Netherlands	Using different transport modes (bicycle, car and public transport) significantly reduces loneliness.
Webb et al. (2016)	ELSA Cross-sectional wave 6 (2012)	≥62	UK	Female bus pass holders had faster gait speed, lower body mass index and waist circumference than women without a pass.
Chiatti et al. (2017)	SEBEM study Cross sectional	75-90	Sweden	Mental health scores are significantly lower among those living far from the closest bus stop and never using public transport.
Rouxel et al. (2017)	ELSA Longitudinal (wave 2: 2004, wave 3: 2006, wave 4: 2008, wave 5: 2010, wave 6: 2012)	≥60	UK	Older adults who did not use public transport had slower walking speeds compared to frequent public transport users.
Laverty et al. (2018b)	ELSA Longitudinal (wave 4: 2008, wave 6: 2012)	≥50	UK	Both starting using and increasing public transport use increases physical activity and may be associated with lower levels of adiposity for elderly women.
Reinhard et al. (2018)	ELSA Longitudinal (wave 2: 2004, wave 3: 2006, wave 4: 2008, wave 5: 2010, wave 6: 2012, wave 7: 2014)	≥50	UK	Using public transport reduces feelings of loneliness, increases volunteering at least monthly, and increases regular contact with and friends.
Jackson et al. (2019)	ELSA Cross-sectional wave 6 (2012-2013)	≥62	UK	Public transport use improves well-being, and this is in part explained by increased physical activity and social interactions.
Reinhard et al. (2019)	ELSA Longitudinal (wave 2: 2004, wave 3: 2006, wave 4: 2008, wave 5: 2010, wave 6: 2012, wave 7: 2014)	≥50	UK	Free bus pass holders used more the public transport and the elderly bus users performed higher to cognitive tests.

3. Methodology

3.1 Variables and descriptive statistics

The data used for the present analysis were drawn from the ISTAT "Aspects of Daily Life" 2017 survey, a yearly cross-sectional and multipurpose national survey on several aspects of everyday life of a representative sample of households and individuals: public services usage, perceived health, social and family relationships, leisure activities, eating habits, lifestyle, etc. (ISTAT, 2019). The 2017 edition gathered information on 48,855 individuals, who answered to 683 questions. For the focus of our analysis, we restricted the sample to participants aged over 60 years. After error-checking and cleaning the data, 15,097 responses have been used for this study.

3.1.1 Outcomes: Mental, physical and self-perceived health

In this study we focus on three outcomes related to the older adults' health. By retrieving and partially adjusting information taken from the survey, we first derived an indicator of the mental health conditions by adding up the Likert-scale values of the following five questions: *1."In the last four weeks, how long do you feel calm and/or peaceful?"* (from 1/never to 6/always); *2. "In the last four weeks, how long do you feel discouraged and sad?"* (from 1/always to 6/never); *3. "In the last four weeks, how long do you feel very agitated?"* (from 1/always to 6/never); *4. "In the last four weeks, how long do you feel down in the dumps?"* (from 1/always to 6/never); *5. "In the last four weeks, how long do you feel happy?"* (from 1/never to 6/always).
On average, the interviewed elders show a quite good mental status. More specifically, as regards the considered negative feelings (question 2, 3 and 4),, only very few of the elderly (less than 2.5%) feel always sad or agitated or down in the dumps (see Figure 1). However, when considering the positive feelings (question 1 and 5) included in the mental health indicator, 60% (i.e. the sum of 1, 2 and 3 levels of the Likert-scale in the second column of Figure 2) stated not often feeling happy.

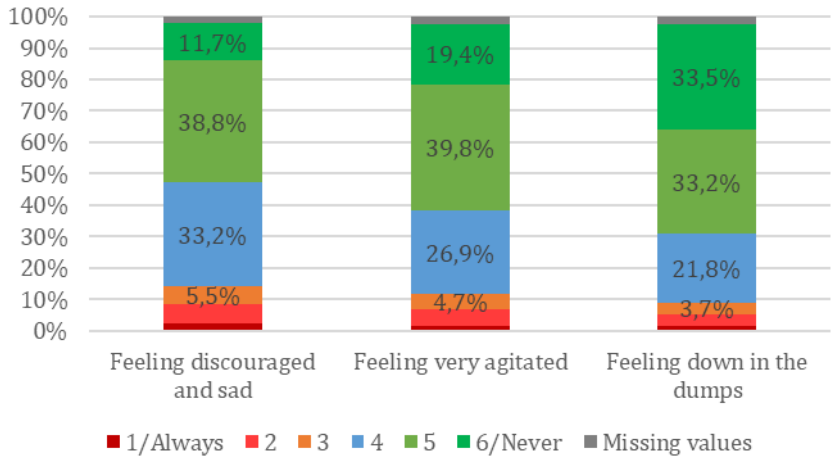

Figure 1 – Mental health indicator - Negative feelings: frequency among older adults interviewed (%)
(Authors' elaboration on ISTAT "Aspects of Daily Life" 2017 survey)

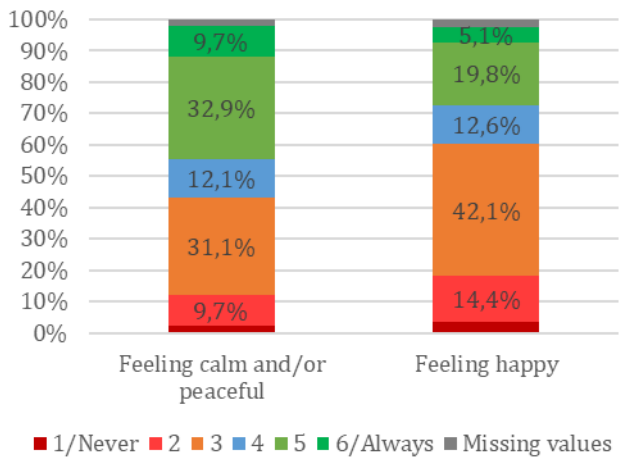

Figure 2 – Mental health indicator - Positive feelings: frequency among older adults interviewed (%)
(Authors' elaboration on ISTAT "Aspects of Daily Life" 2017 survey)

The mental health variable used in the econometric analysis is thus built by summing up the values of the positive and negative feelings, obtaining an aggregated indicator ranging from 5 to 30 (and handled as a continuous dependent variable): the higher the value, the better the older adults' mental health.

In order to develop a study-specific measure of physical conditions, according to the literature linking ageing and health, we selected five key diseases which were found to be more affected by active mobility: diabetes, arterial hypertension, angina pectoris or other heart diseases, arthrosis and/or arthritis and osteoporosis (Wilby, 2019; Poduri, 2017; Nascimento et al., 2015; Norwood, 2014; Zhang et al., 2008; WHO, 2006). As shown in Figure 3, angina pectoris or other heart diseases (82.1%) and diabetes (76.2%) are the most frequent diseases among the older adults interviewed. Summing up the values of the binary answers (Yes/0, No/1) for each question about these pathologies (e.g. *"Do you suffer from diabetes?", "Do you suffer from arterial hypertension?" etc.*), the score ranges from 0 to 5 (treated as a continuous dependent variable within the econometric model), where higher values indicate a better physical health.

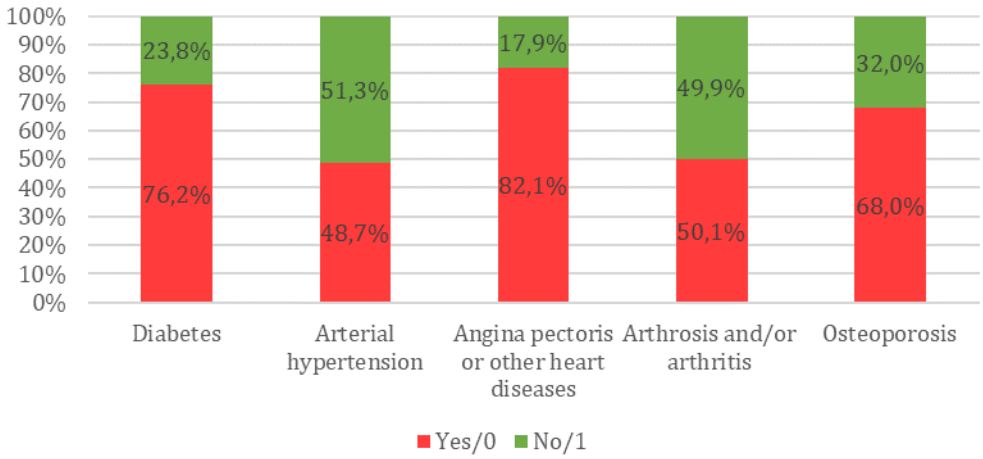

Figure 3 – Physical health indicator: frequency of diseases among older adults interviewed (%)
(Authors' elaboration on ISTAT "Aspects of Daily Life" 2017 survey)

Lastly, we used the outcomes (Likert scale; from 1/very bad to 5/very good) of a general question about subjective health: "*How is your overall health in general?*", which is handled as an ordinal dependent variable in the econometric model. Figure 4 shows the distribution of these self-assessed health responses: only 4% of the interviewed elderly perceive their health as very good, 35.3% perceive to be in good health conditions, while the majority (46%) chose the value in the middle of the scale (nor bad, nor good).

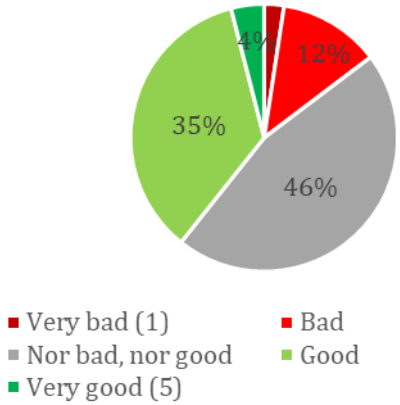

Figure 4 – Frequency of self-perceived health responses (%)
(Authors' elaboration on ISTAT "Aspects of Daily Life" 2017 survey)

3.1.2 Exposures: usage of LPT and private cars

Since the main aim of the study is to investigate the linkages between the older people's mobility in Italy and different dimensions of their health, we assessed the usage frequency of LPT and private cars by retrieving the following survey questions, both measured on a Likert scale (from 1/never to 5/every day): "*How often do you use local public transports (bus, trolley bus and light rail)*?" and "*How often do you drive a private car*?". Table 2 shows the frequency of the responses to the above two variables: only 1.8% of the respondents use LPT every day, while 62.56% never use them. By contrast, 35.99% of the interviewed elderly drives every day a private car, 16.59% uses it sometimes during the week, and 42.03% never drives. Reported missing values (18.68%) related to the usage of LPT are due to the lack of respective services in the neighbourhood/area where older adults reside. For these elderly people, other means of transport (included cars) are an unavoidable choice.

Table 2

Elderly's mobility habits: LPT and private cars usage – Summary statistics

Categories (Likert scale)	**LPT** (use frequency)	**Private car as a driver** (use frequency)
1 (*Never*)	9444 (62.56%)	6346 (42.03%)
2 (*Few times a year*)	1048 (6.94%)	257 (1.70%)
3 (*Few times a month*)	744 (4.93%)	435 (2.88%)
4 (*Few times a week*)	770 (5.10%)	2490 (16.59%)
5 (*Every day*)	271 (1.80%)	5433 (35.99%)
Missing values	2820 (18.68%)	136 (0.90%)

Comparing the answers of the elderly with those of younger age cohorts of the survey, it emerges that in general the Italians do not use frequently the LPT (Figure 5). On average, 61.5% of people aged 60-64 years old, 60.9% of elders with 65-74 years old and 64.8% of the over 75's has never used the public transport services and the tendency is rooted to the earlier years of life course. Notably, 64% of people aged 35-59 years old declared that have never used the LPT. On the other hand, 11.6% of the 14-34 years old use LPTs every day, while the other age cohorts remain below the national average (5.5%). Accordingly, data from ISFORT (2019; p. 4) show that in the last twenty years the mobility rate of the Italian elderly people is consistently lower compared to the mobility of the younger generations and seems to be a bit lower (69.9%) compared to the last decade rate of their peers (71.9%).

