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Health, out-of-home activities and digital inclusion in later life: Implications for emerging mobility services

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A B S T R A C T

This paper focuses on the question of how digital technologies are differentially embedded in day-to-day practices and associated with mobility and health of older citizens. The motivation is to look for evidence that helps us anticipate opportunities and barriers of digital technologies and innovative transport services in enhancing independent living, social inclusion, health and well-being in ageing societies. Using the English Longitudinal Study of Ageing (ELSA), we identify six groups with different day-to-day leisure practices and find that the use of digital technology (Internet use, smart phones) is associated with higher frequencies of out-of-home activities. Barriers associated with lower levels of engagement include health-related restrictions, the same barriers that also prevent patronage of public transport. Although digital technology use has increased during the COVID-19 pandemic, lack of skills, access to equipment and health problems contribute to a continued Digital Divide. We conclude that the digitalisation of both public and transport services is unlikely to support independent living for all by itself and could indeed exacerbate existing inequalities. Instead, addressing issues of exclusion among less active, mobility-restricted groups require targeted service designs that respond to differential health and skills-related barriers in using digital technologies.

1. Introduction

Mobility, the ability to move freely in pursuit of out-of-home activities, is critical to one's independence, well-being and quality of life (Barr 2018; Musselwhite 2018). As numerous studies have shown, limited opportunity to travel can negatively affect health and well-being, in particular when lack of mobility results in unmet social needs, lack of physical activity and inadequate access to key services, such as retail opportunities and health care facilities (Boniface et al., 2015; Lucas 2012, 2019; Ziegler and Schwanen 2011). These issues are amplified for older age groups, since a primary factor that contributes to reduced mobility and in turn social exclusion and isolation is the loss of the ability to drive (Pachana et al, 2016; Musselwhite and Scott 2019).

In increasingly 'hypermobile' societies, high levels of mobility are needed to stay connected to friends, families and communities and to access essential services and facilities (Barr 2018; Musselwhite 2018; Urry 2014). Driving often satisfies the mobility needs of older people (Musselwhite and Scott 2019), and there is evidence that future older generations will become increasingly dependent on private cars as those that are currently middle-aged and younger have higher propensities to own private cars and drive after the age of 65 than the current older population (Jian et al., 2018). Alternative transport solutions that can meet the mobility needs of those that are unable to drive are therefore vital for improving health and inclusion in later life (Crotti et al., 2020).

However, urban transport systems are often designed to efficiently cater to the needs of the commuting population rather than the most vulnerable members of society, such as the older population (Battellino 2007). With previous research showing that mobility needs and demands change over the life course (Clark et al., 2014) and the continued diversification of lifestyle practices (Government Office for Science, 2016; Quan-Haase et al., 2018; Siren and Haustein 2016), it can be expected that the demographic transition in

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Western countries towards older age groups will further shift travel demand from peak-times and radial routes towards spatially and temporally dispersed patterns, while the need for accessible design and door-to-door access may be rising (Cui et al., 2017; Luiu et al., 2017).

At the same time, social inclusion is particularly critical for health and wellbeing among older adults (Sen et al., 2020). In an increasingly mobile and digital society, social inclusion can be achieved through high levels of mobility and engagement with digital technology. Yet, as more and more of business and society is transferred and conducted online, older adults can find themselves without the skills to participate (Hill et al., 2015). This situation is often exacerbated by limited mobility due to physical impairment and a lack of access to suitable transport services.

Digitalisation is likely to transform transport services in the future, which is reflected in current research and policy debates about innovative, 'smart' transport solutions such as autonomous vehicles (AVs) and Mobility as a Service (MaaS) (Cottril 2018; DfT, 2019a). The digitalisation of transport services has the potential to deliver significant benefits to older travellers by affording them greater mobility and independence (Harvey and Edwards 2019). Yet, if these new services require a high degree of digital literacy (Cottril 2018), and for those who are unwilling or unable to engage with technology, these trends may create a new layer of transport disadvantage (Durand et al., 2020; Nimrod 2018). Since access to the Internet and the use of mobile devices will be critical in accessing new transport services or substituting physical travel, for example through online socialising (Woolrych et al., 2021), this raises the question of by whom and how digital technologies are adopted in pursuit of life-enhancing activities.

2. Mobility, health and digital inclusion in later life

In view of demographic shifts and diversification of lifestyles in the UK, mobility practices and needs of older adults will to change in the future. Better healthcare and changes in lifestyle imply that the future older population are likely to be more active and mobile and to continue driving to a later age (Jian et al., 2018). At the same time, digital technologies are transforming transport services. Digitalised services can offer alternatives to physical mobility and participation or can facilitate access to transport services through online booking systems and e-hailing apps. These trends may enhance independence and mobility for some parts of the older population, but they may also increase the risk of social exclusion and isolation for disadvantaged and mobility-restricted groups (Goslightly et 2019; Lucas et al., 2019).

In the absence of direct experience with future travel, an everyday life perspective on digital technology adoption is important for conceiving the technology's broader societal impact and establish the conditions under which the digitalisation of services could meet the diverse needs of the older population, sustain high levels of well-being, address social exclusion while reducing environmental impacts (Cohen et al., 2020). Studies that investigate technology use in the context of day-to-day lifestyles and the realisation of leisure activities by the older population remain rare. A study into Finnish senior citizens by Nasi et al. (2011) found that active Internet use in older age had a strong positive correlation with the number of different leisure activities that were undertaken. Other studies have identified similar relationships, with advanced Internet users found to be more active in leisure time activities than non-Internet and less advanced Internet users (Zhou et al., 2014). Research has also found that Internet use positively influences cognitive functioning in later life, and that this relationship is partly mediated by the number of social and leisure activities that individuals participate in (Kamin et al., 2020). In sum, while the use of digital technologies in the older population is increasing, inequalities persist, as some groups remain less likely and able to participate in travel-dependent, life-enhancing activities.

