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The daily mobility of older adults: Urban/rural differences in ten developed countries

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Abstract

This paper explores the mobility patterns of older adults in ten countries, with a focus on the differences produced by urban environments in their non-work trips. Using detailed time use diaries from the Multinational Time Use Study for the last two decades, we analyze the trips associated with leisure and housework of non-working older adults. The results show that older adults in urban areas spend more time in leisure trips than similar individuals in rural areas. On the other hand, male older adults in urban areas spend less time in housework trips than do their counterparts in rural areas. However, such correlations are found to differ by country, gender, type of trip, and mode of transport, revealing complex correlations between urban forms and older adults' daily mobility. Furthermore, factors such as the number of railway kilometers, gross domestic product growth rates, and the percentage of urban population in the country seem to be associated with differences in the behavior of older adults in their non-work daily trips.

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1 Introduction

Demographic aging has become a generalized and challenging phenomenon in most developed countries. Mobility enhances access to services among the elderly population (Olawole and Aloba 2014; Aguiar and Macário 2017) and mitigates against isolation and social exclusion (Arentze et al. 2008). But aging often implies some loss of functional abilities and thus stricter capacity constraints for mobility, and physical constraints may come into play in daily travel behaviors (Schwanen and Dijst 2002; Banister and Bowling 2004; Spinney et al. 2009). Since one crucial aspect of the aging of the population is the ability to satisfy mobility needs (Alsnih and Hensher 2003; Hess 2009; Wong et al. 2018), the analysis of the mobility patterns of older adults, and various related factors, may be helpful in identifying which groups have more limitations on, and during, their trips and thus may have reduced access to essential services and be either more isolated or socially excluded.

Furthermore, prior research has documented that the use of a private vehicle is the preferred mode of transport for older adults' mobility (Wong et al. 2018), despite that older drivers are more accident-prone and have an increased risk of injury (Gelau et al. 2011). In a world where the use of modes of transport alternative to car use, such as public transport or walking and cycling, are crucial to fight against greenhouse gas (GHG) emissions and global warming (Gimenez-Nadal and Molina 2019; Echeverría et al. 2022a), previous evidence has shown that public transport may be infrequently used by older adults as they grow older, often due to problems in boarding and disembarking from buses, or to concerns about personal safety (Arentze et al. 2008).[1] Thus, the analysis of older adults' mobility habits is important, given the many implications for their health, safety, and well-being, on the one hand, and for climate change and health expenses, on the other.

Within this framework, we analyze the travel behavior of older adults in a set of ten developed countries (Canada, Finland, Hungary, Italy, Korea, the Netherlands, South Africa, Spain, the United Kingdom (UK), and the United States (US)) using time use data obtained from the Multinational Time Use Survey (MTUS). This cross-country analysis allows us to identify the countries where older people are more likely to use public transport, walk, and cycle, for instance, apart from identifying common patterns based on socio-demographic characteristics (e.g., age, gender, education). If in certain countries the likelihood to use public transport, walk, or cycle is lower, policy makers in those countries have the information to try to increase the use of these modes of transport, perhaps via awareness campaigns or incentive schemes. Furthermore, when such differences can be explained by differences in the availability of transport infrastructures (Echeverría et al. 2022b), those countries that rank relatively low in the likelihood to use public transport, walk, or cycle may have relatively low levels of investment in transport infrastructures that boost the use of these modes of transport, which shows them what they should do in the next years.

[1] The use of physical models of transport (walking or cycling) has been reported to be a source of activity that enhances elders' well-being (Mollaoglu et al., 2010; Echeverría et al. 2022b).

We also analyze how the urban/rural dimension relates to travel behavior, including the choice of mode of transport, since existing research has established differences in terms of such trips. For instance, several authors have focused on the relationship between commuting and urban forms and have concluded that there are interrelations between trips and land use (van Acker and Witlox 2011; Jin 2019), urban transformation (Burger et al. 2011), and transport services (Ma et al. 2017; Guirao et al. 2018; Cavallaro and Dianin 2019).[2] While commuting has been extensively analyzed in the literature, little attention has been paid to older adults' non-work trips, including household production and leisure trips (Buehler and Nobis 2010; Wong et al. 2018). These trips are especially important for elder individuals, as they do not commute (given their retirement status) and these trips are their main source of daily mobility. Furthermore, prior research has shown that the aging process is different in suburbs than in other areas of residence and that modes of transport may differ for individuals in suburbs, including older individuals (Lord et al. 2011). Furthermore, the reduction of transportation resources in rural and suburban areas as a result of the commercialization of public transport may mean that older adults, as a vulnerable segment of the population, may be hit the hardest (Smith and Sylvestre 2001). Thus, studying how trips related to leisure and housework may vary between individuals in urban and in rural areas is relevant.

We find a complex relationship between non-work trips and urban characteristics. In particular, we find that, on average, older women living in urban areas spend about 9.6% more time in leisure trips than do similar women in rural areas, while the corresponding difference between the average older man is about 16.1%, with both coefficients being statistically significant. This corresponds to about 4.7 (11.2) more minutes per day spent in these trips by urban women (men), relative to their counterparts in rural areas. On the other hand, older male adults aged 60 or more spend 5.0% less time in trips related to housework, compared to the similar respondent residing in a rural area, a raw difference of 1.2 min per day spent in these trips by urban male respondents. Nevertheless, these differences are found to be heterogeneous both across countries and transport modes, with no clear pattern, suggesting a complex correlation between older adults' non-work mobility and urban characteristics.