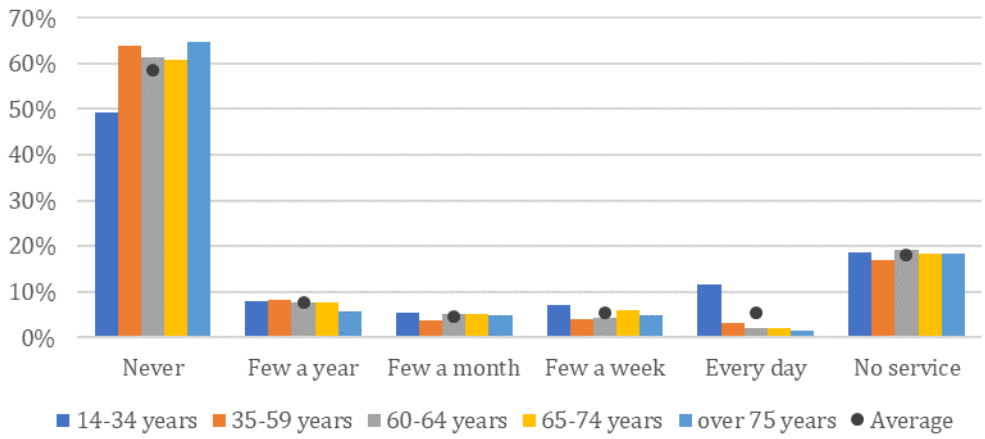

Figure 5 - Frequency of LPT usage among age cohorts (%)
(Authors' elaboration on ISTAT "Aspects of Daily Life" 2017 survey)

Looking at the data of private car driving, Figure 6 shows that car is the favourite transport mode for the everyday travels among the ages of 35-59 years old (65.9% - quite above the national average of 47%). Similar numbers are observed for the car usage few times a week and few times a month among all the age cohorts, with averages of 16.2% and 3.3% respectively. Instead, the percentage use by the elders is lower than younger and the percentage of the interviewed elderly who never drive a private car increases with age progression (20.9% for people aged 60-64 years old, 32.1% for the 65-74 years old, 63.5% for the 75+), probably because they no longer hold a driving license.

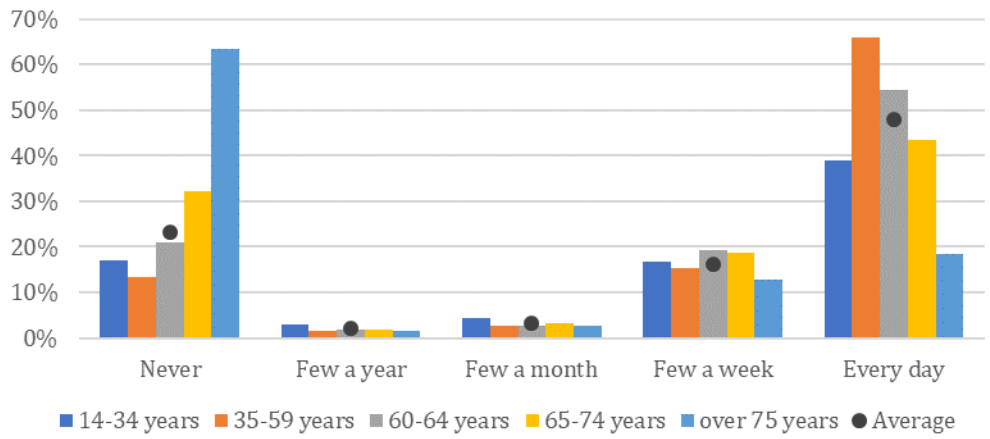

Figure 6 - Frequency of driving a private car among age cohorts (%)
(Authors' elaboration on ISTAT "Aspects of Daily Life" 2017 survey)

The observation that the private car is the favourite transport mean in Italy is confirmed also in the report of ISFORT (2019). According to that, almost six out of ten trips in 2018 have been made by car, five out of which as drivers. Moreover, considering the overall trips of the Italian population, the share of trips undertaken by the elderly (over 65 years old) is 24.1% for cycling, 20.6% for walking, 16.5% by car, 14.5% by LPT and 10.9% by motorcycle. Remarkably, nowadays as regards the elderly people, the LPT usage is lower than ten years ago (16.6% in 2008), while the car usage is higher (11.1% in 2008).

3.1.3 Covariates

In the econometric models, we control for various socio-demographic characteristics that are commonly used in the scientific literature to assess the impact of transport on the health of the elderly people, as previously described (see section 2): age, gender, civil status, family members, source of income, level of education, geographical location across Italian macro-areas and social relations/contacts. Table 3 reports some descriptive statistics.

Table 3

Socio-demographic covariates used – Descriptive statistics

Variable	N	%	Mental health Mean (SD)	Physical health Mean (SD)	Self-perceived health Mean (SD)
Age (classes)					
60-64	3283	21.75%	21.66 (4.55)	4.15 (0.96)	3.57 (0.78)
65-74	5864	38.84%	21.60 (4.73)	3.73 (1.12)	3.32 (0.76)
75+	5950	39.41%	20.71 (4.90)	3.30 (1.23)	3.03 (0.82)
Gender					
Female	8284	54.87%	20.69 (4.87)	3.45 (1.24)	3.18 (0.81)
Male	6813	45.13%	21.97 (4.57)	3.89 (1.05)	3.36 (0.81)
Civil status					
Not married	1034	6.85%	21.67 (4.82)	3.81 (1.13)	3.32 (0.85)
Married	9359	61.99%	21.66 (4.58)	3.79 (1.10)	3.33 (0.79)
Divorced	1035	6.86%	20.91 (4.91)	3.86 (1.13)	3.35 (0.84)
Widowed	3669	24.30%	20.22 (5.06)	3.20 (1.27)	3.04 (0.82)
Family members					
Alone	3781	25.04%	20.65 (5.08)	3.41 (1.26)	3.14 (0.84)
Two	7285	48.25%	21.29 (4.55)	3.82 (1.13)	3.36 (0.79)

More than two	4031	26.70%	21.56 (4.71)	3.69 (1.14)	3.27 (0.80)
Income					
Family aids	1718	11.38%	20.76 (4.79)	3.67 (1.16)	3.28 (0.76)
Self-sufficiency	13379	88.62%	21.33 (4.77)	3.65 (1.18)	3.26 (0.82)
Education					
Primary school	6773	44.86%	20.66 (4.96)	3.38 (1.23)	3.07 (0.81)
Middle school	3771	24.98%	21.45 (4.73)	3.79 (1.12)	3.33 (0.80)
High school	3296	21.83%	21.98 (4.47)	3.91 (1.05)	3.46 (0.77)
University degree	1257	8.33%	22.05 (4.29)	4.01 (1.00)	3.56 (0.76)
Residence area					
North	6379	42.25%	21.76 (4.73)	3.78 (1.11)	3.36 (0.79)
Centre	3001	19.88%	20.95 (4.91)	3.67 (1.16)	3.26 (0.81)
South and Islands	5717	37.87%	20.88 (4.72)	3.50 (1.23)	3.15 (0.83)
Social contacts					
No contacts	3274	20.69%	20.38 (5.16)	3.53 (1.22)	3.11 (0.88)
One group	2468	16.35%	21.01 (5.01)	3.64 (1.19)	3.24 (0.82)
Two groups	9356	61.97%	21.64 (4.53)	3.70 (1.15)	3.32 (0.78)

Concerning the socio-demographic characteristics of our sample, people aged over 75 years are overrepresented (39.41%), also reporting, as intuition suggests, the lowest average scores in all the considered health dimensions. Female elderly (54.87%) are those associated to worse general health conditions, while people married (62%) seem to have better psychological conditions compared to divorced and widowed (probably due to less loneliness), as well as financially self-sufficient people (88.6%) compared to those supported by other family members. Alone older people (25%) report the lowest average scores in all the considered health dimensions. Most of the older adults in the sample hold a primary or middle school license (about 70%), associated to relatively lower scores in all the outcomes. From a geographical perspective, the largest group of interviewed elderly lives in the Northern part of Italy (42.25%), followed by the Southern part and Islands (37.87%). The Northern Italian over 60 citizens seem to be healthier than those living in the remaining part of Italy. Finally, the variable labelled as "Social contacts" captures the elderly social relations using the following three categories: No contacts (i.e., the interviewed stated that they do not have parents, nor friends, nor neighbours: 20.69%); One group (i.e., the interviewed declared to have contacts with one group among friends, family and neighbours: 16.35%); Two groups (i.e., the interviewed stated to have contacts with at least two groups among friends, family and neighbours: 61.97%). The social connectedness seems to be positively related to all the three health variables, confirming the findings of the literature (e.g., see Brown et al., 2018; Green et al., 2014).

3.2 Econometric modelling

In order to study how the usage of LPT (compared to that of private cars) might be related to health measures in later life, we started our analysis by considering potential sources of endogeneity problems (i.e., unobservable factors having an impact on both transport usage and health status). From a methodological perspective, we used two instrumental variables (IVs) to deal with the problem of *self-selection bias*, considering that the respondents' choice to use transport means does potentially lack of exogenous predictors with respect to health conditions (Clougherty et al., 2015). Among the available data, we identified the difficulty of LPT accessibility (e.g., distance from bus stops, low ride frequency, etc.) and residential parking issues (e.g., lacking parking slots), respectively, as IVs that are reasonably correlated with the use of LPT and private cars but not, in principle, with the outcomes described in

section 3.1.1, i.e., mental, physical and self-perceived health (Jackson et al., 2019). In the survey, those features are explicitly captured by the two following questions (measured with a Likert scale, from 1/*Not at all* to 4/*Very high*): "*In the neighbourhood where you live, are there any problems of connection by public transports?*" and *"In the neighbourhood where you live, are there any parking difficulties?"* (Table 4). Interestingly, about 61% of sampled Italian respondents indeed reported LPT accessibility issues, while residential parking deficits are advised by 58% of them. In order to check the suitability of the selected instruments and to be in line with related studies (among others, for LPT see Wong et al., 2017; and for the usage of private cars, see Guo, 2013), the linkage between the use frequency of transports and their limitations has also been analysed by the Spearman correlation test, whose results confirmed that the chosen IVs can be considered as appropriate (ρ: -0.0924, $p < 0.001$ for LPT; ρ: -0.0889, $p < 0.001$ for cars).[1] Similar results were derived running Kendall's rank correlation tests (Gibbons and Chakraborti, 2011).

Table 4

Instrumental variables for LPT and private cars use – Summary statistics

Reported issues (Likert scale)	*LPT accessibility issues* (IV for *LPT use*)	*Residential parking issues* (IV for *Private car use*)
1 (*Not at all*)	4803 (31.81%)	5832 (38.63%)
2	4423 (29.30%)	3858 (25.55%)
3	3082 (20.41%)	2968 (19.66%)
4 (*Very high*)	1731 (11.47%)	2013 (13.33%)
Missing values	1058 (7.01%)	426 (2.82%)
Spearman rank correlation test (ρ)	-0.0924 ($p < 0.001$)	-0.0889 ($p < 0.001$)

Therefore, we specified two functions where the use of LPT and private cars are dependent variables of as many ordered probit models (Kwon et al., 2020; Duncan et al., 1998).
As for the use of public transit, the mechanism follows the process:

$$LPT_i = l \text{ only if } k_{l-1} \leq LPT_i^* = \theta_{i,LPT} + \varepsilon_{i,LPT} < k_l \qquad [1]$$

where $\theta_{i,LPT} = \delta_0 \times Z_{i,LPT} + \boldsymbol{\delta}'\boldsymbol{X_i}$, $k_0 = -\infty$ and $k_5 = \infty$, and LPT_i^* measures unobserved frequencies of LPT use (with l ranging from 1/*Never* to 5/*Every day*) of the i-th respondent; $\varepsilon_{i,LPT}$ is a normally-distributed error; $\boldsymbol{X_i}$ indicates the vector of individual-specific covariates described in section 3.1.3; and $Z_{i,LPT}$ measures the IV related to the use of public transit, i.e., the level of LPT accessibility issues.