Interdependent changes of lifestyle practices and technology use can be prompted by societal events, as recently experienced in the COVID-19 pandemic (Van Jaarsveld 2020). Although digital technology use has accelerated within the older population, a large proportion of the older population remain excluded from digital services because they opt not to use the Internet, lack the necessary devices or are inexperienced in using technology (Seifert 2020; Seifert et al., 2020).

Mihelj et al. (2019) explored how digital media can increase participation and diversity in arts and culture and found that whilst digital media provide important means of engaging new audiences, engagement with museums and galleries both online and offline remains deeply unequal with the gap between the 'haves' and 'have-nots' being greater online than in the case of physical visits. Similar results were found in a study by Ramsetty and Adams (2020), which looked at telehealth and access to healthcare during the COVID-19 pandemic. This study found inequalities in the accessibility of telehealth services due to a lack of access to or engagement with digital technologies and that those whose access was most impeded were also the most vulnerable to poor health outcomes related to COVID-19.

Evidence from these studies suggests that the increasing use of digital technologies in both transport and wider society has the potential to exacerbate the Digital Divide between those that are engaged with and able to use these technologies and those that are less 'tech-savvy' and less connected. The term 'Digital Divide' can be defined as "a division between people who have access and use of digital media and those who do not" (Van Dijk, 2020). Access to and use of digital technologies depend on infrastructure coverage and quality, availability of devices as well as user skills (Cottril 2018), all of which are viewed as increasingly vital for inclusion and participation in society and combating social isolation (Baker et al., 2018). Yet for those with limited physical mobility and a lack of access to digital technologies, the increased digitalisation of public and transport services risks a double burden of both social and digital exclusion in some already disadvantaged groups (Seifert et al., 2020). Therefore, the increasing digitalisation of services also has the potential to exacerbate existing inequalities; and in the UK, the Digital Divide remains of high if not growing concern in transport and mobility (Cottril 2018; Department for Transport DfT, 2019; Lucas et al., 2019).

In this study, we examine trends in the use of technology as part of day-to-day practices within the older population in England. We would argue that charting the configurations and distribution of out-of-home activities, physical travel and digital technology use can help anticipate the impact of future transport innovations and digitalisation on the social inclusion and wellbeing of the older population. Therefore, we focus on practices that are dependent on physical mobility and are thus likely to be crucial in the link between travel and health and well-being. We consider the frequency of out-of-home leisure activities, examine the associated use of digital technology and observe choices and attitudes related to travel given different health conditions. We also review how these dynamics have changed during the COVID-19 pandemic and what these trends might imply for digital inclusion and social participation in later life.

3. Research design

We combine segmentation with regression analysis to identify and compare different configurations of out-of-home practices, the distribution of mobility needs, digital technology adoption and associations with health and well-being. The English Longitudinal Survey of Ageing (ELSA, Banks et al., 2021) collects data of people of age 50 or older on out-of-home activities, travel, access to transport access, attitudes towards and experience with existing transport, which, if related to everyday life, provide information to assess benefits and barriers of novel mobility services and inform design from a long-term lifestyle perspective rather than less stable attitudes.

3.1. Sample

This study used data from Wave 9 (collected 2018/19) of the English Longitudinal Study of Ageing (ELSA). These data are collected from people aged 50 and over in England in order to understand all aspects of ageing. Since 2002, over 18,000 people in total have taken part in the study with data collected from the same respondents every two years. ELSA collects data on physical and mental health, wellbeing, finances, attitudes towards ageing, and how these change over time. A COVID-19 sub-study is also currently underway to investigate the effects of COVID-19 on the older population. Data has been collected from around 7,040 ELSA participants with the first wave of data collection in June/July 2020 and the second in November/December 2020.

For this study data were filtered to include only the 55+ population. This threshold was selected as the focus of this study is on the older population, and those that have therefore retired or will likely retire in the coming years. Data were also filtered for those with full records for all variables of interest. This resulted in a final dataset consisting of 4,924 respondents from 7,349, who participated in wave 9 and were of age 55 or higher.

3.2. Segmentation and group characterisation

All variables that are associated with out-of-home leisure activities were selected (Table 1) and standardised using z-score

Table 1
Out-of-home activities.

Variable	Description	Recoded values for segmentation	Recoded values for regression
Entertainment	The frequency that respondents visit the cinema, theatre, concerts, operas, museums or art galleries.	0 = never 1 = less than once a year 2 = about once or twice a year 3 = every few months 4 = about once a month 5 = twice a month or more	Frequent = 'twice a month or more' and 'about once a month' Infrequent = 'every few months' and 'about once or twice a year' Rare or never = 'less than once a year' and 'never' Reference: Infrequent
Eating out	The frequency that respondents eat out.		
Meeting friends	The frequency that respondents meet up with friends.		
Volunteering	The frequency that respondents undertake voluntary work.		
Organisational memberships	The number of groups or organisations that respondents belong to.	Variable created as the sum of the number of groups or organisations that a respondent mentioned being a part of: Minimum = 0 Maximum = 8	None = 0 One or two = 1-2 Two or more = 2+ Reference: None
Exercise	The intensity of exercise that a respondent undertakes.	Ordinal variable created as the sum of: 1 = mild activity either once a week or more than once a week 2 = moderate activity either once a week or more than once a week 3 = vigorous activity either once a week or more than once a week Minimum = 0 Maximum = 6	Low = 0 Medium = 1-3 High = 4-6 Reference: Low
Recreational travel	The type of recreational travel that a respondent undertakes.	Ordinal variable calculated as the sum of: 1 = day trip 2 = holiday in the UK 3 = holiday abroad Minimum = 0 Maximum = 6	Low = 0 Medium = 1-3 High = 4-6 Reference: Low

normalisation. These include visits to cultural institutions, socialising activities, recreational travel, exercising and civic engagement. We ran exploratory factor analysis (Gorsuch 1983) to detect high correlation between variables and combine them to scales where necessary. All variables related to visits of cultural institutions exhibited high correlation and were averaged to a new scale indicating cultural entertainment (Cronbach's alpha = .78).