We contribute to the literature by studying the time spent by older adults in their daily non-work trips, using a harmonized database based on time-use diaries for ten developed countries. Time use data allow us to measure the time spent by respondents in their daily activities, including travel time, more accurately than other databases measuring trips from stylized questionnaires, such as National Transport Surveys (Yee-Kan 2008). The analysis allows us to characterize patterns of use of public transport, walking, and cycling, according to the socio-demographic characteristics of the individuals, apart from characterizing which countries have a higher likelihood to use this type of transport. We examine differences in the time spent in non-work trips, depending on whether older adults reside in urban or rural areas, controlling for the means of transport used during these trips, and respondent sociodemographic characteristics. To the best of our knowledge, this is the first joint

[2] Gimenez-Nadal et al. (2020) provide a recent literature review on this issue.

empirical analysis of its kind on the relationship between urban structure and the place of residence.

The remainder of the paper is structured as follows: Section 2 introduces the MTUS data, the sample, and the variables used in the analysis. Section 3 describes the empirical strategy, and Sect. 4 shows the main results. Section 5 presents our conclusions.

2 Data and variables

We use data from the Multinational Time Use Study (MTUS), which includes detailed time use diaries for a range of countries, along with a series of demographic, economic, and geographic attributes of the respondents. Hence, the MTUS data provide us with socioeconomic attributes, but also with information on individual time use based on diaries, in which respondents report their activities during the 24 h of the day, from 4 to 4 am of the next day. The data includes selected harmonized information about activity locations, the mode of transport, and who else was present during the reported activities. The advantage of 24-h, self-reported diary data over other surveys collecting transport times via stylized questionnaires is that diaries produce more reliable and accurate estimates (Yee-Kan 2008). Thus, time use diaries have become the gold standard in the analysis of daily behaviors (Aguiar and Hurst 2007; Harms et al. 2019).

We select older adults, defined as respondents who are 60 years old or over.[3] We restrict the sample to countries with information available for the last two decades (year 2000 and onwards), for an updated view of the mobility of older adults. Individuals with missing information on the variables used in the analysis are omitted. Given that the age restriction may include non-working and working older adults, including full-time workers, we retain only non-working individuals, and we restrict the analysis to non-working older adults, as most of the individuals belong in this group (very few individuals are working).[4] This provides a sample of 105,526 individuals, of whom 63,819 are women and 41,707 are men. The final sample includes information for the following countries: Canada, Finland, Hungary, Italy, Korea, the Netherlands, South Africa, Spain, the UK, and the USA.[5]

One of our variables of interest is the time devoted to non-work activities, mainly household production and leisure activities. We define "leisure trips" as all the time spent in trips associated with leisure, including activities such as cycling, taking a walk, walking the dog, and trips associated with shopping. We define "housework trips" as all the time spent in trips associated with childcare, adult care, or housework.[6] Both kinds of trip are measured in minutes per day and are homogeneous for

[3] See https://www.who.int/health-topics/ageing.

[4] Travel behavior of working older adults may differ from that of non-working individuals (Bianchi 2000; Krueger and Mueller 2012; Ulfarsson et al. 2015). Results for working older adults are available upon request.

[5] See Table A1 for details on the composition of the sample.

[6] See Table A2 for a description of activities and MTUS codes.

Table 1 Summary statistics

Variables	Women					Men				
	Rural		Urban		Difference	Rural		Urban		Difference
	Mean	S.Dev	Mean	S.Dev		Mean	S.Dev	Mean	S.Dev	
Leisure travel time	45.7	60.9	48.6	61.9	−2.9***	71.3	83.2	69.9	81.8	1.4***
In private vehicle	13.8	36.3	16.6	37.5	−2.7***	18.8	43.1	21.2	43.8	−2.5***
In active mode	20.3	42.4	18.5	40.7	1.8***	35.8	67.3	31.1	63.3	4.7***
In public transport	1.0	13.2	2.3	17.0	−1.4***	0.7	10.3	2.0	16.2	−1.2***
Housework travel time	13.6	36.9	18.5	46.2	−4.9***	20.9	46.1	23.8	51.0	−3.0***
In private vehicle	8.0	28.0	10.7	32.8	−2.6***	12.0	36.2	14.7	39.1	−2.8***
In active mode	2.6	12.2	3.7	15.6	−1.1***	4.4	17.2	4.3	17.6	0.1
In public transport	1.0	16.0	2.4	21.9	−1.4***	1.1	17.4	2.3	21.0	−1.3***
Observations	17,907		45,912			12,089		29,618		

The sample (MTUS 2000–2018) is restricted to non-working respondents aged 60 and older. Leisure travel times and housework travel times are measured in minutes per day. *P*-values for the differences between rural and urban areas computed according to t-type tests. Differences computed as mean values in rural areas, minus mean values in urban areas. Summary statistics and *p*-values computed using sample weights. *** Significant at 99%; ** significant at 95%; * significant at 90%