Analogously, for what concerns the use of private cars (as a driver), we consider the following mechanism:

[1] In order to rule out not suitable exclusion restrictions related to such IVs, we checked that LPT accessibility issues and residential parking problems have not a cross-impact on the usage of studied transport means among the elderly. In particular, Spearman rank correlation tests were applied, where the ρ between LPT issues and the use of private cars is -0.0139 (p-value = 0.836) and that between parking issues and the use of LPT is 0.0850 (p-value = 0.114). Of course, since we have considered the use of cars as a driver only, probably LPT accessibility issues may have a significant effect on the resort to cars as a passenger, or to carpooling. However, those data were not available in the analysed survey.

$Cars_i = h$ only if $k_{h-1} \leq Cars_i^* = \theta_{i,Cars} + \varepsilon_{i,Cars} < k_h$ [2]

where $\theta_{i,Cars} = \tau_0 \times Z_{i,Cars} + \boldsymbol{\tau}'\boldsymbol{X_i}$, $k_0 = -\infty$ and $k_5 = \infty$, and the value h of the latent variable $Cars_i^*$ ranges from $1/Never$ to $5/Every\ day$ for the i-th respondent; $\varepsilon_{i,Cars}$ is a normally-distributed random term; while $Z_{i,Cars}$ captures the IV related to the use of private cars, i.e., the level of residential parking issues. For both the ordered probit models, observed variables are in a censored form, with thresholds k_g and k_h (for $g, h = 1, .., 5$) defining the intervals into which $LPT_i^*$and $Cars_i^*$ might fall (Wooldridge, 2010).
Since they have been used to control for endogeneity between health and transports usage, the above two functions were natural ingredients of three recursive systems of equations (as described in the Appendix A), where endogenous variables appear on the right-hand side of them (Greene, 2012). Therefore, as far as the effects of the use of LPT and private cars on health in later life are concerned, we developed one system of equations for each outcome, where function [1] and [2] are in common. Specifically, while the self-perceived health (S) is measured by an ordered variable, instead mental (M) and physical (P) conditions are captured by continuous indicators. As for those two latter outcomes, we have:

$M_i = \theta_{i,M} + \varepsilon_{i,M}$ [3]

where $\theta_{i,M} = \alpha_0 + \alpha_1 \times LPT_i + \alpha_2 \times Cars_i + \boldsymbol{\alpha}'\boldsymbol{X_i}$, and

$P_i = \theta_{i,P} + \varepsilon_{i,P}$ [4]

where $\theta_{i,P} = \beta_0 + \beta_1 \times LPT_i + \beta_2 \times Cars_i + \boldsymbol{\beta}'\boldsymbol{X_i}$.

For each i-th respondent, the impact of the use of LPT and private cars and other established covariates $\boldsymbol{X_i}$ are estimated. As for the self-perceived health (S), its linkage with transports is explored by using an ordered probit model, as follows:

$S_i = s$ only if $k_{s-1} \leq S_i^* = \theta_{i,S} + \varepsilon_{i,S} < k_s$ [5]

where $\theta_{i,S} = \gamma_1 \times LPT_i + \gamma_2 \times Cars_i + \boldsymbol{\gamma}'\boldsymbol{X_i}$, $k_0 = -\infty$ and $k_5 = \infty$, and S_i^* represents the unobserved (latent) self-perceived health of the elderly.

In order to estimate the three systems of equations where health conditions and transports usage are investigated, we follow a recursive mixed-process: different types of models (linear and non-linear) are combined and all the parameters – i.e., $\delta_0, \tau_0, \boldsymbol{\delta}, \boldsymbol{\tau}$ for function [1] and [2], and $\alpha_0, \alpha_1, \alpha_2, \boldsymbol{\alpha}, \beta_0, \beta_1, \beta_2, \boldsymbol{\beta}, \gamma_1, \gamma_2, \boldsymbol{\gamma}$ for function [3], [4] and [5], respectively – are simultaneously estimated for each system by maximum likelihood (Roodman, 2011). Details of the recursive ML procedures are provided in the Appendix A.
In the next section, estimations are presented, starting from the determinants of transports usage (i.e., functions [1] and [2] that the systems have in common) and then moving to the relationship between the use of transports and health outcomes, as expressed in [3], [4] and [5]. The goodness of fit of the ML estimations (that are performed by using Stata 16; Gould,

2010) is computed for each system of equations and evaluated by the likelihood-ratio (LR) test, whose scores are reported in the related tables.[2]

4. Estimation results

4.1 Determinants of LPT and private cars use

For each system of equations, the estimation of functions [1] and [2] first helps retrieving the choice to use or not more frequently the public transport and/or private cars in later life, by controlling for the most relevant socio-economics variables (also used as covariates in the estimation of functions [3], [4] and [5]). As expected, the findings about the determinants of the use of LPT and cars are very similar across the three systems (as displayed in Table 5, 6 and 7). Firstly, the coefficients show that LPT accessibility and residential parking issue (described in section 3.2) are negatively correlated with the probability to use LPT (range from -0.087 to -0.084, $p < 0.001$) and/or cars more frequently (from -0.115 to -0.101, $p < 0.001$).

Dealing with individual characteristics affecting transport use, as recognized in the recent ageing literature (Shrestha et al., 2017; Aguiar and Macário, 2017; Somenahalli et al., 2016; Klein-Hitpaß and Lenz, 2011), we found a striking heterogeneity of the elderly as a population group. Ageing is significantly related to an increasing use of LPT across the estimated systems (especially as age increases from 60-64 to 65-74 years, the coefficients range from +0.121 to +0.127, $p < 0.001$). By contrast, it is detected a lower probability of driving cars when entering the 65-74 age interval (coefficients ranging from -0.280 to -0.277, $p < 0.001$) and even more for over 75 (estimates around -0.958, $p < 0.001$). With respect to women, men reported to be less prone to use LPT many times a week (coefficients between -0.224 and -0.218, $p < 0.001$), but instead to be more willing to drive cars (range from +1.074 and +1.076, $p < 0.001$). As expected, living in larger families may imply the need for a higher trip flexibility (e.g., errands to run), therefore the LPT usage turns out to be reduced when being married (coefficients between -0.167 and -0.161, $p < 0.001$) and/or living with more than two persons (range from -0.194 to -0.184, $p < 0.001$), while driving a private car is more likely when being in a couple (about +0.382 in the three systems, $p < 0.001$). For increasing levels of education, better economic conditions (here proxied by income self-sufficiency) and intense social contacts, a more frequent use of cars (as a driver) is reported, suggesting a substitution effect between public and private means among old citizens, when the former are conceivably more affordable in case of family-aided elderly, and vice-versa (the coefficients related to the LPT use in case of self-sufficiency range from -0.120 to -0.109, $p < 0.001$). Lastly, with respect to the northern regions in Italy, older adults living in central or southern regions display lower transit-related mobility rates, probably because of lacking or inadequate services.

[2] The LR test considers the (double) difference between the log-likelihood of unrestricted models (including all the covariates) and that of (restricted) intercept-only models. In case of ordered probit models, intercepts are interpreted as the first cut point with reverse sign, since it reflects the predictive cumulative probabilities at zero-valued covariates (Greene and Hensher, 2010). The related LR test statistics (distributed χ_2 with degrees of freedom equal to the number of removed parameters in the restricted models) is associated with a *p-value* indicating whether the null hypothesis of indifference between the models can be rejected (see Table 5, 6 and 7).

4.2 Relationship between use frequency of transports and psycho-physical health

By inspecting Table 5, 6 and 7, respectively, the reported estimates of functions [3], [4] and [5] provide indications about how the use frequency of LPT and cars could be related to the three considered outcomes, i.e., mental, physical and self-perceived health in later life.
For what concerns the first outcome (mental health), other things being equal, we have found that, compared to people never using the LPT, older adults taking buses, trams and/or subway trains are more likely to feel joy and/or less depressive, with their everyday usage being particularly effective (+2.563, $p < 0.001$). In a similar way, compared to never driving a car, doing this more times a week lets older people overcome psychological harms, such as anxiety and melancholy (few times a week: +1.276, $p < 0.001$; every day: +1.691, $p = 0.002$). Among other covariates, we found that ageing, household composition, education and income type are not significantly related to the mental health condition, while its score is positively associated to: being male (+0.460, $p = 0.026$), not being divorced (-1.129, $p < 0.001$) or widowed (-0.746, $p < 0.001$), living in the North of Italy (Centre: -0.456, $p < 0.001$; South: -0.304, $p = 0.009$) and having strong ties with relatives and friends (two groups: +0.836, $p < 0.001$).

Insert Table 5 here

As far as the correlation between transports usage and physical conditions is concerned, interestingly the relative impacts are quite different for LPT and private cars. On the one hand, taking public transit is associated to overall better health conditions (captured in our data by the lack of key ageing-related diseases), especially when the usage frequency is few times a week (+0.324, $p = 0.002$) or every day (+0.459, $p = 0.002$), meaning that LPT policies should stimulate a more intense usage of active travels among the elderly. On the other hand, instead the ability to drive a car at increasing frequency rates was found not to be significantly related to physical conditions, except for a positive effect when considering older adults driving a car few times a month (+0.194, $p = 0.015$). Since car driving is clearly not an active transport mode, yet that occasional use of private cars might probably improve elderly's physical conditions only because healthcare services (including hospitals) are relatively easier to be reached. As for the other controls, ageing is a strong determinant of physical conditions, whose scores decline for people aged between 65 and 74 years (-0.370, $p < 0.001$) and over 75 years (-0.652, $p < 0.001$). Being male is associated to a better physical health status (+0.324, $p < 0.001$), while positive effects are detected also for married people (widowed: -0.214, $p < 0.001$), with higher education (middle school: +0.091, $p = 0.002$; high school: +0.163, $p < 0.001$; university degree: +0.241, $p < 0.001$) and living in the North of Italy (South and Islands: -0.228, $p < 0.001$). In our sample, other covariates are not statistically significant.

Insert Table 6 here

Interestingly, as regards the self-perceived health conditions in later life, we lastly found that the usage of LPT is associated to increasing odds of better overall health only when the elderly take transit every day (with respect to never: +0.315, $p < 0.001$), meaning that the subjective health status is likely improved when daily activities and trips are regularly supported by public transports. By contrast, as happened in the case of mental conditions, accessing and/or

driving a private car is a strong precondition for reporting a good self-perceived health even for a more sporadic usage (few times a month: +0.311, $p < 0.001$; few times a week: +0.397, $p < 0.001$; everyday: +0.496, $p < 0.001$). As far as other covariates are concerned, the subjective perception of health is worsened by age (65-74: -0.283, $p < 0.001$; 75+: -0.473, $p < 0.001$), being divorced (-0.132, $p = 0.014$) or widowed (-0.094, $p = 0.037$), having a lower education (middle school: +0.067, $p = 0.013$; high school: 0.188, $p < 0.001$; university degree: 0.312, $p < 0.001$), living in central or southern regions of Italy (Centre: -0.097, $p < 0.001$; South and Islands: -0.208, $p < 0.001$) and maintaining a contact with family and/or friends (one group: +0.095, $p = 0.003$; two groups: +0.142, $p < 0.001$). Considering other factors (included the financial self-sufficiency), they are not statistically related to own self-perceived health.

Insert Table 7 here

5. Discussion and policy implications

This paper aimed at contributing to the literature that considers local public transports not only as a mobility system to reach destinations (Metz, 2000), but also as an *active* way of travelling associated with health conditions of the heterogeneous elderly population. Moreover, by framing the analysis in the Italian context, the study highlights some interesting elements, implying potential policy patterns to improve the elderly's health conditions.