We use crosstabulations to measure the distribution of demographics and socioeconomic characteristics of respondents: 5-year age groups, sex, general health and the National Statistics Socio-economic Classification (NS–SeC), employment status and respondents live alone. In terms of health, we include general health and devise a measure of frailty based on the National Health Service (NHS) Electronic Frailty Index (eFI) (Clegg et al., 2016), which looks at 20 'disease states' as well as symptoms, such as dizziness and falls and disabilities. We identify equivalent variables in ELSA and calculate the ratio of the sum of these variables (1 = respondent has disease/symptom/disability, 0 = respondent does not) and the total number of frailty variables (78). For the cross-group comparison, we age-standardise the index.

Digital technology and Internet use is measured as the frequency of Internet use, whether individuals used smartphones to access the Internet and the kinds of activities that respondents have used the Internet for in the last three months. ELSA also holds information on the type of device used for accessing the Internet: desktop computer, laptops, tablets, and smartphones. With respect to mobility and the potential use of digitalised transport services, portable devices are particularly relevant. Therefore, we assign a 'portability' level to each device type (1 = desktop computer to 4 = smartphone). The sum of these indicate both the number of devices used and the portability of these devices, with a minimum of 0 indicating that a respondent did not use any devices and a maximum of 10 indicating that a respondent used a variety of both portable and non-portable devices. Internet use during the COVID-19 pandemic come from ELSA's COVID sub-study. These variables included whether respondents' Internet use had increased, decreased or remained the same since the start of the outbreak, whether they would like to use the Internet more and the reasons that they do not use the Internet more.

Finally, variables related to transport include whether individuals had access to a private car or van when needed and if so, whether they drove this car or van themselves. Frequency of public transport use was also explored, as well as respondents' reasons for not using public transport.

We use a two-stage combined Ward hierarchical and k-means clustering procedure (Arai and Barakbah 2007; Chen et al., 2005; Peterson et al., 2018) that has proven robust and most informative in lifestyle and mobilty-related analysis (Kandt, 2018; Kandt et al., 2015). The two-stage clustering procedure generates cluster centres at the stage of hierarchical clustering and feeds those into the k-means algorithm, thus avoiding issues of sensitivity to initialisation (Sasirekha and Baby 2013). We assess cluster tendency using the *Hopkins statistic* (Lawson and Peter, 1990) and conducted sensitivity testing using alternative numbers of cluster centres and an alternative algorithm, Self-Organising Maps (Kohonen 1982), which is better suited to identify unusual cluster shapes. We compare the agreement between different cluster solutions alongside the within-cluster sum of squares (WCSS) and the interpretability of cluster solutions. On all counts, the two-stage clustering approach suggests better levels of cluster quality.

We use the WCSS as part of the 'elbow method' (Hughes and Moreno 2013) to determine the optimal number of clusters. Since the WCSS is a measure of the variability of the observations within each cluster, plotting the WCSS of a successive number of clusters allows to identify the point at which increasing the number of clusters further does not significantly decrease the average total WCSS. Six clusters seem optimal (Fig. 1), which we investigate regarding lifestyle practices, their socio-demographic composition and tendencies with regard to health and transport use. We test differences between the clusters' mean z-scores for statistical significance using one-way ANOVA and Tukey post hoc tests (Tukey 1949).

3.3. Stepwise logistic regression

We use backward stepwise logistic regression (Bewick et al., 2005; Zhang 2016) to estimate association of out-of-home activities

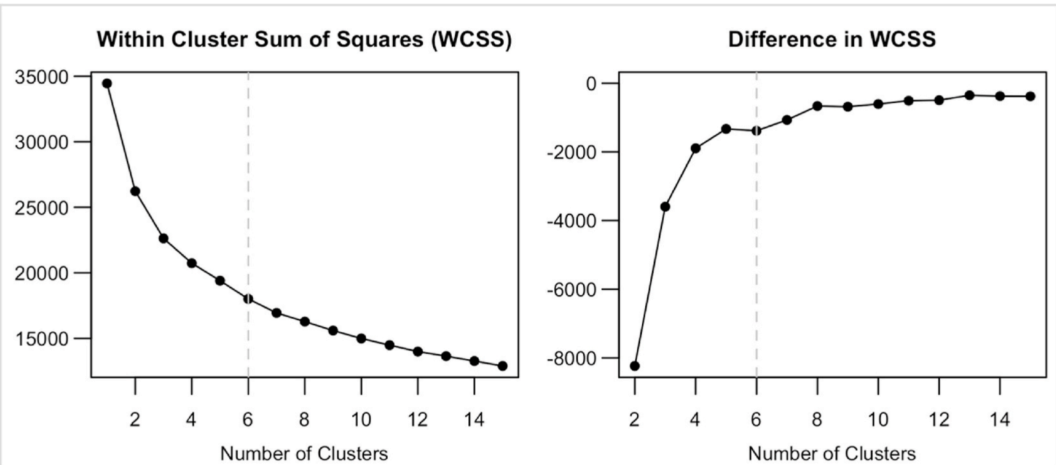

Fig. 1. Average total WCSS for values of k ranging from 2 to 15.

with two variables of interest – Internet use and car ownership – while controlling for socio-demographics and health. The dependent variables were recoded into binary form, 'every day' use of the Internet and having access to one or more cars. We calculate odds ratios for each variable indicating the degree of change that a category is associated with a change in the binary dependent variables with respect to the reference category. The out-of-home activity variables are the same as used for the cluster analysis, but they are aggregated to three ordinal classes (Table 1).