Table 2 Average travel times, by country

			Leisure trips	Housework trips	Obs
Canada	Women	Rural	35.6	19.3	1215
		Urban	40.8	19.4	3046
	Men	Rural	42.9	32.5	817
		Urban	49.6	23.7	1781
Finland	Women	Rural	51.6	15.9	211
		Urban	41.6	25.8	752
	Men	Rural	42.3	33.1	168
		Urban	51.3	24.9	611
Hungary	Women	Rural	16.6	13.2	1850
		Urban	27.2	18.9	3354
	Men	Rural	21.1	15.8	1074
		Urban	34.4	25.7	2169
Italy	Women	Rural	53.5	9.9	5081
		Urban	59.5	9.3	7670
	Men	Rural	95.3	19.6	3627
		Urban	104.7	17.9	5468
Korea	Women	Rural	42.0	31.8	220
		Urban	59.7	38.2	3213
	Men	Rural	65.3	29.9	76
		Urban	91.2	46.7	1705
Netherlands	Women	Rural	24.3	25.4	481
		Urban	30.1	29.5	2042
	Men	Rural	34.3	29.4	571
		Urban	38.8	31.5	1779
South Africa	Women	Rural	5.4	23.8	226
		Urban	12.8	25.0	357
	Men	Rural	9.1	26.8	104
		Urban	17.3	31.7	202
Spain	Women	Rural	63.7	11.0	3575
		Urban	71.2	15.2	5819
	Men	Rural	107.0	20.9	2842
		Urban	125.2	21.8	4009
UK	Women	Rural	42.5	19.8	159
		Urban	45.8	23.4	1633
	Men	Rural	63.1	26.8	120
		Urban	54.4	29.0	1245
US	Women	Rural	43.2	17.3	4889
		Urban	43.7	18.5	18,026
	Men	Rural	48.9	21.0	2690
		Urban	48.8	23.1	10,649

The sample (MTUS 2000–2018) is restricted to non-working respondents aged 60 and older. Leisure travel times, and housework travel times are measured in minutes per day. Summary statistics computed using sample weights

all the years and countries included in the sample. Our second variable of interest is the mode of transport. The MTUS data include the following classification: (1) by car, etc., (2) public transport, (3) walking/on foot, (4) other physical transport, and (5) other/unspecified transport. From this classification, we define the following modes of transport: by private vehicle (by car, etc.), active (walking, other physical transport), and by public transport (public transport), and we compute the total time spent for leisure and housework trips.

The explanatory variable of interest is the urban structure of respondents' area of residence. The MTUS data identify whether individuals reside in an urban or a rural area. This variable is available in the MTUS with the following description: "URBAN indicates whether or not the respondent lives in an urban area"; it is comparable across all samples and has been harmonized. Identification and comparability of urban and rural areas are detailed in the MTUS data page, including different identifications across countries and years, and comparability issues.[7] With this, 72.21% of the sample are reported living in an urban area, while the remaining 27.79% live in a rural area.

The MTUS also allows us to define several sociodemographic characteristics of respondents. Controlling for these socio-demographic characteristics of individuals is important, given that both observed and unobserved heterogeneity of individuals is important in shaping older adults' travel behavior. We control for respondents' gender, as prior research has shown gender differences in travel patterns (White 1986; Sandow and Westin 2010; Gimenez-Nadal and Molina 2016). The level of education is also important, as higher education may imply both a higher opportunity cost of time and a higher household income, factors that may affect both the time spent traveling and the mode of transport. We distinguish individuals who have completed primary education, secondary education, and University education. The marital status of respondents is defined as a dummy that takes value "1" for those who cohabit with a married or unmarried partner, "0" otherwise. Marital status may be important, since those who live in couple may spend less time traveling for leisure, as they do not feel so isolated. Also, the presence of a partner may affect the mode of transport chosen for traveling. Household composition has also been found to be an important determinant of travel times, and so we define the number of individuals in the family unit, and the number of children (aged 17 or younger).

We control for the labor status of respondents (van Ommeren and van der Straaten 2008; McQuaid and Chen 2012). The employment status of respondents is considered via a dummy variable taking value "1" for employed respondents, "0" otherwise. We include a dummy that identifies full-time workers (value 1, 0 otherwise), and we consider the number of weekly work hours (set to 0 for non-working individuals). All these variables are common controls when studying individual time allocations (Aguiar and Hurst 2007; Gimenez-Nadal et al. 2021). Unfortunately, the MTUS does not include information on other variables that may affect respondents' travel behaviors, such as transport infrastructure, or housing information, and so we must acknowledge the potential bias that may arise from such missing information.

[7] See https://www.mtusdata.org/mtus-action/variables/URBAN#comparability_section.