First, for what concerns the usage frequency of local public transports (with respect to private cars) in later life, when people get older than 65 years the usage of cars (as a driver) diminishes, while that of LPT increases (especially until 75 years). This finding is in line with the literature (Chatterjee et al., 2019; Kim and Ulfarsson, 2004) and confirms an overall trend related to physical disabilities, which limit the ability to drive in later life (Sikder and Pinjari, 2012). From the analysis emerges that the elderly men are more likely to be on the car drivers' seat than women. In fact, the percentage of old men holding a driving license is higher than women as affirmed in other studies (Ryan, 2020; Siren and Haustein, 2013). Such tendency seems to be smoothened in the last years as more women are involved in driving (Oxley et al, 2005). Instead, the elderly women are more frequent passengers of public transport than men as already indicated by other researchers (Ryan, 2020; Berg et al., 2015; Kim and Ulfarsson, 2004). Having said that, we emphasize the importance of investing in public transports systems to take care of social groups characterized by ageing-related fragilities and their own mobility needs (Johnson et al., 2017). More, from a social perspective, whereas older adults living in the North of Italy (i.e., the richest part of the country) (ISFORT, 2018), having a bachelor degree and keeping in contact with family members and friends (Ryan, 2020; Sikder and Pinjari, 2012), are conceivably more inclined to use private transport means; instead, living alone (Hess, 2009) and being not financially self-sufficient are conditions which were found to induce older citizens to resort to LPT (Ryan, 2020; Hess, 2009), that are relatively more affordable than cars (Yang 2018; Kim and Ulfarsoon, 2004). The need for infrastructural and/or service-oriented policies tailored to the older population is of primary importance and, thus, highly encouraged for the policy makers' toolkit. This aspect was pointed out in our analysis when LPT accessibility and residential parking issues have been used as instrumental variables to help removing endogeneity problems from the quantitative framework. A well-served public transport system facilitates participation in out-of-home social activities (Nordbakke, 2019). As described in section 2, relevant research verifies that the introduction of ageing-targeted transport policies, such as the free bus policy in the UK, will remove the financial burden and will encourage the over 65's to increase the public transport use (Reinhard et al. 2019; Laverty et al., 2018a). Recently, Willstrand et al. (2018) evaluated the effect of subsidized public transport for older citizens in three municipalities of Sweden and confirmed indeed that the lower the income the more the elderly exploit their transport card. Furthermore, Nocera et al. (2020) provide some general guidelines on how to best evaluate first-last mile accessibility of the transport systems, i.e., (a) identify first and last mile, (b) find the problem and perform cost analysis, (c) select the involved stakeholders, (d) spot the critical points of the process and (e) finally go for the best cost reduction strategies. The described process could be applied in an age-friendly transport system as well. Notably, whereas the usage of cars is affected by the supply of residential parking (Guo, 2013) – implying that mobility needs satisfied by motorized private vehicles would ask for additional slots in urban areas, with the consequence of

reducing green or traffic-free zones – our results confirm the fact that LPT services should be instead improved in terms of accessibility and connection in residence areas to make public transit a preferable and more frequent mobility choice for ageing people. In this case, the findings are in line with a recent literature (e.g., Chiatti et al., 2017; Ståhl et al., 2013), suggesting that public interventions might effectively increase the resort to LPT by the elderly and enhance their own social inclusion.

Second, regarding the relationship between transports usage and health conditions, it is important to stress the fact that in our analysis, in addition to having an impact on how often LPT and cars are used by the older people, the above-mentioned public transit accessibility and parking issues are alleged to have a mediated effect on health conditions. From a mental health perspective, for instance, since in our study a more intense use of LPT is associated with increasing feelings of joy and happiness (or, reducing anxiety and depression), therefore it would be essential to incentivize more frequent (or perhaps, daily) trips by LPT among the elderly, in order to prevent psychological harms that were found to be linked to a relative lack of social contacts and more present in the central and southern regions of Italy. Our findings are in line with recent British data (ELSA survey, 7th wave) where the LPT usage (enhanced in the UK by free bus passes) acted against depressive symptoms, also as a mediator for community and social participation (Jackson et al., 2019; Reinhard et al., 2018). Similarly, in a Swedish study about over 75 years old people (Chiatti et al., 2017) and in another one from the Netherlands (Van den Berg et al., 2016), well-organized LPTs (together with age-friendly built environments) were found to be linked to less depressive symptoms.
Turning to physical conditions, while in the Italian case they are reasonably worsened by age (in particular, above 75 years), two aspects which might slow down the ageing process are related to a higher education (presumably because of a better knowledge of health-preserving habits and more financial resources to access healthcare services) and the fact of living in relatively richer regions (in the South of Italy respondents reported worse physical conditions). How could transports have an impact on this? Since in our study driving a private car did not reveal significant effects on physical status, interestingly we found that LPT (especially when used at least some times a week) may have a sound link to better scores related to ageing-related harms, such as Type-2 diabetes, heart diseases and musculoskeletal problems (WHO, 2006). Of course, this relationship should be put in context. Given that being independent and maintain better health conditions is strictly connected to the ability to reach healthcare services and increase own physical activity (Syed et al., 2013; Schwanen et al., 2012), an additional attention should be given to the planning and organization of LPT (e.g., in terms of travel times and capillarity) in order to promote the overall quality of life of older people (Aguiar and Macàrio, 2017; Musselwhite and Haddad, 2010). In general, our findings confirmed the empirical evidence retrieved by not-Italian studies, which showed how LPT usage is associated with better overall physical health. For instance, in Australia, among the elderly aged between 60 and 84 years, LPT usage increased physical activity (ameliorating bones strength and flexibility) up to 33 mins per day (Rissel et al., 2012). Furthermore, although the present Italian survey lacks specific responses on cognitive-based conditions, an intuitive interpretation of the results would suggest that, compared to non-users, public transit users might also perform better in cognitive measures, e.g., memory, cognitive function, etc. (e.g., this aspect was considered in Reinhard et al., 2019).
Helping the elderly people remain healthy and active in our communities is valuable and well established in the scientific literature for the prevention of age-related pathologies such as

Parkinson (von Coelln et al., 2019), urinary incontinence (Fritel et al., 2013) and executive function (Tian et al., 2015). It merits here referring to the strong family ties of the southern European countries, also recognized in Alesina and Giuliano (2010). As a result, the longer the older people stay mobile the more they build on their own self-sufficiency (McPhee et al., 2016) and they are less dependent on the younger generations (Petretto and Pili, 2020).
Lastly, as for the self-perceived health of the elderly, similarly to the physical status, getting old and living in Italian southern regions are preconditions for lower subjective health scores. By contrast, having a better education and/or maintaining rather intense social contacts might contribute to lift the overall perception of wellness in later life. For what concerns the usage of transport means, it is interesting to notice that, besides the feelings of independence in daily activities connected to the lack of assistance needs, it is recognized that driving a car is also associated with a sense of accomplishment, and the literature provided evidence that also the elderly may consider the ability to drive a car many times a week a valuable activity in itself (Ory and Mokhtarian, 2005; Meyer, 1999). Whereas our findings are quite in line with that argument, by contrast, we found that the LPT usage is significantly associated to a good perceived health only when the public transit is used every day. Thus, *active* transportation among older people would be probably enhanced by acting on two kinds of policies. On the one hand, 'de-marketing' measures could aim at reducing the symbolic affection to private cars, or the intrinsic value of driving alone (Bergstad et al., 2011; Handy, 2005). On the other hand, transport-oriented policymakers should specifically organize transit systems to allow the elderly to use them with a higher intensity.

6. Conclusions

Although the present study has a few limitations, we still believe that its findings add evidence to the existing literature about the relationship between transports and health in later life and provide interesting policy implications. To the best of our knowledge, this is the first study covering the Italian case, where the aging population is rapidly increasing and where, as in other EU countries, both the accessibility to public transports and their usage is a key factor to ensure social inclusion and active aging in the future (Shergold et al., 2015). In fact, in the current status, no solid comparisons (where available) can be done at a country level, thus constraining our discussion the evidence in Italy with respect to other European countries. As regards the limitations of our study, they are mainly related to the type of available survey data. First, the used data are only cross-sectional, thus making it difficult to demonstrate causality relationships between variables. Exploiting panel data for different survey waves would therefore be useful to further improve the analysis. Second, referring to the used health indicators, the available data do not allow us to consider the relative weights of different pathologies. Secondary health data measuring the heterogeneous impact of specific diseases on the elderly' status might be retrieved and possibly used in a future analysis. Moreover, since the general health status is measured by self-perceived assessments, its values could be overestimated or underestimated. The shortage of informative datasets about transport, health and other life aspects therefore underlines the need to further enrich the data collection process, and the preliminary interesting findings of the study encourage more research efforts on this issue (Mulley et al., 2016). The availability of large datasets might allow future extension of the present work, considering for example

as outcome not only health but a comprehensive multidimensional indicator of well-being, feeding powerful techniques of data interpretation such as data mining (Tan et al., 2018).

As above highlighted, from a policy perspective, as the population pyramid is changing shape, our paper suggested that including transport systems in the wider toolkit of health promotion actions has become of primary importance. Particularly in urban and residential contexts, local public transports should be promoted as they assure more environmental sustainability than the private cars. Since the current COVID-19 pandemic has highlighted the need to reorganize the transport system (Musselwhite et al., 2020), it would be crucial to take the opportunity to implement specific age-friendly measures, taking in consideration the elderly needs as one of the most fragile and vulnerable social groups. Focusing on the Italian situation, the paper findings also highlight the need to promote a national transport policy for the elderly population, as it happens for instance in the UK (Butcher, 2015). In Italy, since the supply and demand for local public transport services are highly heterogeneous (ISFORT, 2019), also specific regional interventions should be promoted to support all the elderly mobility, wherever it is located. At present, systematic efforts to record the existing ageing-focused policies, exchange paradigms of successful planning and create synergies is missing and thus highly encouraged for the future research. Finally, the elderly mobility is a complex topic which takes place on several space levels as described in Webber et al. (2010) and the attribute factors can be either internal, i.e., psychological factors (Mifsud et al., 2019) or/and external to the older people i.e. the physical environment (Siu, 2019). Thus, a mixture of interventions, i.e., measures which facilitates accessibility to the built environment (van Hoven and Meijering, 2019), and the LPT system (Kim, 2011) together with actions of forming the elderly's perceptions about public transport (Kizony et al., 2020), are key ingredients for the promotion of LPT use.

APPENDIX A

In this appendix, we explicitly derive the three systems of equations which are the basis of the maximum likelihood (ML) estimation for each health outcome we considered in the study. Specifically, we used the mixed-process estimation method developed by Roodman (2011) that suitably applies to *recursive* systems (Greene, 2012), where certain equations use endogenous factors (in our case, the use frequency of transports) as dependent variables and other ones include them as explanatory variables for other outcomes – i.e., mental, physical and self-perceived health. Starting from the mental health (M), whose system is composed by functions [1], [2] and [3]:

$$\begin{cases} LPT_i = l \text{ only if } k_{l-1} \leq LPT_i^* = \theta_{i,LPT} + \varepsilon_{i,LPT} = \delta_0 \times Z_{i,LPT} + \boldsymbol{\delta}'\boldsymbol{X_i} + \varepsilon_{i,LPT} < k_l \\ Cars_i = h \text{ only if } k_{h-1} \leq Cars_i^* = \theta_{i,Cars} + \varepsilon_{i,Cars} = \tau_0 \times Z_{i,Cars} + \boldsymbol{\tau}'\boldsymbol{X_i} + \varepsilon_{i,Cars} < k_h \\ M_i = \theta_{i,M} + \varepsilon_{i,M} = \alpha_0 + \alpha_1 \times LPT_i + \alpha_2 \times Cars_i + \boldsymbol{\alpha}'\boldsymbol{X_i} + \varepsilon_{i,M} \end{cases}$$

The estimation of the impact of transport use on mental conditions in [3] takes advantage on estimates related to the determinants of the use of LPT and private cars themselves in [1] and [2], respectively. Besides the sequential nature of the process, the used method performs a ML simultaneous estimation, where the link function mapping from (potentially unobserved) predictors to observed values is the vector $\boldsymbol{y_M} = g(LPT^*; Cars^*; M^*) = \big(l \text{ if } k_{l-1} \leq LPT^* <$

k_l; h if $k_{h-1} \leq Cars^* < k_h$; $\theta_{i,M})'$. Normally-distributed error terms are in the vector $\boldsymbol{\varepsilon} = (\varepsilon_{LPT}, \varepsilon_{Cars}, \varepsilon_M)' \sim N(0, \Sigma_M)$, where Σ_M is the 3 x 3 covariance matrix of random terms related to the three above system equations.