4. Results

4.1. Leisure participation profiles

The six clusters show different configurations of out-of-home activities with different degrees of routinisation (Table 2). These range from extensive out-of-home (OOH) participation in Cluster 1 to low OOH participation in Cluster 2. The remaining clusters show engagement with selected OOH activities. The distribution of socio-demographic and economic characteristics reveals members of more active clusters are younger, healthier and more affluent than members of clusters marked by low participation (Table 3). Beyond these expected patterns, there are nuances that relate to particular practices.

Cluster 1 shows high participation across various OOH activities. This cluster has a higher retirement rate, and nine out of ten members rate their health as good. Members of this cluster tend to have higher qualifications and the highest occupational status. Their high mobility profile likely reflects a combination of better health, higher disposable incomes and favourable time budgets.

Cluster 2 shows low participation across all OOH activities, in particular social OOH activities such as eating out and meeting friends. Nearly half of this cluster's members report poor health and accordingly have a high mean Frailty Index score. They also have a large percentage of members in lower occupational status of routine occupations and with no educational qualification. They exhibit low retirement rates combined with higher unemployment or economically inactivity.

Cluster 3 is characterised by low level of civic engagement, cultural participation and exercising but higher participation of travel, social and cultural activities. Members are comparatively younger and most often have intermediate levels of education but they can come from all levels of occupational status. Four in five respondents of this group rate their health as good, while the frailty index is slightly higher indicating a small, relative health disadvantage.

Cluster 4 shows lower OOH participation with the exception of exercise intensity, which is the greatest among all clusters. This cluster has the highest percentage of members in the youngest age group and the highest employment rate. This profile may reflect better physical health and more limited time budgets to conduct other activities. This is also the only cluster that shows a higher proportion of men; all other clusters have a greater percentage of female than male members, which may reflect gender differences in life expectancy.

Cluster 5 shows relatively low engagement across all OOH practices except for volunteering. This cluster has the largest proportion of members in the 65–74 age group and lowest proportion in the younger 55–64 age group. Two in three members are retired, which is the highest retirement rate among all clusters.

Cluster 6 shows very low OOH participation except for domestic visits of friends. Over 42% of the members of this cluster are recorded as having poor health and their mean Frailty Index score is the highest of all clusters. Two in five members have no qualifications and over 60% are in routine occupations. One third in Cluster 6 live alone, and this is highest compared to the other clusters. Visiting friends seems therefore an important if not existential OOH activity for the disadvantaged Cluster 6. Low activity levels may be explained by health disadvantage and likely lower disposable income.

4.2. Associations with technology use and transport

Differences in digital technology use are very pronounced between clusters (Table 4). More active clusters tend to use the Internet and smartphones more often than clusters with lower OOH participation. Accordingly, Cluster 1 has by far the greatest percentage of everyday users and Clusters 2 and 6, the least active of all clusters, contains the lowest percentage.

Table 2
The out-of-home lifestyle clusters, their statistical tendencies and their sizes.

Cluster	1	2	3	4	5	6
Short name	Extensive OOH participation	Low OOH participation	Travel & eating out	Exercise & travel	Volunteering	Low OOH participation & visiting friends
Size (%)	797 (16.2)	502 (10.2)	1220 (24.8)	843 (17.1)	800 (16.2)	762 (15.5)
Variables:						
Entertainment	**1.030**	**-.814**	.186	.308	-.155	**−1.020**
Eating out	.484[3]	**-.949**[6]	.426[1]	.282	.051	**-.927**[2]
Visiting friends	.392[6]	**−1.880**	.102[4,5]	.093[3,5]	.136[3,4]	**.415**[1]
Volunteering	**1.180**	-.562[4,6]	-.667[4,6]	-.620[2,3,6]	**1.430**	-.611[2,3,4]
Participation	**1.370**	-.713[6]	-.257	-.051	.110	-.612[2]
Exercise intensity	.593	-.523[3]	-.564[2]	**1.260**	-.064	-.699
Travel intensity	.658	-.841	.375[4]	.421[3]	-.068	**−1.130**

NotesAll pairwise differences are statistically significant at $p \leq .05$, except those pairs that are indicated in superscript above.

Table 3
Distribution of socio-demographic characteristics among out-of-home lifestyle clusters.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Age						
55–64	37.8	42.0	39.4	**55.1**	**31.2**	38.7
65–74	44.7	30.5	40.6	35.0	**46.0**	29.2
75–84	16.6	21.0	16.4	**9.2**	19.5	22.4
85+	0.8	**6.5**	3.6	0.8	3.3	**9.8**
Sex						
Male	42.8	48.8	45.5	**53.5**	48.6	47.7
Female	**57.2**	51.2	54.5	46.5	51.4	52.3
General Health						
Good	**92.4**	53.7	79.2	**91.6**	81.3	**57.7**
Poor	7.6	**46.3**	20.8	8.4	18.8	42.3
Frailty						
Age-standardised mean	.053	**.126**	.088	.043	.076	**.143**
Education						
Higher education degree	**50.6**	15.9	20.7	28.1	28.2	11.4
Below degree or other	45.4	56.6	**63.4**	60.0	57.3	47.8
None	4.0	**27.5**	15.9	11.9	14.5	**40.7**
NS-SeC						
Managerial	**58.6**	**25.3**	36.9	46.4	43.0	**20.7**
Intermediate	27.3	25.7	29.4	26.4	28.4	20.7
Routine	14.0	**49.0**	33.7	27.3	28.6	**58.5**
Employment status						
Employed	33.8	29.3	33.4	**44.4**	26.1	26.1
Unemployed/economically inactive	3.7	**15.4**	6.9	7.9	7.1	**13.9**
Retired	62.4	55.3	59.8	**47.7**	**66.8**	60.0
Living alone						
Yes	19.7	23.6	23.2	18.2	22.3	**32.8**
No	80.3	76.4	76.8	81.8	77.7	67.2