Table 3 Main estimates

Variables	(1)	(2)	(3)	(4)
	Leisure trips		Housework trips	
	Women	Men	Women	Men
Urban status	0.096***	0.161***	0.026	−0.050**
	(0.020)	(0.023)	(0.016)	(0.023)
Age	−0.382***	−0.355***	−0.156***	−0.173***
	(0.025)	(0.032)	(0.021)	(0.030)
Log-age	24.241***	23.710***	9.295***	10.428***
	(1.762)	(2.283)	(1.485)	(2.138)
Education: secondary	0.309***	0.160***	0.174***	0.136***
	(0.023)	(0.026)	(0.020)	(0.026)
Education: University	0.580***	0.379***	0.381***	0.250***
	(0.026)	(0.029)	(0.024)	(0.029)
Married/cohabiting	0.035	0.059**	0.037*	−0.008
	(0.023)	(0.029)	(0.019)	(0.028)
Family size	−0.149***	−0.075***	−0.120***	−0.098***
	(0.013)	(0.016)	(0.011)	(0.015)
Number of children	0.052*	−0.095**	0.201***	0.209***
	(0.029)	(0.037)	(0.025)	(0.038)
Weekday	0.147***	0.203***	−0.133***	−0.115***
	(0.016)	(0.019)	(0.014)	(0.019)
Constant	−73.721***	−73.289***	−26.992***	−30.575***
	(5.754)	(7.444)	(4.865)	(6.991)
Country F.E	Yes	Yes	Yes	Yes
Year F.E	Yes	Yes	Yes	Yes
Observations	63,819	41,707	63,819	41,707
R-squared	0.095	0.153	0.081	0.063

The sample (MTUS 2000–2018) is restricted to non-working respondents aged 60 and older. The dependent variables are the log-of-minutes spent doing leisure trips and housework trips. *** Significant at 99%; ** significant at 95%; * significant at 90%

2.1 Descriptive statistics

Table 1 shows the summary statistics of the main variables for the full sample, by gender and rural/urban status.[8] The average time traveling for leisure activities is 45.7 min per day among females in rural areas, vs 48.6 min for females in urban areas, with the difference being statistically significant. The average female respondent in a rural (urban) area spends 13.8 (16.6) minutes traveling for leisure purposes in a private vehicle, 20.3 (18.5) minutes actively, and 1.0 (2.3) minute in public transport mode. The differences between urban and rural areas are all statistically significant, according to t-type tests ($p < 0.001$). Regarding housework trips, females

[8] All the statistics and estimates are computed using sample weights. Summary statistics of demographics are shown in Table A3 in the Appendix A.

in rural areas spend 8.0 min traveling in a private vehicle, 2.6 min actively, and 1.0 min in public transport, for a total average of 13.6 min. For housework trips of females in urban areas, on average, 10.7 min are spent traveling in a private vehicle, 3.7 min actively, and 2.4 min in public transport, an average total of 18.5 min. All these differences between rural and urban areas are statistically significant.

Males in rural areas spend about 71.3 min per day in leisure trips (18.8 min in a private vehicle, 35.8 min actively, 0.7 min in public transport, and the remaining time in other/non-identified transport mode), compared to 69.9 min spent by males in urban areas (21.2 min in a private vehicle, 31.1 min actively, and 2.0 min in public transport). The average male in a rural (urban) area spends 20.9 (23.8) minutes traveling for housework purposes, of which 12.0 (14.7) minutes are in a private vehicle, 4.4 (4.3) minutes in active transport, and 1.1 (2.3) minutes in public transport. All the differences between urban and rural areas are statistically significant, except that for active housework trips.

Table 2 shows country averages of the time spent in trips associated with leisure and with housework, by gender and by urban status.[9] In Canada, both women and men living in urban areas spend more time in leisure trips than do women and men in rural areas. The same trend for leisure trips is reported by both women and men in Hungary, Italy, Korea, the Netherlands, South Africa, and Spain. Finnish women in rural areas spend more time in leisure trips than do women in urban areas, while men in urban areas spend more time in leisure trips than men in rural areas. The opposite is found in the UK, where women (men) in urban (rural) areas spend more time in leisure trips than women (men) in rural (urban) areas. In the USA, averages in Table 2 do not show differences between women in urban and rural areas regarding leisure trips (both about 43 min per day), nor between men in rural and urban areas (about 49 min per day). Table 2 also shows quantitative differences among countries in the times spent in leisure trips. For instance, the longest leisure trips are estimated among Spanish and Italian men in urban areas, with 125.2 and 104.7 min per day, respectively. The shortest trips are found in South Africa (between 5.4 and 17.3 min per day). In the rest of the countries, the time spent in leisure trips varies between about 25 and 60 daily minutes, with averages of about 40–50 min being common in Canada, Finland, Korea, the UK, and the USA.

Focusing now on housework travel times, female respondents in rural and urban areas of Canada spend similar time to these trips. However, males in rural areas report longer times than males in housework travel in urban areas. In Finland, females in urban areas spend more time in housework trips than females in rural areas, while males in rural areas spend more time in these trips than males in urban areas. Both males and females spend more time in housework trips in urban areas than in rural areas in Hungary, Korea, the Netherlands, South Africa, Spain, the UK, and the USA. The opposite is found among Italian older adults, as both males and females in rural areas devote more time to these trips than males and females in urban areas. We also find by-country differences in housework trips, though these differences are quantitatively smaller than the differences found regarding leisure trips. For instance, the longest time traveled for

[9] Times by transport mode are shown in Table A4 in the Appendix A.