Since errors can be correlated (implying a multidimensional distribution), the likelihood is computed by the integration of the normal probability distribution (whose covariance is Σ_M) over the feasible regions of errors. Hence, for sake of exposition, we define $f_{\varepsilon_{LPT}}(\varepsilon_{LPT})$, $f_{\varepsilon_{Cars}}(\varepsilon_{Cars})$ and $f_{\varepsilon_M}(\varepsilon_M)$ as the probability distribution functions over $(k_{l-1} - \theta_{i,LPT}, k_l - \theta_{i,LPT}]$, $(k_{h-1} - \theta_{i,Cars}, k_h - \theta_{i,Cars}]$ and $(-\infty, -\theta_{i,M}]$, respectively. Given that the integration of normal probability functions of recursive equations implies conditional distributions (i.e., ε_M given ε_{LPT} and ε_{Cars}) of a multivariate normal, by the Lemma 1 in Roodman (2011, p. 172), we can state the likelihood function as follows:

$$L_i(\delta_0, \boldsymbol{\delta}, \tau_0, \boldsymbol{\tau}, \alpha_0, \alpha_1, \alpha_2, \boldsymbol{\alpha}; \boldsymbol{y_{i,M}} | \theta_{i,LPT}, \theta_{i,Cars}, \theta_{i,M})$$
$$= \int_{k_{l-1}-\theta_{i,LPT}}^{k_l-\theta_{i,LPT}} \int_{k_{h-1}-\theta_{i,Cars}}^{k_h-\theta_{i,Cars}} \int_{-\infty}^{-\theta_{i,M}} \left(f_{\varepsilon_{LPT}(\varepsilon_{i,LPT})} f_{\varepsilon_{Cars}(\varepsilon_{i,Cars})} f_{\varepsilon_M|\varepsilon_{LPT},\varepsilon_{Cars}} \right) d\varepsilon_M d\varepsilon_{Cars} d\varepsilon_{LPT}$$
$$= \Phi\left\{ \left[(k_{l-1} - \theta_{i,LPT}, k_l - \theta_{i,LPT}), (k_{h-1} - \theta_{i,Cars}, k_h - \theta_{i,Cars}), -\theta_{i,M} \right]'; \Sigma_M \right\} \qquad \text{[A.1]}$$

where $\Phi\{\cdot\}$ is the related cumulative normal distribution. Analogously, when dealing with the physical status (P), the related system does include the functions [1], [2] and [4]:

$$\begin{cases} LPT_i = l \text{ only if } k_{l-1} \leq LPT_i^* = \theta_{i,LPT} + \varepsilon_{i,LPT} = \delta_0 \times Z_{i,LPT} + \boldsymbol{\delta}'\boldsymbol{X_i} + \varepsilon_{i,LPT} < k_l \\ Cars_i = h \text{ only if } k_{h-1} \leq Cars_i^* = \theta_{i,Cars} + \varepsilon_{i,Cars} = \tau_0 \times Z_{i,Cars} + \boldsymbol{\tau}'\boldsymbol{X_i} + \varepsilon_{i,Cars} < k_h \\ P_i = \theta_{i,P} + \varepsilon_{i,P} = \beta_0 + \beta_1 \times LPT_i + \beta_2 \times Cars_i + \boldsymbol{\beta}'\boldsymbol{X_i} + \varepsilon_{i,M} \end{cases}$$

and the likelihood function takes the following formulation, like in A.1:

$$L_i(\delta_0, \boldsymbol{\delta}, \tau_0, \boldsymbol{\tau}, \beta_0, \beta_1, \beta_2, \boldsymbol{\beta}; \boldsymbol{y_{i,P}} | \theta_{i,LPT}, \theta_{i,Cars}, \theta_{i,P})$$
$$= \int_{k_{l-1}-\theta_{i,LPT}}^{k_l-\theta_{i,LPT}} \int_{k_{h-1}-\theta_{i,Cars}}^{k_h-\theta_{i,Cars}} \int_{-\infty}^{-\theta_{i,P}} \left(f_{\varepsilon_{LPT}(\varepsilon_{i,LPT})} f_{\varepsilon_{Cars}(\varepsilon_{i,Cars})} f_{\varepsilon_P|\varepsilon_{LPT},\varepsilon_{Cars}} \right) d\varepsilon_P d\varepsilon_{Cars} d\varepsilon_{LPT}$$
$$= \Phi\left\{ \left[(k_{l-1} - \theta_{i,LPT}, k_l - \theta_{i,LPT}), (k_{h-1} - \theta_{i,Cars}, k_h - \theta_{i,Cars}), -\theta_{i,P} \right]'; \Sigma_P \right\} \qquad \text{[A.2]}$$

As far as the last outcome is concerned, since in this study self-perceived health conditions (S) are measured in an ordinal way, the following system of equations (including functions [1], [2] and [5]):

$$\begin{cases} LPT_i = l \text{ only if } k_{l-1} \leq LPT_i^* = \theta_{i,LPT} + \varepsilon_{i,LPT} = \delta_0 \times Z_{i,LPT} + \boldsymbol{\delta}'\boldsymbol{X_i} + \varepsilon_{i,LPT} < k_l \\ Cars_i = h \text{ only if } k_{h-1} \leq Cars_i^* = \theta_{i,Cars} + \varepsilon_{i,Cars} = \tau_0 \times Z_{i,Cars} + \boldsymbol{\tau}'\boldsymbol{X_i} + \varepsilon_{i,Cars} < k_h \\ S_i = s \text{ only if } k_{s-1} \leq S_i^* = \theta_{i,S} + \varepsilon_{i,S} = \gamma_1 \times LPT_i + \gamma_2 \times Cars_i + \boldsymbol{\gamma}'^{\boldsymbol{X_i}} + \varepsilon_{i,S} < k_s \end{cases}$$

the related likelihood function incorporates the fact that all the equations are modelled as ordered probit models. As a consequence, we can state this as:

$$L_i(\delta_0, \boldsymbol{\delta}, \tau_0, \boldsymbol{\tau}, \gamma_1, \gamma_2, \boldsymbol{\gamma}; \boldsymbol{y_{i,S}} | \theta_{i,LPT}, \theta_{i,Cars}, \theta_{i,S})$$
$$= \int_{k_{l-1}-\theta_{i,LPT}}^{k_l-\theta_{i,LPT}} \int_{k_{h-1}-\theta_{i,Cars}}^{k_h-\theta_{i,Cars}} \int_{k_{s-1}-\theta_{i,S}}^{k_s-\theta_{i,S}} \left(f_{\varepsilon_{LPT}(\varepsilon_{i,LPT})} f_{\varepsilon_{Cars}(\varepsilon_{i,Cars})} f_{\varepsilon_S|\varepsilon_{LPT},\varepsilon_{Cars}} \right) d\varepsilon_S d\varepsilon_{Cars} d\varepsilon_{LPT}$$
$$= \Phi\left\{\left[(k_{l-1} - \theta_{i,LPT}, k_l - \theta_{i,LPT}), (k_{h-1} - \theta_{i,Cars}, k_h - \theta_{i,Cars}), (k_{s-1} - \theta_{i,S}, k_s - \theta_{i,S})\right]'; \Sigma_S\right\}$$
[A.3]

Again, following Roodman (2011, p. 181), in order to estimate integrals of multivariate normal distributions of dimension 3 or higher (as in our case for each system of equations) for probit models, the likelihood of cumulative distributions is simulated by numerical methods base on the Monte Carlo technique (Train, 2009). In particular, in order to estimate cumulative probabilities over bounded regions, the Stata-based used estimation resorts to the Geweke-Hajivassiliou-Keane (GHK) algorithm (Gates, 2006; Hajivassiliou and McFadden, 1998; Keane, 1994; Geweke, 1989), which samples data in a recursive way (we set 10 draws for each estimation; Drukker and Gates, 2006) from a truncated normal distribution and approximates the multivariate normal distribution. Details about the GHK algorithm are also provided in Roodman (2011, p. 182; Appendix C, p. 204).

References

Abdullah, N.N., Ahmad Saman, M.S., Kahn, S.M., Al-Kubaisy, W., 2018. Older People with Mobility Disability (Quality Of Life). Asian Journal of Quality of Life, 3(11), 103-111. https://doi.org/10.21834/ajqol.v3i11.126.

Aguiar, B., Macário, R., 2017. The need for an elderly centred mobility policy. Transportation Research Procedia, 4355–4369. https://doi.org/10.1016/j.trpro.2017.05.309.

Alesina, A., Giuliano, P., 2010. The power of the family. Journal of Economic Growth, 15, 93–125. https://doi.org/10.1007/s10887-010-9052-z

American Public Transport Association (APTA), 2020. The COVID-19 pandemic public transportation responds: safeguarding riders and employees. Retrieved from: https://www.apta.com/wp-content/uploads/COVID-19_Transit_Guide_FINAL_04132020.pdf.

Beimborn, E. A., Greenwald, M. J., Jin, X., 2003. Accessibility, connectivity, and captivity, Transportation Research Record, 1835, pp. 1–9. https://doi.org/10.3141/1835-01.

Berg, J., Levin, L., Abramsson, M., Hagberg, J., 2015. "I want complete freedom": car use and everyday mobility among the newly retired. European Transport Research Review, 7(31), 1-10. https://doi.org/10.1007/s12544-015-0180-6.

Bergstad, C. J., Gamble, A., Hagman, O., Polk, M., Garling, T., Olsson, L. E., 2011. Affective-symbolic and instrumental-independence psychological motives mediating effects of socio-demographic variables on daily car use. Journal of Transport Geography, 19, 33–38. https://doi.org/10.1016/j.jtrangeo.2009.11.006.

Brown, J.R., Duncan, M., Horner, M.W., Bond, M., Wood, J., 2018. Provider perspectives on six strategies to overcome the barriers to older adult use of alternative transportation services: Evidence from seven communities. Case Studies on Transport Policy, 6, 237–245. https://doi.org/10.1016/j.cstp.2018.04.004.

Butcher, L., 2015. Concessionary bus fare Briefing paper SN 01499. House of Commons Library. Retrieved from https://www.gov.uk/apply-for-elderly-person-bus-pass.

Chatterjee, K., Clark, B. Nguyen, A., Wishart, R., Gallop, K., Smith, N., Tipping, S., 2019 Access to Transport and Life Opportunities, Department for Transport. Retrieved from