Table 4
Distribution of Internet and technology use among out-of-home lifestyle clusters.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Internet use frequency						
Every day	92.0	**57.7**	76.1	84.7	76.4	**51.4**
Less frequent	**8.0**	42.3	23.9	15.3	23.6	48.6
Smartphone users						
Yes	**79.1**	53.9	69.8	**76.7**	65.6	51.7
No	20.9	**46.1**	30.2	23.3	34.4	**48.3**
Internet activities in the last 3 months						
Email	**98.4**	85.3	90.8	94.3	94.3	**73.7**
Video calls	50.3	**25.6**	38.2	44.6	34.0	**22.6**
Searching for health-related information	**94.4**	**69.4**	84.3	88.7	85.2	**62.5**
Visiting news sites	**69.9**	45.7	57.2	**64.7**	51.6	**39.6**
Shopping	85.2	72.3	77.5	86.7	78.8	**63.2**
Social networking	53.0	42.9	55.5	53.8	53.9	43.5
Games	23.5	29.8	**32.0**	25.9	29.2	25.9
Portability score (average)	**6.6**	5.0	6.0	**6.5**	5.7	**4.8**
COVID-19 Sub-study						
Change in Internet use since the coronavirus outbreak						
Less than it was	0.7	**7.2**	3.5	1.8	2.2	**6.0**
About the same	42.6	61.9	52.4	55.5	53.8	68.9
More than it was	**56.7**	**30.9**	44.2	42.7	43.9	**25.1**
Would like to use the Internet more						
Yes	14.1	17.5	12.1	11.9	15.5	**21.9**
Of those that said yes … reason for not using the Internet more						
IT skills not good enough	57.7	**64.0**	53.7	61.2	**47.9**	**66.1**
Don't trust the Internet	30.6	33.1	30.9	**44.1**	36.9	**41.1**
Lack of access to equipment	12.5	10.5	17.3	8.7	12.4	**32.1**
Health problems	1.5	**22.8**	1.5	2.4	0.0	3.6

ELSA records the Internet activities that respondents have undertaken over the previous 3 months. Comparing all clusters, the most active clusters have a higher percentage undertaking all Internet activities, except for playing games. Cluster 3, characterised as socially active but otherwise inactive, has the highest percentage of respondents that undertook gaming activities. The greatest differences are evident for searching for health information and visiting news sites, with the most active clusters found to be much more likely to undertake these activities than less active clusters.

Active clusters also have higher average portability scores. Clusters 1, 3 and 4 all have scores of 6 or more, indicating respondents use a smartphone and at least a laptop or tablet. Cluster 6, the least active, has an average portability score of 4.8, almost 2 points fewer than Clusters 1 and 4. This suggests that these respondents are less likely to use a variety of technology devices and are also less likely to use portable technology devices than more active clusters.

Clear differences are evident in the use of the Internet services since the coronavirus outbreak. A higher percentage of respondents in the more active clusters increased their Internet use since the coronavirus outbreak compared to those that were less active. However, when asked whether respondents would like to use the Internet more, the least active clusters were more likely to say that they would. One in five respondents in Cluster 6 state that they would like to increase their Internet use, and over 17% in the Cluster 2.

When these respondents were asked why they did not use the Internet more, Clusters 2 and 6 had a higher percentage of respondents that mentioned lack of IT skills. Respondents in Cluster 6 are most likely to lack access to equipment, with one on three stating that this was the reason they did not use the Internet more. By contrast, almost one quarter of respondents in Cluster 2 stated that health problems presented a barrier to Internet use. These results suggest that respondents in these least active clusters would be willing to be more engaged with technology but would likely require support in doing so and that the support needed would differ between clusters.

4.3. Longitudinal trends in technology use including the pandemic

Longitudinal 'tracing' of clusters reveal how interactions between mobility, health and technology use have changed over time and during the pandemic (Fig. 2). The COVID-19 sub-study contains generally comparable variables, but there is no data for smartphone use and general health is reported as health over the previous month. This may explain the increase in health observed for some clusters.

The percentage of respondents reporting good health generally has declined whereas the percentage of respondents that are everyday Internet users and smartphone users has increased. Yet, the latter occurs at unequal paces. Clusters 1 and 4, characterised as generally the most active, show a comparable steady increase in smartphone use. In comparison, the more selectively engaged clusters (Clusters 3 and 5) increased their usage at a marginally slower rate. Clusters 2 and 6, characterised by low OOH participation, also experience an increase in smartphone use between Wave 6 and Wave 9 but this was smaller than the other clusters.

Although frequent Internet use has increased in all clusters over the study period, the magnitude of this increase differed. Cluster 6