Table 4 Interaction estimates

Variables	(1)	(2)	(3)	(4)
	Leisure trips		Housework trips	
	Women	Men	Women	Men
Urban status	0.049	0.093*	0.022	0.009
	(0.034)	(0.047)	(0.032)	(0.046)
Urban status X				
Country: Canada	0.133*	0.125	−0.056	−0.296***
	(0.075)	(0.096)	(0.069)	(0.096)
Country: Finland	−0.317*	0.035	0.238	0.122
	(0.189)	(0.213)	(0.160)	(0.199)
Country: Hungary	0.328***	0.314***	0.056	0.211**
	(0.064)	(0.088)	(0.060)	(0.083)
Country: Italy	0.008	0.020	−0.069	−0.145**
	(0.055)	(0.065)	(0.043)	(0.063)
Country: Korea	0.329**	0.018	−0.096	0.282
	(0.158)	(0.254)	(0.148)	(0.269)
Country: Netherlands	−0.046	0.258**	0.003	0.021
	(0.106)	(0.111)	(0.104)	(0.108)
Country: South Africa	0.293**	−0.018	0.147	0.255
	(0.139)	(0.201)	(0.164)	(0.256)
Country: Spain	−0.000	0.084	0.095**	−0.155**
	(0.055)	(0.066)	(0.047)	(0.065)
Country: UK	0.155	−0.221	0.105	0.148
	(0.175)	(0.204)	(0.166)	(0.210)
Constant	−73.945***	−73.108***	−26.980***	−29.984***
	(5.759)	(7.444)	(4.866)	(6.990)
Sociodemographics	Yes	Yes	Yes	Yes
Country F.E	Yes	Yes	Yes	Yes
Year F.E	Yes	Yes	Yes	Yes
Observations	63,819	41,707	63,819	41,707
R-squared	0.096	0.153	0.081	0.064

The sample (MTUS 2000–2018) is restricted to non-working respondents aged 60 and older. The dependent variables are the log-of-minutes spent doing leisure trips and housework trips. *** Significant at 99%; ** significant at 95%; * significant at 90%

housework purposes is in Korea, where males in urban areas devote 46.7 min per day to these activities. The shortest time is found among Italian women, with about 9 min spent in these trips. Nonetheless, most of the times lie between 15 and 30 min per day (as is the case in Canada, Finland, Hungary, the Netherlands, South Africa, Spain, the UK, and the USA).

3 Empirical strategy

We explore the existence of different trip behaviors among non-working older adults according to their urban/rural status. To that end, we estimate a linear regression model using ordinary least squares (OLS), on the log-of-trip time, as follows:

$$\log\left(1+T_i\right)=\beta_0+\beta_U U_i+\beta_X X_i+\varepsilon_i \tag{1}$$

where T_i represents the minutes of leisure/housework trip of individual "i", and U_i is the dummy that identifies workers in urban areas. X_i is a vector of demographic and labor characteristics, and ε_i is the error term. Equation (1) is estimated separately for males and females and for the type of trip. The vector X_i includes the following controls: age (measured in years), the log of age (to account for declining time spent traveling among older individuals), education, cohabiting status, number of individuals in the household, and number of children. For education, the reference category is "primary education". We additionally control for the day of the week when diaries are filled in.[10] All the estimates include country fixed effects, with robust standard errors clustered at the country level. To control for the temporal aspect of the MTUS data, we follow recent analyses by Borra et al. (2021) and Gimenez-Nadal et al. (2021), and all estimates include year-fixed effects. All the results are computed using sample weights.

Equation (1) is re-estimated to include interactions between U_i and country dummies (taking the US as reference), to account for cross-country differences in the relationship between traveling times and residing in an urban area. Furthermore, we estimate Eq. (1) considering the time spent in leisure and housework trips by transport mode.

4 Results

Table 3 shows the results of estimating Eq. (1). Columns (1) and (2) show the results for leisure trips of non-working older women and men, respectively, while Columns (3) and (4) show similar results for housework trips. We find that living in an urban area is correlated with about 9.6% more time in leisure trips for women, and 16.1% more time for men, relative to a counterpart in a rural area (i.e., net of systematic country differences, and net of individual observed heterogeneity). Living in an urban area is correlated with about 2.6% more time spent in housework trips for women, with the associated coefficient not being statistically significant at standard levels, but with 4.0% less time for men. The estimated coefficients differ between women and men, as the correlation is stronger for men in leisure trips ($p=0.035$),

[10] The MTUS data includes diaries filled in during weekdays and weekends, and weights in the survey are adjusted so that all the days of the week are equally represented. However, even among non-working individuals, trips on the weekend may differ from trips during weekdays (Yang et al. 2016). To control for this potential difference, we include a dummy variable that takes value 1 for individuals who filled in the diary during weekdays, and value 0 for individuals who filled in the diary during weekends.

while the coefficients for housework trips are opposite and are statistically different ($p = 0.014$) according to a t-type tests.

This indicates that, net of worker observable factors, and country- and year-fixed effects, the correlation between urban areas and trips differs depending on the type of trip. Results suggest that older adults in urban areas enjoy leisure activities further away from their home than older adults in rural areas, or that the former do more trips for leisure than the latter. Thus, improving transport services in order to enhance the mobility of older adults to access leisure services seems to be a greater challenge in urban areas, as results indicate that these individuals require more time to do their everyday leisure activities. This difference is especially relevant among male older adults, indicating that either males in rural areas prefer to do leisure activities close to their homes, or males in urban areas search for more specific leisure services than do their female counterparts. Conversely, males in urban areas spend less time traveling for housework purposes than similar males in rural areas. The reason behind such difference remains unclear, and it could be that older adults in urban areas have a lower participation in everyday housework and prefer to only do chores close to their homes, than similar male older adults in rural areas. The fact that female older adults, who have been traditionally in charge of chores (Sevilla et al. 2010; Borra et al. 2021), spend similar times traveling for housework purposes suggests that, on average, trips for housework purposes are similar in urban and rural areas. To the best of our knowledge, the deep analysis of these trips is an understudied phenomenon, and this paper opens doors for future research.