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831766/access_to_transport_report.pdf.
Chiatti, C., Westerlund, Y., Ståhl, A., 2017. Access to public mobility services and health in old age: A cross-sectional study in three Swedish cities. Journal of Transport & Health, 7, 218–226. https://doi.org/10.1016/j.jth.2017.09.001.
Clougherty, J.A., Duso, T., Muck, J., 2015. Correcting for self-selection based endogeneity in management research: review, recommendations and simulations. Organizational Research Methods, 19(2), 286-347. https://doi.org/10.1177/1094428115619013
Coronini-Cronberg, S., Millett, C., Laverty, A.A., Webb, E., 2012. The impact of a free older persons' bus pass on active travel and regular walking in England. American Journal of Public Health, 102(11), 2141–2148. https://doi.org/10.2105/AJPH.2012.300946.
Curcio, F., Basile, C., Liguori, I., Della-Morte, D., Gargiulo, G., Galizia, G., Testa, G., Langellotto, A., Cacciatore, F., Bonaduce, D., Abete P., 2016. Tinetti mobility test is related to muscle mass and strength in non-institutionalized elderly people. Age, 38, 525–533. https://doi.org/10.1007/s11357-016-9935-9.
Dabelko-Schoeny, H., Fields, N.L., White, K., Sheldon Kristen Ravi, M., Robinson, S.R., Murphy, I.E. Jennings, C., 2020. Using Community- Based Participatory Research Strategies in Age-Friendly Communities to Solve Mobility Challenges, Journal of Gerontological Social Work, https://doi.org/10.1080/01634372.2020.1769787.
Doblas, J. L., Conde, M. D. P. D., 2018. Widowhood, loneliness, and health in older age. Revista Espaniola de Geriatria y Gerontologia, 53(3), 128-133. https://doi.org/10.1016/j.regg.2017.09.005.
Drukker, D. M., Gates, R. 2006. Generating Halton sequences using Mata. Stata Journal, 6, 214–228. https://doi.org/10.1177/1536867X0600600204
Duncan, C. S., Khattak, A. J., and F.M. Council, 1998. Applying the ordered probit model to injury severity in truck-passenger car rear-end collisions, Transportation Research Record, 1635(1), 63–71. https://doi.org/10.3141/1635-09
Fishman, E., Boecker, L., Helbich, M., 2015. Adult active transport in the Netherlands: an analysis of its contribution to physical activity requirements. Plos One, 10, 4. https://doi.org/10.1371/journal.pone.0121871.
Fritel, X., Lachal, L., Cassou, B., Fauconnier, A., Dargent-Molina, P., 2013. Mobility impairment is associated with urge but not stress urinary incontinence in community-dwelling older women: Results from the Ossébo study. BJOG. 120(12), 1566–1572. https://doi.org/10.1111/1471-0528.12316.
Gagliardi, C., Marcellini, F., Papa, R., Giuli, C., Mollenkopf, H., 2010. Associations of personal and mobility resources with subjective well-being among older adults in Italy and Germany. Archives of Gerontology and Geriatrics, 50, 42–47. https://doi.org/10.1016/j.archger.2009.01.007.
Gates, R., 2006. A Mata Geweke–Hajivassiliou–Keane multivariate normal simulator, Stata Journal 6(2), 190–13. https://doi.org/10.1177/1536867X0600600203.
Geweke, J., 1989. Bayesian inference in econometric models using Monte Carlo integration. Econometrica, 57, 1317–1339. https://doi.org/10.2307/1913710.
Gibbons J.D., Chakraborti S., 2011. Nonparametric Statistical Inference. In: Lovric M. (eds) International Encyclopedia of Statistical Science. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-04898-2_420.
Gould, W., J. Pitblado, and B. Poi, 2010. Maximum Likelihood Estimation with Stata, 4th ed. College Station, TX: Stata Press.
Green, J., Jones, A., Roberts, H., 2014. More than A to B: the role of free bus travel for the mobility and wellbeing of older citizens in London. Ageing and Society, 34, 472–494. https://doi.org/10.1017/S0144686X12001110.
Greene, W. H., 2012. Econometric Analysis (7th ed.), Upper Saddle River, NJ: Prentice Hall.
Green, W.H., Hensher, D., 2010. Modeling ordered choices: a primer. Cambridge University Press. https://doi.org/10.1017/CBO9780511845062

Grenier, A., Griffin, M., Andrews, G., Wilton, R., Burke, E. Ojembe, B., Feldman, B., Papaioannou, A., 2019. Meanings and feelings of (Im)mobility in later life: Case study insights from a 'New Mobilities' perspective. Journal of Aging Studies, 51, 100819. https://doi.org/10.1016/j.jaging.2019.100819.

Guo, Z., 2013. Does residential parking supply affect household car ownership? The case of New York City. Journal of Transport Geography, 26, 18-28. https://doi.org/10.1016/j.jtrangeo.2012.08.006.

Hajivassiliou, V. A., and D. L. McFadden, 1998. The method of simulated scores for the estimation of LDV models, Econometrica, 66, 863–896.

Hansen, S., Newbold, KB, Scott, DM, Vrkljan, B., Grenier, A., 2020. To drive or not to drive: Driving cessation amongst older adults in rural and small towns in Canada. Journal of Transport Geography, 86, 102773.https://doi.org/10.1016/j.jtrangeo.2020.102773.

Handy, S. L., Weston, L., Mokhtarian, P.L., 2005. Driving by choice or necessity? Transportation Research Part A: Policy and Practice, 39(2-3), 183–203. https://doi.org/10.1016/j.tra.2004.09.002.

Hess, D.B., 2009. Access to public transit and its influence on ridership for older adults in two US cities. Journal of Transport and Land Use, 2(1), 3–27. https://doi.org/10.5198/jtlu.v2i1.11.

Holt-Lunstad, J., Smith, T.B., Layton, J.B. 2010. Social relationships and mortality risk: A meta-analytic review. PLoS Medicine, 7, e1000316. https://doi.org/10.1371/journal.pmed.1000316.

Hounsell, N.B., Shrestha, B.P., McDonald, M., Wong, A., 2016. Open data and the needs of older people for public transport information. Transportation Research Procedia, 14, 4334–4343. https://doi.org/10.1016/j.trpro.2016.05.355.

ISFORT, 2019. Osservatorio "Audimob" sulla mobilità degli italiani. Retrieved from https://www.isfort.it/progetti/16-rapporto-sulla-mobilita-degli-italiani-audimob/.

ISFORT, 2018. Osservatorio "Audimob" sulla mobilità degli italiani. Retrieved from https://www.isfort.it/progetti/rapporto-sulla-mobilita-in-italia-2018/

ISTAT, 2019. Multipurpose survey "Aspects of Daily Life", 2017 data. ISTAT, Rome, Italy. Retrieved from https://www.istat.it/it/archivio/129956.

Jackson, S.E., Firth, J.A., Firth, J., Veronese, N., Gorely, T., Grabovac, I., Yang, L., Smith, L., 2019. Social isolation and physical activity mediate associations between free bus travel and wellbeing among older adults in England. Journal of Transport & Health, 13, 274–284. https://doi.org/10.1016/j.jth.2019.03.006.

Johnson, R., Shaw, J., Berding, J., Gather, M., Rebstock, M., 2017. European national government approaches to older people's transport system needs. Transport Policy, 59, 17–27. https://doi.org/10.1016/j.tranpol.2017.06.005.

Keane, M. P., 1994. A computationally practical simulation estimator for panel data. Econometrica, 62, 95–116.

Kim, S., 2011. Assessing mobility in an aging society: Personal and built environment factors associated with older people's subjective transportation deficiency in the US. Transportation Research Part F: Traffic Psychology and Behaviour, 14, 422-429. https://doi.org/10.1016/j.trf.2011.04.011.

Kim, J., Schmöckerb, J. D., Nakamura, T., Uno, N., Iwamoto, T., 2020. Integrated impacts of public transport travel and travel satisfaction on quality of life of older people Transportation Research Part A: Policy and Practice, , 15-27. https://doi.org/10.1016/j.tra.2020.04.019.

Kim, S., Ulfarsson, G., 2004. Travel mode choice of the elderly – effects of personal, household, neighborhood, and trip characteristics. Transportation Research. Record. 1894, 117–126. https://doi.org/10.3141/1894-13.

Kizony, R., Schreuer, N., Rotenberg, S., Shach-Pinsly, D., Sinoff, G., Plaut, P., 2020. Participation in out-of-home activities among older adults: the role of mobility, attitudes and travel behaviors. Journal of Transport & Health, 17, 100846. https://doi.org/10.1016/j.jth.2020.100846.

Klein-Hitpaß, A., Lenz, B., 2011. Mobility of the Elderly – Facts and Projections, in: Kronenberg, T., Kuckshinrichs, W. (Eds.), Demography and Infrastructure. Springer Netherlands, Dordrecht, 167–188. https://doi.org/10.1007/978-94-007-0458-9_9.

Kuosmanen, K., et al., 2016. Determinants of self-rated health and self-rated physical fitness in middle and old age. European Journal of Mental Health, 11 (1-2), 128–143. https://doi.org/10.5708/EJMH.11.2016.1-2.8.

Kwon, Y., Byun, J., and S. Park, 2020. Exploring the determinants of bus drivers job satisfaction: Evidence from South Korea, Research in Transportation Business & Management. https://doi.org/10.1016/j.rtbm.2020.100436.

Laverty, A.A., Mindell, J.S., Webb, E.A., Millett, C., 2013. Active travel to work and cardiovascular risk factors in the United Kingdom. American Journal of Preventive Medicine, 45(3), 282–288. https://doi.org/10.1016/j.amepre.2013.04.012.

Laverty, A.A., Millett, C., Webb, E., 2018a. Take up and use of subsidised public transport: Evidence from the English Longitudinal Study of Ageing. Journal of Transport & Health, 8, 179–182. https://doi.org/10.1016/j.jth.2018.01.004.

Laverty, A.A., Webb, E., Vamos, E.P., Millett, C., 2018b. Associations of increases in public transport use with physical activity and adiposity in older adults. International Journal of Behavioral Nutrition and Physical Activity. 15(1), 31. https://doi.org/10.1186/s12966-018-0660-x.

Lee, S., Choi, H., 2019. Impact of older adults' mobility and social participation on life satisfaction in South Korea. Asian Social Work and Policy Review, 00:1–7. https ://doi.org/10.1111/aswp.12187.

Legendre, A., Keerle, R., Gonguet, S., 2014. Elderly women's use of public transport and evolution from before to after retirement. Proceedings Women issues in transportation "Bridging the Gap". 5th International Conference - Paris 14-16 April 2014. Retrieved from: https://wiit-paris2014.sciencesconf.org/conference/wiit-paris2014/pages/Proceedings_The_5th_International_Conference_on_WIiT.pdf.

Levin, L., Berg, J., 2009. Older Women and Men in Public Transport: Active Actors in Creating their own Mobility? Proceedings of the Sustaining Everyday Life Conference: April 22–24 2009; Campus Norrköping; Sweden, 038, 117-118. Retrieved from: https://ep.liu.se/ecp/038/020/ecp0938020.pdf.

Litman, T., 2010. Evaluating public transportation health benefits. The American Public Transportation Association. Victoria Transport Policy Institute. Retrieved from https://todresources.org/app/uploads/sites/2/2016/06/tran_health.pdf.

Liu, Y., Cheng, T., 2018. Understanding public transit patterns with open geodemographics to facilitate public transport planning. Transportmetrica A: Transport Science, https://doi.org/10.1080/23249935.2018.1493549.

López Doblas, J., Díaz Conde, M. del P., 2018. Viudedad, soledad y salud en la vejez. Revista Española de Geriatría y Gerontología, 53, 128–133. https://doi.org/10.1016/j.regg.2017.09.005.

Lund, R., Nilsson, C.J., Avlund, K., 2010. Can the higher risk of disability onset among older people who live alone be alleviated by strong social relations? A longitudinal study of non-disabled men and women. Age and Ageing, 39 (3), 319–326. https://doi.org/10.1093/ageing/afq020.

Mariotti, I., Brouwer, A.E., Gelormini, M., 2018. Is Milan a City for Elderly? Mobility for Aging in Place. Journal of Land Use, Mobility and Environment, 95–104. https://doi.org/10.6092/1970-9870/5764.

Marottoli, R.A., de Leon, C.F.M., Glass, T.A., Williams, C.S., Cooney, L.M., Berkman, L.F., Tinetti, M.E., 1997. Driving cessation and increased depressive symptoms: prospective evidence from the New Haven EPESE. Journal of the American Geriatrics, 45, 202–206. https://doi.org/10.1111/j.1532-5415.1997.tb04508.x.

McPhee, J.S., French, D.P., Jackson, D., Nazroo, J., Pendleton, N., Degens, H., 2016. Physical activity in older age: perspectives for healthy ageing and frailty. Biogerontology, 17, 567–580. https://doi.org/10.1111/10.1007/s10522-016-9641-0.