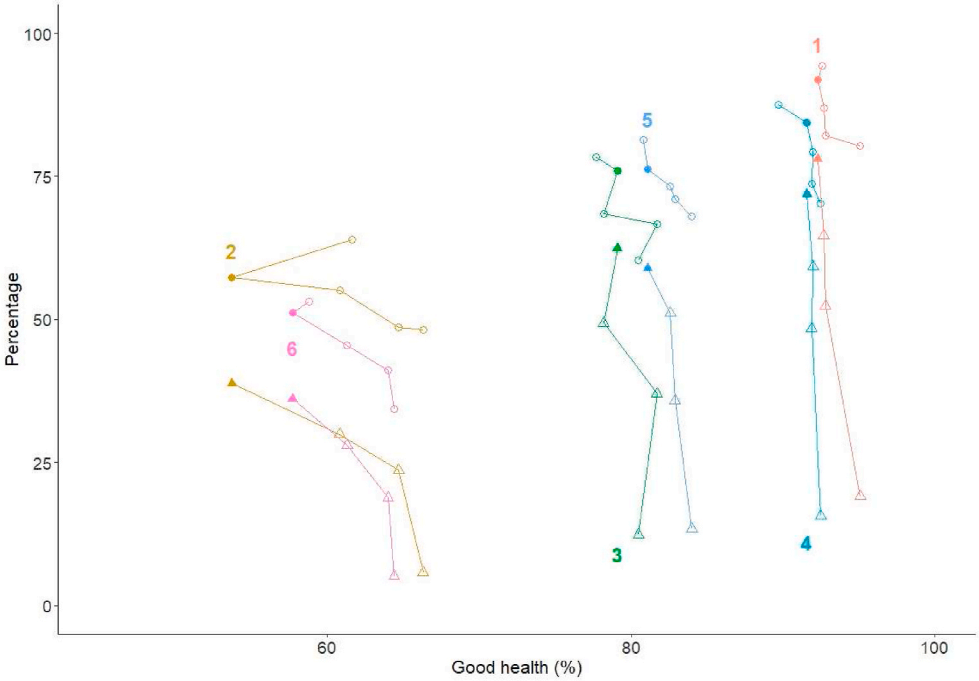

Fig. 2. Percentage of each cluster classed as having good health plotted against the percentage of every day Internet users (circles) and smartphone users (triangles) for Waves 6, 7, 8 and 9 (solid fill) and the COVID-19 sub-wave.

has experienced the greatest increase (19%) in everyday Internet users between Wave 6 and the COVID-19 sub-wave, whereas Clusters 1, 2 and 5 have experienced the smallest increase, of around 13–15. The smaller increase for Cluster 1 may be explained by the fact that frequent Internet usage was already high in Wave 6, with over 80% of respondents classed as everyday Internet users. The smaller increase for Clusters 2 and 5, however, is likely more indicative of a reluctance to engage with technology. There is also evidence of increasing inequalities, where health is declining while smartphone adoption has also been slowing in low OOH participation clusters in recent years. Despite overall increasing everyday Internet use during the coronavirus outbreak, risks of deepening social exclusion remain through widening divergences in the pace of digital technology adoption. The overall increasing everyday Internet use during the coronavirus outbreak appears to bode well for technology engagement in older age groups in the future.

4.4. Transport use and attitudes

The most OOH active clusters have a higher percentage of respondents with access to private transport than those clusters that are less active (Table 5). This may go some way to explaining these low levels of activity, with private transportation allowing for greater and more flexible travel and participation. The most active clusters are also the most likely to drive cars themselves.

The most active clusters are also the most likely to use public transport services frequently, although these differences are greater for monthly users than weekly users. Reasons for not using public transport services differ between clusters, when comparing Clusters 2 and 6 to the other ones. The percentage of respondents that state that they do not use public transport services due to mobility difficulties or their health preventing them from doing so is much greater in these least active clusters. By contrast, for the most mobile cluster 1, the barriers in using public transport are related to the level and type of service – destinations and frequency.

4.5. Digital technology and car use for out-of-home leisure activities

The regression models reveal that older respondents are less likely to be everyday Internet users than younger respondents (Table 6). This finding is consistent with previous research that found that the Internet and technology is more common among younger populations (ONS 2017). Women are less likely to be frequent Internet users than men, with a decrease in odds of almost 32%. Previous research supports this finding, with men found to be more engaged with technology than women (*ibid*). In terms of occupational status (NS–SeC), those in managerial occupations are more likely to be frequent Internet users than those in routine occupations. Respondents of poor health are also less likely to be frequent Internet users, with a reduction in the odds ratio of around 18% compared to those of good health. This relationship is similar to previous studies (e.g. Clarke et al., 2017) that have found a positive relationship between health and frequent Internet use due to the use of online health resources. Similar associations are found for Frailty Index score with more frail respondents less likely to frequently use the Internet.

In terms of OOH activities, associations with Internet use exist for entertainment, eating out and civic engagement. Those that rarely or never partake in entertainment activities are less likely to be everyday Internet users than those that infrequently do so, and those that undertake these activities frequently are over 30% more likely to regularly use the Internet. Those that rarely or never eat out are 35% less likely to be everyday Internet users compared with those that eat out infrequently. Those who are a member of one or two groups or organisations are over 19% more likely to be an everyday Internet user than those who are a member of none, and those who are a member of more than two are over 82% more likely.

'Travel intensity' also exhibits a significant relationship with Internet use. 'High travel intensity' includes respondents that had undertaken at least a holiday abroad as well as a day trip or a holiday in the UK in the last 12 months. With respect to those that did not undertake any travel over the previous 12 months, those with the highest travel intensities are over 81% more likely to be frequent Internet users, indicating that those that undertake greater travel are much more likely to frequently use Internet services.

Similar results can be seen for car access in terms of the relationships with demographic characteristics. Older age groups are less

Table 5
Distribution of transport use and attitudes among lifestyle clusters.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Whether respondent has access to a private car or van						
Yes	96.0	**81.3**	90.4	95.3	92.5	**77.5**
If yes, whether respondent drives this car or van themselves						
Yes	95.8	**77.2**	87.7	94.1	90.5	**75.9**
How often respondent uses public transport						
Several times a week	20.4	17.3	21.6	18.2	19.6	18.5
Several times a month	28.0	**9.5**	19.6	18.8	21.8	**13.9**
Once a month or less	40.7	**23.7**	36.3	39.5	38.3	**21.3**
Never	**10.9**	**49.5**	22.4	23.6	20.3	**46.2**
Reason for not using public transport						
None available	16.5	13.8	10.1	13.3	13.3	**7.3**
Does not go where wanted	**37.9**	18.9	25.7	29.9	27.9	13.4
Too infrequent	15.4	**8.6**	12.9	15.6	16.9	**5.3**
Health prevents it	1.4	**18.3**	5.8	0.4	1.8	**22.7**
Difficulties with mobility	1.1	**11.7**	4.5	0.2	2.8	**15.2**

Table 6
Stepwise logistic regressions with Internet use frequency ('every day' and 'less frequent') and car access ('yes' and 'no') as the dependent variables.