Regarding the rest of the explanatory variables, results in Table 3 show a negative correlation between respondents' age and travel times, which may be due to decreasing health status (see Chatterjee et al. 2020, for a recent review), but a positive correlation with the log-age, suggesting the existence of nonlinear effects (e.g., very old respondents may have different trip behaviors due to poorer health which requires less or additional time spent in trips). Unfortunately, the MTUS data do not provide information to test for this. Education level is correlated with more time spent in both leisure and housework daily trips, consistent with similar trends in commuting times (Ross and Zenou 2008). Regarding the marital status of respondents, females who cohabit spend more time in housework trips, consistent with the household responsibilities hypothesis, while cohabiting males spend more time in leisure trips, but not on housework trips, relative to singles. On the other hand, greater family size is correlated with less time spent in both kinds of trip, while the number of children is correlated with more time spent in leisure trips among females (but less among males), and more time in housework trips for both. Finally, leisure trips seem to last longer on weekdays than during the weekend for female and male older adults, whereas the opposite is found for housework trips.

4.1 Robustness checks

We run certain robustness checks. First, since the time spent in both leisure and housework trips is censored, we have estimated similar equations using Tobit models. The results are shown in Table A5 in Appendix A, and the coefficients

Table 5 Estimates by mode of transport

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Leisure trips						Housework trips					
	Private		Active		Public		Private		Active		Public	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
Urban status	0.014	0.039	0.112***	0.138***	0.030***	0.048***	−0.017	−0.029	0.016*	0.018	0.032***	0.028***
	(0.035)	(0.047)	(0.017)	(0.029)	(0.007)	(0.007)	(0.031)	(0.045)	(0.009)	(0.014)	(0.005)	(0.008)
Urban status X												
Country: Canada	−0.007	−0.002	−0.034	−0.097*	0.118***	0.024	−0.020	−0.270***	−0.039	−0.036	−0.008	0.002
	(0.071)	(0.094)	(0.043)	(0.059)	(0.018)	(0.020)	(0.066)	(0.094)	(0.027)	(0.035)	(0.016)	(0.016)
Country: Finland	−0.302*	−0.201	0.023	0.076	0.041	−0.015	0.149	0.004	0.103	0.135*	−0.039	−0.073
	(0.166)	(0.185)	(0.107)	(0.083)	(0.033)	(0.019)	(0.135)	(0.189)	(0.096)	(0.080)	(0.052)	(0.058)
Country: Hungary	−0.123***	−0.145**	−0.093***	−0.099**	0.191***	0.127***	−0.002	0.120**	−0.055**	−0.014	0.232***	0.291***
	(0.038)	(0.057)	(0.031)	(0.044)	(0.023)	(0.029)	(0.038)	(0.060)	(0.025)	(0.033)	(0.025)	(0.033)
Country: Italy	0.006	−0.148**	−0.146***	−0.001	0.084***	0.022	0.004	0.017	−0.048**	−0.116***	−0.020*	−0.025*
	(0.049)	(0.070)	(0.049)	(0.064)	(0.017)	(0.018)	(0.037)	(0.057)	(0.024)	(0.036)	(0.010)	(0.014)
Country: Korea	−0.255**	−0.347**	0.637***	0.398	−0.109	−0.080	−0.003	−0.145	0.020	0.492**	0.092	0.013
	(0.099)	(0.170)	(0.145)	(0.261)	(0.095)	(0.144)	(0.087)	(0.191)	(0.136)	(0.217)	(0.073)	(0.163)
Country: Netherlands	−0.197**	0.159	−0.036	0.066	0.002	−0.022	−0.172*	0.083	0.138**	−0.109	0.025	−0.024
	(0.085)	(0.097)	(0.085)	(0.079)	(0.034)	(0.023)	(0.092)	(0.096)	(0.067)	(0.067)	(0.037)	(0.032)
Country: South Africa	0.337***	0.183	−0.206*	−0.332**	0.012	−0.067	0.014	−0.059	0.022	−0.006	0.052***	0.054***
	(0.098)	(0.144)	(0.106)	(0.161)	(0.032)	(0.073)	(0.036)	(0.052)	(0.024)	(0.034)	(0.013)	(0.017)
Country: Spain	−0.077**	−0.167***	−0.053	0.173***	0.054***	0.024*	−0.115	0.147	0.008	−0.129	0.161***	0.149***
	(0.039)	(0.056)	(0.049)	(0.061)	(0.014)	(0.014)	(0.163)	(0.196)	(0.015)	(0.079)	(0.046)	(0.028)
Country: UK	−0.112	−0.169	0.098	−0.282	0.158**	0.062	0.255***	0.340**	−0.120	−0.121	0.009	−0.001
	(0.152)	(0.194)	(0.176)	(0.225)	(0.080)	(0.074)	(0.092)	(0.159)	(0.148)	(0.236)	(0.023)	(0.043)