Metz, D.H., 2000. Mobility of older people and their quality of life. Transport Policy, 7, 149–152. https://doi.org/10.1016/S0967-070X(00)00004-4.
Meyer, M., 1999. Demand management as an element of transportation policy: using carrots and sticks to influence travel behaviour. Transportation Research Part A: Policy and Practice, 33, 575–599. https://doi.org/10.1016/S0965-8564(99)00008-7.
Mifsud, D., Attard, M., Ison, S., 2019. An exploratory study of the psychological determinants of mobility of older people in Malta. Research in Transportation Business & Management 30, 100373. https://doi.org/10.1016/j.rtbm.2019.100373.
Mulley, C., Rizzi, L.I., Millett, C., Shiftan, Y., 2016. Public transport and health: Publicising the evidence. Journal of Transport & Health, 3, 131–132. https://doi.org/10.1016/j.jth.2016.05.129.
Murray, A., Musselwhite, C., 2019. Older peoples' experiences of informal support after giving up driving. Research in Transportation Business & Management, 30, 100367. https://doi.org/10.1016/j.rtbm.2019.100367.
Musselwhite, C., Avineri, E., Susilo, Y., 2020. Editorial JTH 16 –The Coronavirus Disease COVID-19 and implications for transport and health. Journal of Transport & Health, 16, 100853. https://doi.org/10.1016/j.jth.2020.100853.
Musselwhite, C., Haddad, H., 2010. Mobility, accessibility and quality of later life. Quality in Ageing and Older Adults, 11, 25–37. https://doi.org/10.5042/qiaoa.2010.0153.
Musich, S., Wang, S.S., Ruiz, J., Hawkins, K., Wicker, E., 2018. The impact of mobility limitations on health outcomes among older adults. Geriatric Nursing, 39, 162–169. https://doi.org/10.1016/j.gerinurse.2017.08.002.
Nascimento, C.D.M., Mambrini, J.V.D.M., De Oliveira, C.M., Giacomin, K.C., Peixoto, S.V., 2015. Diabetes, hypertension and mobility among Brazilian older adults: Findings from the Brazilian National Household Sample Survey (1998, 2003 and 2008). BMC Public Health, 15. https://doi.org/10.1186/s12889-015-1956-2.
Nakanishi, H., Black, J.A., 2015. Travel habit creation of the elderly and the transition to sustainable transport: an exploratory research based on a retrospective survey. International Journal of Sustainable Transportation. http://dx.doi.org/10.1080/15568318.2015.1059526.
National Academies of Sciences, Engineering, and Medicine 2014. A Guide for Public Transportation Pandemic Planning and Response. Washington, DC: The National Academies Press. https://doi.org/10.17226/22414.
Ngandu, T., et al., 2015. A 2-year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. Lancet, 385 (9984), 2255–2263. https://doi.org/10.1016/S0140-6736(15)60461-5.
Nocera, S., Pungillo, G., Bruzzone, F., 2020. How to evaluate and plan the freight-passengers first-last mile. Transport Policy. https://doi.org/10.1016/j.tranpol.2020.01. 007.
Nordbakke, S., 2019. Mobility, Out-of-Home Activity Participation and Needs Fulfilment in Later Life. International Journal of Environmental Research of Public Health. 16, 5109. https://doi.org/10.3390/ijerph16245109.
Nordbakke, S., Schwanen, T., 2015. Transport, unmet activity needs and wellbeing in later life: exploring the links. Transportation, 42, 1129–1151. https://doi.org/10.1007/s11116-014-9558-x.
Nordbakke, S., Schwanen, T., 2014. Well-being and Mobility: A Theoretical Framework and Literature Review Focusing on Older People. Mobilities, 9, 104–129. https://doi.org/10.1080/17450101.2013.784542.
Norwood, P., 2014. Active travel intervention and physical activity behaviour: An evaluation. Social Science & Medicine, 113, 50-58. http://dx.doi.org/10.1016/j.socscimed.2014.05.003.
Ory, D. T., Mokhtarian, P. L., 2005. When is getting there half the fun? Modelling the liking for travel, Transportation Research Part A: Policy and Practice, 39, 97–123. https://doi.org/10.1016/j.tra.2004.09.006.

Oxley, J., Charlton, J., Fildes, B., Koppel, S., Scully, J., Congiu, M., Moore, K., 2005. Crash risk of older female drivers, Monash University Accident Research Centre, Report No. 245. Retrieved from: https://www.monash.edu/muarc/archive/our-publications/reports/muarc245.

Pantelaki, E., Maggi, E., Crotti, D., 2020 (forthcoming). Elderly mobility under the microscope: a multidisciplinary systematic review. Pedestrians, Urban spaces and Health. Proceedings of the XXIV International Conference on Living and Walking in Cities (LWC 2019), September 12-13, 2019, Brescia, Italy, Taylor & Francis.

Petretto, D.R., Pili, R., 2020. Ageing and COVID-19: What is the Role for Elderly People? Geriatrics 5, 25. https://doi.org/10.3390/geriatrics5020025.

Poduri, K.R., 2017. Geriatric rehabilitation: from bedside to curbside. CRC Press, Taylor & Francis Group, Boca Raton.

Rantanen, T., et al., 2015. The effect of an outdoor activities' intervention delivered by older volunteers on the quality of life of older people with severe mobility limitations: a randomized controlled trial. Aging and Clinical Experimental Research, 27 (2), 161–169. http://dx.doi.org/10.1007/s40520-014-0254-7.

Reinhard, E., Carrino, L., Courtin, E., van Lenthe, F.J., Avendano, M., 2019. Public transportation use and cognitive function in older age: a quasi-experimental evaluation of the free bus pass policy in the United Kingdom. American Journal of Epidemiology, 188, 1774–1783. https://doi.org/10.1093/aje/kwz149.

Reinhard, E., Courtin, E., van Lenthe, F.J., Avendano, M., 2018. Public transport policy, social engagement and mental health in older age: a quasi-experimental evaluation of free bus passes in England. Journal of Epidemiology and Community Health, 72, 361–368. https://doi.org/10.1136/jech-2017-210038.

Rissel, C., Curac, N., Greenaway, M., Bauman, A., 2012. Physical activity associated with public transport use—a review and modelling of potential benefits. International Journal of Environmental Research and Public Health, 9, 2454–2478. https://doi.org/10.3390/ijerph9072454.

Rojas-Rueda, D., de Nazelle, A., Teixidó, O., Nieuwenhuijsen, M.J., 2012. Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: A health impact assessment study. Environment International, 49, 100–109. https://doi.org/10.1016/j.envint.2012.08.009.

Ryan, J., Wretstrand, A. and Schmidt, S.M., 2015. Exploring public transport as an element of older persons' mobility: A Capability Approach perspective. Journal of Transport Geography, 48, 105–114. https://doi.org/10.1016/j.jtrangeo.2015.08.016.

Ryan, J., 2020. Examining the Process of Modal Choice for Everyday Travel among Older People. International Journal of Environmental Research & Public Health, 17, 691. https://doi.org/10.3390/ijerph17030691.

Roodman, D., 2011. Fitting Fully Observed Recursive Mixed-process Models with *cmp*. The Stata Journal, 11, 159–206. https://doi.org/10.1177/1536867X1101100202

Rouxel, P., Webb, E., Chandola, T., 2017. Does public transport use prevent declines in walking speed among older adults living in England? A prospective cohort study. BMJ Open, 7, e017702. https://doi.org/10.1136/bmjopen-2017-017702.

Sallis, J.F., Cervero, R.B., Ascher, W., Henderson, K.A., Kraft, M.K., Kerr, J., 2006. An ecological approach to creating active living communities. Annual Review of Public Health, 27, 297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100.

Shergold, I., Lyons, G., and C. Hubers, 2015. Future mobility in an ageing society – Where are we heading? Journal of Transport & Health, 2(1), 86-94. https://doi.org/10.1016/j.jth.2014.10.005

Shrestha, B.P., Millonig, A., Hounsell, N.B., McDonald, M., 2017. Review of public transport needs of older people in European context. Population Ageing, 10, 343–361. https://doi.org/10.1007/s12062-016-9168-9.

Sikder, S., Pinjari, A.R., 2012. Immobility levels and mobility preferences among elderly in the United States. Transportation Research Record: Journal of Transportation Research Board, 2318, 137-147. http://dx.doi.org/10.3141/2318-16.

Siren, A., Haustein, S., 2013. Babyboomers' mobility patterns and preferences: what are the implications for future transport? Transport Policy, 29, 136–144. http://dx.doi.org/10.1016/j.tranpol.2013.05.001.

Siu, B.W.Y., 2019. Assessment of physical environment factors for mobility of older adults: A case study in Hong Kong. Research in Transportation Business & Management, 30, 100370. https://doi.org/10.1016/j.rtbm.2019.100370.

Somenahalli, S., Hayashi, Y., Taylor, M., Akiyama, T., Adair, T., Sawada, D., 2016. Accessible transportation and mobility issues of elderly — how does Australia compare with Japan? Journal of Sustainable Urbanization, Planning and Progress, 1(1), 31–43. http://dx.doi.org/10.18063/JSUPP.2016.01.001.

Spinney, J.E.L., Newbold, K.B., Scott, D.M., Vrkljan, B., Grenier, A., 2020. The impact of driving status on out-of-home and social activity engagement among older Canadians. Journal of Transport Geography, 85, 102698. https://doi.org/10.1016/j.jtrangeo.2020.102698.

Ståhl, A., et al., 2008. "Let's go for a walk!": identification and prioritisation of accessibility and safety measures involving elderly people in a residential area. European Journal of Ageing, 5 (3), 265–273. https://doi.org/10.1007/s10433-008-0091-7.

Sugai, K., Michikawa, T., Takebayashi, T., Nishiwaki, Y., 2019. Association between muscle strength, mobility, and the progression of hyperkyphosis in the elderly: The Kurabuchi Cohort Study. Journals of Gerontology - Series A Biological Sciences and Medical Sciences, 74 (12), 1987–1992. https://doi.org/10.1093/gerona/glz136.

Sunderaraman, P., Maidan, I., Kozlovski, T., Apa, Z., Mirelman, A., Hausdorff, J.M., Stern, Y., 2019. Differential associations between distinct components of cognitive function and mobility: implications for understanding aging, turning and dual-task walking. Frontiers in Aging Neuroscience, 11, 13. https://doi.org/10.3389/fnagi.2019.00166.

Syed, S.T., Gerber, B.S., Sharp, L.K., 2013. Traveling towards disease: transportation barriers to health care access. Journal of Community Health, 38 (5), 976–993. https://doi.org/10.1007/s10900-013-9681-1.

Tan, P.-N., Steinbach, M., Karpatne, A., & Kumar, V., 2018. Introduction to data mining (2nd ed.). New York, NY: Pearson.

Tian, Q., Resnick, S.M., Ferrucci, L., Studenski, S.A., 2015. Intra-individual lap time variation of the 400-m walk, an early mobility indicator of executive function decline in high-functioning older adults? Age, 37: 115. https://doi.org/10.1007/s11357-015-9855-0

Train, K., 2009. Discrete choice methods with simulation. Cambridge University Press. https://doi.org/10.1017/CBO9780511805271

United Nations, Department of Economic and Social Affairs, Population Division, 2020. World population ageing, 2019 highlights. Retrieved from https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Highlights.pdf.

von Coelln, R., Dawe, R.J., Leurgans, S.E., Curran, T.A., Truty, T., Yu, L., Barnes, L.L., Shulman, J.M., Shulman, L.M., Bennett, D.A., Hausdorff J.M., Buchman A.S., 2019. Quantitative mobility metrics from a wearable sensor predict incident parkinsonism in older adults. Parkinsonism and Related Disorders, 65, 190–196. https://doi.org/10.1016/j.parkreldis.2019.06.012.

van den Berg, P., Kemperman, A., de Kleijn, B., Borgers, A., 2016. Ageing and loneliness: The role of mobility and the built environment. Travel Behaviour and Society, 5, 48–55. https://doi.org/10.1016/j.tbs.2015.03.001.

van Hoven, B., Meijering, L., 2019. Mundane mobilities in later life - Exploring experiences of everyday trip-making by older adults in a Dutch urban neighbourhood. R Research in Transportation Business & Management, 30, 100375. https://doi.org/10.1016/j.rtbm.2019.100375.

Webb, E., Laverty, A., Mindell, J., Millett, C., 2016. Free bus travel and physical activity, gait speed, and adiposity in the English Longitudinal Study of Ageing. American Journal of Public Health, 106, 136–142. https://doi.org/10.2105/AJPH.2015.302907.

Webb, E., Netuveli, G., Millett, C., 2012. Free bus passes, use of public transport and obesity among older people in England. Journal of Epidemiology and Community Health, 66, 176–180. https://doi.org/10.1136/jech.2011.133165.

Webber, S.C., Porter, M.M., Menec, V.H., 2010. Mobility in older adults: a comprehensive framework. The Gerontologist, 50, 443–450. https://doi.org/10.1093/geront/gnq013.

Wilby, M.L., 2019. Physical mobility impairment and risk for cardiovascular disease. Health Equity, 3, 527–531. https://doi.org/10.1089/heq.2019.0065.

Wooldridge, J. M., 2010. Econometric Analysis of Cross Section and Panel Data, 2nd ed. Cambridge, MIT Press.