Independent variable (reference category)	Internet use frequency				Car access			
	Estimate	Std. Error	p-value	Odds Ratio	Estimate	Std. Error	p-value	Odds Ratio
Intercept	1.908	.262	3.24E-13 ***	6.740	2.538	.440	7.87E-09 ***	12.650
Age Group (55–64)								
65–74	-.712	.110	1.03E-10 ***	.490	-.062	.156	6.89E-01	.939
75–84	−1.773	.123	<2E-16 ***	.170	-.281	.170	9.86E-02 .	.755
85+	−2.514	.199	<2E-16 ***	.080	-.608	.230	8.34E-03 **	.545
Sex (Male)								
Female	-.384	.081	2.11E-06 ***	.681	-.624	.120	2.21E-07 ***	.536
NS-SeC (Intermediate)								
Managerial	.508	.103	7.52E-07 ***	1.662	.244	.155	1.15E-01	1.276
Routine	-.543	.097	1.89E-08 ***	.581	-.264	.139	5.79E-02 .	.768
General Health (Good)								
Poor	-.199	.104	5.65E-02 .	.820	–	–	–	–
Frailty Index (< mean)								
>=mean	-.209	.096	2.93E-02 *	.812	-.503	.123	4.11–05 ***	.604
Entertainment (Infrequent)								
Frequent	.266	.123	3.06E-02 *	1.304	–	–	–	–
Rare or never	-.473	.094	4.43E-07 ***	.623	–	–	–	–
Eating Out (Infrequent)								
Frequent	.136	.089	1.23E-01	1.146	.179	.128	1.61E-01	1.196
Rare or never	-.430	.174	1.33E-02 *	.650	-.762	.188	5.16E-05 ***	.467
Visiting Friends (Infrequent)								
Frequent	–	–	–	–	-.316	.121	8.75E-03 **	.729
Rare or never	–	–	–	–	.030	.218	8.90E-01	1.031
Volunteering (Infrequent)								
Frequent	.103	.195	5.98E-01	1.108	-.351	.355	3.23E-01	.704
Rare or never	-.151	.186	4.15E-01	.860	-.654	.340	5.45E-02 .	.520
Participation (None)								
More than two	.602	.133	5.70E-06 ***	1.825	–	–	–	–
One or two	.174	.094	6.48E-02 .	1.190	–	–	–	–
Exercise Intensity (Low)								
High	–	–	–	–	.978	.227	1.70E-05 ***	2.659
Medium	–	–	–	–	.419	.177	1.76E-02 *	1.521
Travel Intensity (Low)								
High	.597	.138	1.46E-05 ***	1.816	1.262	.180	2.08E-12 ***	3.532
Medium	.060	.128	6.38E-01	1.062	.539	.149	3.06E-04 ***	1.714
Pseudo $R^2 = 0.21$					Pseudo $R^2 = 0.15$			

likely to have access to a private car or van, with those aged 85 and over more than 45% less likely than those aged 55–64. Women are also around 46% less likely to have private car or van access than men and those in routine occupations are 23% less likely than those in intermediate occupations. General health does not have a significant relationship with car access; however, frailty has a strong negative relationship with car access. Those with a Frailty Index score of 0.08 or higher are almost 40% less likely than those with score of less than 0.08 to have access to a private car or van.

Five OOH activities have a statistically significant relationship with car access. Those that rarely or never eat out are less likely to have car access than those that infrequently eat out, with a reduction in odds of almost 53%. Those that visit friends frequently are almost 27% more likely to have access to a private car or van. Compared to those that volunteer infrequently, those that rarely or never volunteer are significantly less likely to have private car or van access. Some of the strongest relationships are with exercise and travel intensity. Compared to those with a low exercise intensity, those with medium and high intensities are significantly more likely to have access to a private car or van. Similar results can be seen with travel intensity, with those with a high travel intensity over 250% more likely to have access to a private car or van.

Although the pseudo R^2 values of 0.21 and 0.15 are relatively low, it is also a usual level of explanatory power in comparable studies (Nasi et al., 2011); and it may further be explained by unmeasured activities and contextual characteristics.

5. Discussion

5.1. Heterogeneity of practices, needs and vulnerabilities

Adopting an everyday life perspective, we identify heterogenous profiles of out-of-home activities among the older population of age 55 plus. These profiles are linked to differential needs and forms of exclusion related to mobility and digital services among older people in England. Less affluent and less healthy individuals tend to engage in fewer out-of-home activities, and they use digital technologies less often. Although the adoption of digital technologies has risen rapidly across all groups during the pandemic, inequalities remain pronounced because uptake of digital technology is stronger in clusters that already used these technologies more often. The positive association between frequent and diverse use of the Internet and portable devices with frequent participation in leisure activities reflects the increasing importance of the role of digital technology in everyday life.

This trend renders barriers to technology adoption significant obstacles to participation in an ageing society. Lack of IT skills, lack of access to equipment and health problems are relevant to different degrees in different out-of-home lifestyle clusters. Nevertheless, the clusters with the lowest out-of-home participation expressed the highest level of desire to use digital technology more often. Those more vulnerable clusters are also significantly less likely to have access to private transport modes when needed or be able to access public transport services. Viewed alongside the relationships with Internet use frequency, these clusters are at risk of further exclusion, both physically and virtually, as forms of mobility become increasingly dependent on digital technology.

These trends suggest an existing and possibly increasing divide between those that are able to participate in out-of-home activities and those that are not, with implications for inequalities in health and well-being. If the more active and healthier groups are better connected in terms of both physical and virtual mobility, they are also better able to access the benefits of technology. With the potential of the COVID-19 pandemic to increase the Digital Divide (Van Jaarsveld 2020), mobility-restricted and less well-resourced older population may be at an increased risk of exclusion and current barriers of adoption among disadvantaged groups need to be urgently overcome.