Table 5 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Leisure trips						Housework trips					
	Private		Active		Public		Private		Active		Public	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
Constant	−8.621** (4.160)	−30.999*** (6.246)	−60.339*** (5.062)	−53.560*** (7.107)	−7.261*** (2.009)	−7.598*** (2.148)	−1.522 (3.801)	−8.517 (5.569)	−15.046*** (2.936)	−16.757*** (4.432)	−6.391*** (1.707)	−5.447** (2.432)
Sociodemographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country F.E	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	63,819	41,707	63,819	41,707	63,819	41,707	63,819	41,707	63,819	41,707	63,819	41,707
R-squared	0.227	0.170	0.280	0.345	0.025	0.018	0.118	0.095	0.179	0.155	0.028	0.033

The sample (MTUS 2000–2018) is restricted to non-working respondents aged 60 and older. The dependent variables are the log-of-minutes spent doing leisure trips. *** Significant at 99%; ** significant at 95%; * significant at 90%

are qualitatively robust. Second, we re-estimate Eq. (1) on working individuals. Because most of the older adults in the sample were non-working and the trip behavior of working older adults may be very different from those of non-working older adults, deeper analysis is left for further research (results for working individuals are available upon request). Third, we also estimate Eq. (1) including indicators defined at the country level, aimed at measuring cross-country differences in transportation infrastructures, economic development, etc. Results are also robust and are shown in Appendix B.

Fourth, we re-estimate Eq. (1), but including interactions between the dummy identifying workers in urban areas, and dummies at the country level. These estimates are shown in Table 4. The coefficient associated with the urban dummy variable now identifies the baseline correlation between travel times and residing in an urban area (relative to individuals in rural areas), which corresponds to the reference country (the US). Then, the coefficients associated with the interaction terms correspond to differential correlations between residing in an urban area and travel times, taking as reference the correlation in the US. This cross-country perspective may be important, as similar results for all the analyzed countries would reveal that urban forms are related to leisure and housework trips of older adults in similar ways among the analyzed countries. Thus, urban planners could follow similar measures to address similar challenges in different countries. Conversely, a complex relationship that is different in the analyzed countries would indicate that policy makers should focus on particular regions to enhance, for instance, transport infrastructure or public transport services to improve the mobility of older adults.

The results in Table 4 indicate that, in the USA, the only difference between workers in rural and urban areas is found for leisure trips of males, who spend about 9.3% more time in these trips. Taking these results as the benchmark, estimates show significant differences among the countries analyzed, since no single country presents the same results as any other. For instance, in Canada, female respondents in urban areas spend about 13.3% more time in leisure trips than similar females in a rural area, while male respondents in urban areas spend about 29.6% less time in housework trips than similar respondents in a rural area. In Finland and the UK, differences between individuals in rural and urban areas are similar to the estimated differences in the US, although female older adults in urban areas of Finland spend about 31.7% less time in leisure trips than similar females in rural areas. In Hungary, female and male respondents in urban areas spend about 32% more time in leisure trips than similar respondents in a rural area, while males in urban areas spend 21.1% more time in housework trips. Differences between urban and rural areas in Italy are similar to those in the USA regarding leisure trips, but male older adults in urban areas spend 14.5% less time in housework trips than similar individuals in rural areas. In Korea, females in urban areas spend 32.9% more time in leisure trips than do similar females in rural areas. In the Netherlands, the only statistically significant coefficient indicates a larger difference than in the USA between males in urban and rural areas regarding leisure trips. In South Africa, older females in urban areas spend more time in leisure trips than similar females in rural areas. Finally, in Spain, female (male) older individuals in urban areas spend more (less) time in

housework trips than similar respondents in rural areas. None of the remaining differences are statistically significant at standard levels.

4.2 Estimates by transport mode

Table 5 shows the main results of estimating Eq. (1), including interactions between the dummy variable identifying individuals in urban/rural areas, and the country dummies, separately for the times spent in either leisure or housework trips, by mode of transport. Columns (1) and (2) show estimates on leisure trips of women and men by private vehicle, Columns (3) and (4) show similar estimates on the time traveled by an active mode of transport, and Columns (5) and (6) on the time by public transport. Columns (7) to (12) report equivalent estimates but on housework times. Additional coefficients are available upon request. It is important to study these trips by mode of transport, as different means of transport have been associated with different outputs for travelers, and travel time crucially depends on the mean of transport (Gallo and Marinelli 2020; Jacob et al. 2021). Furthermore, mode choices differ between senior and older adults (Du et al. 2021). For instance, trips by private vehicle allow relatively fast access to far-away services but are responsible for a significant amount of greenhouse gas emissions (Yang et al. 2016) and have been associated with high levels of stress and decreased psychological well-being (Stutzer and Frey 2008). Conversely, active trips may be slower and require more time than trips by private vehicle, and only allow access to nearby services, but are associated with increased health, which may be desirable among older adults (Tajalli and Hajbabaie 2017). Finally, trips by public transport depend on the availability and access to public services (Cavallaro and Dianin 2019). By exploring how trips differ between urban and rural areas by means of transport, the results may help to identify country differences and thus to focus planners on the design of policies, such as those aiming to improve public transport services in rural areas, or those focusing on green transport modes in cities.