Wong, R.C.P., Szeto, W.Y., Yang, L., Li, Y.C., Wong, S.C., 2018. Public transport policy measures for improving elderly mobility. Transport Policy, 63, 73–79. https://doi.org/10.1016/j.tranpol.2017.12.015.

WHO, 2018. The Global Network for Age-friendly Cities and Communities: Looking back over the last decade, looking forward to the next. Retrieved from: https://www.who.int/ageing/publications/gnafcc-report-2018/en/.

WHO, 2006. Physical activity and health in Europe: evidence for action. WHO Regional Office for Europe, Copenhagen. Retrieved from: http://www.euro.who.int/_data/assets/pdf_file/0011/87545/E89490.pdf.

Xuan, J., Kirchdoerfer, L.J., Bayer, J.G., Norwood, G.J., 1999. Effects of comorbidity on health-related quality-of-life scores: an analysis of clinical trial data. Clinical Therapeurics, 21(2). https://doi.org/ 10.1016/S0149-2918(00)88295-8.

Yang, Y., Xu, Y., Rodriguez, D.A., Michael, Y., Zhang, H., 2018. Active travel, public transportation use, and daily transport among older adults: the association of built environment. Journal of Transport & Health, 9, 288–298. https://doi.org/10.1016/j.jth.2018.01.012.

Yu, L., Boyle, P.A., Leurgans, S.E., Wilson, R.S., Bennett, D.A., and Buchman, A.S., 2019. Incident mobility disability, mild cognitive impairment, and mortality in community-dwelling older adults. Neuroepidemiology, 53, 55–62. https://doi.org/10.1159/000499334.

Zhang, W., Moskowitz, R.W., Nuki, G., Abramson, S., Altman, R.D., Arden, N., Bierma-Zeinstra, S., Brandt, K.D., Croft, P., Doherty, M., Dougados, M., Hochberg, M., Hunter, D.J., Kwoh, K., Lohmander, L.S., Tugwell, P., 2008. OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. Osteoarthritis and Cartilage, 16, 137–162. https://doi.org/10.1016/j.joca.2007.12.013.

Ziegler, F., Schwanen, T., 2011. 'I like to go out to be energised by different people': an exploratory analysis of mobility and wellbeing in later life. Ageing and Society, 31, 758–781. https://doi.org/10.1017/S0144686X10000498.

Table 5

Mental health system of equations (function [1], [2], [3]) - Estimation results

Explanatory variables		Dependent variables								
		Determinants of LPT and private cars use						Relationship between the use of transports and mental health [3]		
		LPT use [1]			Private car use [2]					
		Coefficient		*S.E.*	*Coefficient*		*S.E.*	*Coefficient*		*S.E.*
LPT use (ref: *Never*)										
	Few times a year							1.114	***	0.287
	Few times a month							1.409	***	0.355
	Few times a week							2.171	***	0.427
	Every day							2.563	***	0.615
Private car use (ref: *Never*)										
	Few times a year							0.353		0.389
	Few times a month							0.936	**	0.331
	Few times a week							1.276	***	0.303
	Every day							1.691	**	0.541
Instrumental variables	LPT accessibility	-0.089	***	0.013						
	Residential parking				-0.103	***	0.010			
Age (ref.: *60-64*)										
	65-74	0.127	***	0.034	-0.280	***	0.028	0.138		0.130
	75+	0.082	*	0.038	-0.958	***	0.032	0.018		0.207
Gender (ref.: *Female*)										
	Male	-0.223	***	0.028	1.075	***	0.023	0.460	*	0.206
Civil status (ref.: *Not married*)										
	Married	-0.163	**	0.056	0.382	***	0.048	-0.120		0.212
	Divorced	0.042		0.062	0.342	***	0.055	-1.129	***	0.240
	Widowed	-0.118	*	0.054	-0.027		0.047	-0.746	***	0.195
Family members (ref.: *Alone)*										
	Two	-0.057		0.043	-0.013		0.039	0.087		0.153
	More than two	-0.184	***	0.047	-0.086	*	0.041	-0.181		0.164
Income type (ref.: *Family aid)*										
	Self-sufficiency	-0.109	*	0.045	0.374	***	0.037	0.082		0.172
Education (ref.: *Primary school*)										
	Middle school	0.262	***	0.033	0.337	***	0.027	-0.079		0.128
	High school	0.444	***	0.034	0.585	***	0.029	0.157		0.156
	University degree	0.574	***	0.045	0.656	***	0.040	0.177		0.203
Residence area (ref.: *North*)										
	Centre	-0.226	***	0.032	0.034		0.028	-0.456	***	0.117
	South and Islands	-0.439	***	0.030	-0.186	***	0.024	-0.304	**	0.116
Social contacts (ref.: *No contacts*)										
	One group	0.037		0.041	0.099	**	0.034	0.313	*	0.142
	Two groups	0.035		0.032	0.227	***	0.027	0.836	***	0.116
Constant								19.613	***	0.305
Log-likelihood								-57942.09		
Likelihood-ratio test (Prob > χ^2)								8106.38 (0.0000)		

Notes: observations: 14,753; ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively. Ordered probit models cut-points: [1] – k_1: 0.29, k_2: 0.64, k_3: 0.98, k_4: 1.67; [2] – k_1: 0.44, k_2: 0.51, k_3: 0.62, k_4: 1.22. The correlations between error terms (off the 1-valued diagonal) of the Σ_M matrix are: $\varepsilon_{LPT}\varepsilon_{Cars} = -.276$; $\varepsilon_{LPT}\varepsilon_M = -.198$; and $\varepsilon_{Cars}\varepsilon_M = -.032$.

Table 6

Physical health system of equations (function [1], [2], [4]) - Estimation results

Explanatory variables		Dependent variables								
		Determinants of LPT and private cars use						Relationship between the use of transports and physical health [4]		
		LPT use [1]			Private car use [2]					
		Coefficient		*S.E.*	*Coefficient*		*S.E.*	*Coefficient*		*S.E.*
LPT use (ref: *Never*)										
	Few times a year							0.134		0.069
	Few times a month							0.186	*	0.085
	Few times a week							0.324	**	0.103
	Every day							0.459	**	0.148
Private car use (ref: *Never*)										
	Few times a year							-0.179		0.093
	Few times a month							0.194	**	0.080
	Few times a week							0.132		0.076
	Every day							0.042		0.138
Instrumental variables	LPT accessibility	-0.084	***	0.013						
	Residential parking				-0.101	***	0.010			
Age (ref.: *60-64*)										
	65-74	0.121	***	0.034	-0.279	***	0.028	-0.370	***	0.030
	75+	0.075	*	0.038	-0.959	***	0.032	-0.652	***	0.051
Gender (ref.: *Female*)										
	Male	-0.224	***	0.028	1.076	***	0.023	0.324	***	0.051
Civil status (ref.: *Not married*)										
	Married	-0.161	**	0.056	0.381	***	0.048	0.015		0.050
	Divorced	0.046		0.062	0.341	***	0.055	-0.052		0.056
	Widowed	-0.115	*	0.054	-0.028		0.047	-0.214	***	0.045
Family members (ref.: *Alone)*										
	Two	-0.062		0.043	-0.013		0.039	-0.008		0.035
	More than two	-0.193	***	0.047	-0.087	*	0.041	0.036		0.038
Income type (ref.: *Family aid)*										
	Self-sufficiency	-0.112	*	0.045	0.372	***	0.037	-0.014		0.040
Education (ref.: *Primary school*)										
	Middle school	0.262	***	0.033	0.337	***	0.027	0.091	**	0.030
	High school	0.443	***	0.034	0.586	***	0.029	0.163	***	0.378
	University degree	0.578	***	0.045	0.655	***	0.040	0.241	***	0.049
Residence area (ref.: *North*)										
	Centre	-0.228	***	0.032	0.033		0.028	-0.052		0.027
	South and Islands	-0.443	***	0.030	-0.186	***	0.024	-0.228	***	0.028
Social contacts (ref.: *No contacts*)										
	One group	0.032		0.041	0.101	**	0.034	0.026		0.033
	Two groups	0.026		0.032	0.230	***	0.027	0.040		0.027
Constant								3.845	***	0.079
Log-likelihood								-41401.59		
Likelihood-ratio test (Prob > χ^2)								8817.68 (0.0000)		

Notes: observations: 14,760; ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively. Ordered probit models cut-points: [1] – k_1: 0.28, k_2: 0.63, k_3: 0.97, k_4: 1.66; [2] – k_1: 0.44, k_2: 0.51, k_3: 0.62, k_4: 1.22. The correlations between error terms (off the 1-valued diagonal) of the Σ_P matrix are: $\varepsilon_{LPT}\varepsilon_{Cars} = -.275$; $\varepsilon_{LPT}\varepsilon_P = -.178$; and $\varepsilon_{Cars}\varepsilon_P = -.094$.

Table 7

Self-perceived health system of equations (function [1], [2], [5]) - Estimation results

Explanatory variables		Dependent variables								
		Determinants of LPT and private cars use						Relationship between the use of transports and self-perceived health [5]		
		LPT use [1]			Private car use [2]					
		Coefficient		*S.E.*	*Coefficient*		*S.E.*	*Coefficient*		*S.E.*
LPT use (ref: *Never*)										
	Few times a year							0.028		0.041
	Few times a month							0.055		0.048
	Few times a week							0.113	*	0.052
	Every day							0.315	***	0.081
Private car use (ref: *Never*)										
	Few times a year							0.102		0.078
	Few times a month							0.311	***	0.061
	Few times a week							0.397	***	0.037
	Every day							0.496	***	0.047
Instrumental variables	LPT accessibility	-0.084	***	0.013						
	Residential parking				-0.115	***	0.010			
Age (ref.: *60-64*)										
	65-74	0.126	***	0.034	-0.277	***	0.028	-0.283	***	0.028
	75+	0.070		0.038	-0.958	***	0.032	-0.473	***	0.034
Gender (ref.: *Female*)										
	Male	-0.218	***	0.028	1.074	***	0.023	0.016		0.027
Civil status (ref.: *Not married*)										
	Married	-0.167	**	0.056	0.383	***	0.048	-0.017		0.047
	Divorced	0.040		0.063	0.340	***	0.055	-0.132	*	0.054
	Widowed	-0.123	*	0.054	-0.029		0.047	-0.094	*	0.045
Family members (ref.: *Alone)*										
	Two	-0.059		0.043	-0.014		0.039	-0.049		0.035
	More than two	-0.194	***	0.047	-0.091	*	0.041	0.008		0.037
Income type (ref.: *Family aid)*										
	Self-sufficiency	-0.120	**	0.045	0.374	***	0.037	-0.062		0.037
Education (ref.: *Primary school*)										
	Middle school	0.261	***	0.034	0.338	***	0.027	0.067	*	0.027
	High school	0.444	***	0.034	0.589	***	0.029	0.188	***	0.029
	University degree	0.574	***	0.045	0.661	***	0.040	0.312	***	0.040
Residence area (ref.: *North*)										
	Centre	-0.232	***	0.032	0.033		0.028	-0.097	***	0.026
	South and Islands	-0.447	***	0.030	-0.186	***	0.024	-0.208	***	0.024
Social contacts (ref.: *No contacts*)										
	One group	0.035		0.041	0.098	**	0.034	0.095	**	0.032
	Two groups	0.031		0.032	0.229	***	0.026	0.142	***	0.025
Constant								NA		
Log-likelihood								-36870.17		
Likelihood-ratio test (Prob > χ^2)								8679.34 (0.0000)		

Notes: observations: 14,760; ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively. Ordered probit models cut-points: [1] – k_1: 0.27, k_2: 0.62, k_3: 0.97, k_4: 1.66; [2] – k_1: 0.42, k_2: 0.48, k_3: 0.60, k_4: 1.20, [5] – k_1: -2.19, k_2: -1.20, k_3: 0.26, k_4: 1.87. The correlations between error terms (off the 1-valued diagonal) of the Σ_S matrix are: $\varepsilon_{LPT}\varepsilon_{Cars} = -.168$; $\varepsilon_{LPT}\varepsilon_S = -.007$; and $\varepsilon_{Cars}\varepsilon_S = .003$.