5.2. Implications for 'smart' mobility services

Although information regarding the increasing digitalisation of future mobility services is not included, the findings provide suggestions for the design of such services over and above findings from studies on more transient attitudinal patterns. Improvements in digital technology and increased automation promise significant changes in transport services and provision over the coming years (Cottril 2018; Metz 2017). Although these services have the potential to provide many benefits for the older population, including greater mobility and independence (Harvey and Edwards 2019), not all individuals have equal access to digital technologies and services and thus may experience increased social exclusion (Walsh et al. 2021).

The clusters reveal diverse activity profiles and mobility needs among senior citizens; specifically they show that individuals who pursue a wide range of out-of-home activities are generally more engaged with digital technologies than lower activity clusters. These individuals may be more likely to take up digitally enabled e-hailing services or MaaS packages to enhance their mobility even further. Widening inequalities are inevitable, however, if such services are unaffordable or inaccessible to disadvantaged and disability-restricted groups or those groups that are unwilling or unable to engage with digital technology (Golightly et al., 2019; Lucas et al., 2019). In one low participation cluster, the practice of visiting friends seems crucial in sustaining social participation and well-being, and in the context of restricted mobility and disadvantaged residential location, this would require affordable, possibly shared and slower, economically operated door-to-door service, which may be unattractive to more affluent groups. Reluctance or inability to engage with digital technologies would need to be considered in the design and provision of targeted transport services.

A similar division of preferences is revealed by attitudes towards public transport, where more active groups identify issues of convenience and service as barriers to use whereas low participating groups emphasise mobility difficulties, which again is indicative of different design priorities for future transport innovations related to frequency, flexibility and speed vis-à-vis physical accessibility of vehicles and accompanied journeys resembling more conventional ring-and-ride services. The varying transport needs within the older population will likely require different types of services with different financial and operating models and levels of government support.

As future public services, including transport services, will likely require interaction with and adoption of technology (Rahman et al., 2020), there is a risk that low participating clusters will be further excluded if those barriers to digital technology remain unaddressed. The increased digitalisation of services bear potential to reduce social barriers, enhance equity, and increase autonomy only if they become accessible and useable to populations that to date have interacted little with digital technology throughout their lives.

All these considerations suggest that a clearer debate is needed on future transport and service innovations, who they serve, who may use them for which purpose and what the resulting heterogeneity implies for design requirements as well as social and environmental consequences. As digital technologies have become more closely embedded in OOH practices and mobility during the pandemic, it is at the intersection of digitalisation, physical and virtual mobility and everyday practices where fault lines of transport and social exclusion in later life are likely to be reinforced, if these interdependencies are not carefully considered in the design and operation of ever smarter transport system. Multidimensional OOH activity clusters, such as the ones developed here, may serve as a basis to develop everyday life scenarios of mobility, health and well-being in later life against which the differential benefits and risks of digitalised transport innovations can be anticipated and evaluated.

5.3. Study limitations

ELSA contained little direct information on emerging mobility services, there is no direct information on the current use of technology for the purpose of travel, and there are no questions about attitudes towards emerging mobility services. Yet, since the focus of this study is to review the everyday life context in which digital technologies and emerging mobility services may operate, information on often changeable and transient attitudes are less essential to this research.

The survey provides a limited set of variables related to mobility-dependent leisure practices, such as accessing and enjoying nature, although physical exercise may in parts capture such activities. Other unrecorded, relevant activities relate to socio-cultural practices, such as attending religious ceremonies, or a wider range of interests and forms of entertainment, such as gardening, pub visits or adult education. Variables covering the use of digital technologies are limited to Internet use and mobile devices and have not been consistently collected in all waves.

As with all social surveys, samples are small and may be biased, but the usual sampling procedures ensure that it is as representative of the older population in England as possible. There is no information on residential context of participants, which is well known to affect accessibility, travel practices and perceptions about transport. Despite all these limitations, ELSA remains one of the most comprehensive data sources on lifestyles, mobility and health in later life and thus is suitable to assess the dynamics of changing out-of-home leisure practices, the embedded use of technology and equitable mobility and health.

Limitations in relation to methods include deterministic cluster assignments. K-means clustering is a hard clustering method assigning each individual to a single cluster. The method aims to maximise intra-class similarity and minimise inter-class similarity. Therefore, the segmentation masks potential ambiguity in assigning cases to clusters, for example when cases are similarly far apart from several statistical cluster centres. This is a common issue of cluster analysis, and this uncertainty should be borne in mind when interpreting the results.

The causal relationship between OOH practices, mobility and digital technology use likely operates in multiple directions. People may use more or less digital technology depending on their need to use or substitute physical transport; and vice versa lack of use of digital technology may constrain people's mobility. Based on a combination of case-based comparison of clusters and regression-based analysis of transport and digital technology use, our study reveals the everyday social and mobility context in which they are used.

6. Concluding remarks

With an ageing population in the UK, it is increasingly important to understand the mobility needs and day-to-day lifestyles of the older population. The ability of older populations to engage in out-of-home activities is likely to remain a crucial determinant of health and well-being and thus a parameter in health and social equity in later life. Whether new, digital technologies and transport innovations can make positive contributions of equitable health and mobilities will be a question of increasing prominence in debates about ageing in place and sustainable transport.

The findings of this study provide important evidence on the differential role of Internet and technology in everyday life. Future research should further explore whether increased Internet use acts to facilitate the participation in leisure activities, whether those that participate in leisure activities are more prone to adopting and engaging with new technologies and what kinds of emerging mobility services may best serve diverse social needs. Since the diffusion and embedding of digitally connected technology in everyday life inevitably increases, understanding their differential adoption and impact on independent living and well-being in later life becomes vitally important in evaluating inclusive and healthy mobility in ageing societies.

Author statement

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Declaration of competing InterestCOI

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

Data availability

The data source is accessible for research purposes and is referenced in manuscript.

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Appendix A. Supplementary data

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