For leisure trips, the results suggest that when individual socio-demographics are considered, there is a non-statistically significant correlation between the time spent by private vehicle and residing in an urban area, in the USA, Canada, and the UK. However, we estimate negative correlations among Finnish women, Hungarian women and men, Italian men, Korean women and men, Dutch women, South African women, and Spanish women and men. For the time spent traveling actively for housework, we estimate a positive correlation between such time and living in an urban area in the USA (the reference country) and in Canada, Finland, Korea, the Netherlands, and Spain (with the correlation being especially significant among Korean women and men, and Spanish men). Negative coefficients for Hungary lead to a non-statistically significant correlation in that country, and among Italian women, and to negative correlations for South African women and men, and UK men. Regarding the time spent traveling for leisure in public transport modes, the results show a positive correlation with living in an urban area for the reference country (the US), and for the remaining set of countries except for Korea, and for women in South Africa. That positive correlation is especially strong in Hungary

and among women in Canada and Italy, women and men in Spain, and women in the UK, since the interactions associated with these countries are positive and statistically significant.

Regarding the time spent in housework trips by mode of transport, the results in Columns (7) and (8) indicate that living in an urban area is not correlated with the time spent by private vehicle in these trips in a statistically significant way in the USA, Finland, Italy, Korea, South Africa, and Spain. Conversely, women (men) in urban areas spend less time than women (men) in rural areas in trips by private vehicle in Canada (the Netherlands). Hungarian men spend more time in these trips by private vehicle when they reside in an urban area, rather than similar respondents in rural areas. UK men and women in urban areas spend more time in housework trips by private vehicle than similar respondents in rural areas. For the time of housework trips by physical means of transport (active), the results show a positive correlation between living in an urban area and such trips among older adult women in the US, and among Finnish men and women, Korean women, Dutch women, South African women, and Spanish women. Similar results are found among Korean men. The results also reveal that Hungarian women, and Italian women and men in urban areas spend less time in active housework trips than do their counterparts in rural areas. Finally, regarding housework trips done by public transport, the results show a positive correlation between such time, and living in an urban area in all the countries but Italy, where the negative interaction term, plus the average general coefficient, produces a non-statistically significant correlation. The estimated positive correlation is similar for women and men in the USA, Canada, Finland, the Netherlands, and South Africa, while it seems to be stronger in Hungary, Korea, Spain, and the UK.

All in all, the results in Table 5 indicate differences in the conditional correlations between urban/rural status and travel times and the time spent in leisure and housework trips via the different means of transport considered, both across countries and by gender. Since the estimates include a wide set of individual sociodemographic characteristics, the differences are net of observable factors included in the econometric specification. Thus, there is a complex relationship between urban forms and transport times, in line with the existing research (van Acker and Witlox 2011; Gimenez-Nadal et al. 2021).

5 Conclusions

This paper examines the relationship between the daily time spent by non-working older adults (i.e., aged 60 and over) in leisure and housework trips, and the urban/rural structures of their region of residence. Using time use diaries from the MTUS for the period 2000–2018, we compute the minutes per day spent in trips for leisure and housework purposes in Canada, Finland, Hungary, Italy, Korea, the Netherlands, South Africa, Spain, the UK, and the USA. In general terms, we find that individuals in urban areas spend more time in leisure trips than do similar individuals in rural areas. On the other hand, male older adults in urban areas spend less time in housework trips than do their counterparts in rural areas, while female older adults spend similar times doing

housework trips in urban and rural areas. However, cross-country differences reveal a more complex relationship, which depends on the country studied, the gender of the respondent, and the means of transport used.

These results complement prior research on travel behaviors of the elder population (see Feng 2017; Cheng et al. 2019; and Du et al. 2021; for recent reviews), though most of the existing research has focused on commuting behaviors of working-age population and urban forms (Gimenez-Nadal et al. 2020). Studying the reasons behind urban/rural differences in leisure trips and housework trips and also in other daily mobility behaviors may help to understand mobility patterns of older adults and consequently may serve as a guide for planners who aim at enhancing the mobility of older adults, including public transit services, transport infrastructure, and improving greener or more active means of transport.

This study may be relevant for planners and policy makers, as we present evidence of the impact of urban/rural forms on older people's daily trip behavior. We show the existence of a complex relationship that depends on the country and gender analyzed, but also on the means of transport. Given that active trips, as well as trips by public transport, seem to last longer in urban areas than in rural areas, the results suggest that better public transport and active transport infrastructure in rural areas may be beneficial for improving older adults' daily mobility. Indeed, we find that the availability of transport infrastructure, which is of key importance for both urban planners and older adults' mobility, is linked to decreased time spent in housework trips and increased time spent in leisure trips, suggesting that this may help older adults to do their chores activities faster, while at the same time help them to access a greater range of leisure facilities. Promoting green and active means of transport (e.g., carpooling, public transport, and active trips) may lead to environmental benefits, on the one hand, and health benefits—via increased physical activity—on the other.

Our analysis has certain limitations. First, since time use surveys are cross-sectional, the empirical analysis is limited to conditional correlations, since estimates may suffer from reverse causality and endogeneity. Thus, our results should be interpreted as correlations, and not as causal links. Second, travel behaviors have been found to depend on non-observable and stochastic factors, such as transport infrastructure, the weather, and having a driver's license. Thus, the accuracy of the estimated models is limited, yet is in line with certain prior studies on commuting times (see van Ommeren and van der Straaten 2008).

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Declarations

Conflict of interest The authors declare no potential conflicts of interest.

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