Author(s): Portegijs, Erja; Timmermans, Erik J.; Castell, Maria V.; Dennison, Elaine M.; Herbolsheimer, Florian; Limongi, Federica; van der Pas, Suzan; Schaap, Laura A.; van Schoor, Natasja; Deeg, Dorly J. H.

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Neighborhood resources associated with active travel in older adults – a cohort study in six European countries

Erja Portegijs,[1] PhD, Erik J. Timmermans,[2] PhD, M Victoria Castell,[3,4,5] PhD, Elaine M. Dennison,[6] PhD, Florian Herbolsheimer,[7] PhD Federica Limongi,[8] PhD, Suzan van der Pas,[2,9] PhD, Laura A. Schaap,[10] PhD, Natasja van Schoor,[2] PhD, Dorly J.H. Deeg,[2] PhD

[1] Faculty of Sport and Health Sciences and Gerontology Research Center, University of Jyvaskyla, Jyväskylä, Finland.
[2] Department of Epidemiology and Biostatistics, Amsterdam University Medical Center, VU University Medical Center, Amsterdam Public Health Research Institute, Amsterdam, the Netherlands.
[3] Department of Preventive Medicine and Public Health, Unit of Primary Care and Family Medicine, Faculty of Medicine, Universidad Autonoma de Madrid.
[4] Doctor Castroviejo Primary Care Health University Center, Northern Primary Care Health Directorate.
[5] Hospital La Paz Institute for Health Research (IdiPAZ). Madrid, Spain.
[6] MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, UK.
[7] Simon Fraser University, Department of Gerontology, Vancouver, Canada.
[8] National Research Council, Aging Branch, Institute of Neuroscience, Padua, Italy.
[9] Faculty of Social Work & Applied Psychology, University of Applied Sciences Leiden, Leiden, the Netherlands.
[10] Department of Health Sciences, Faculty of Science, Vrije Universiteit Amsterdam, Amsterdam Public Health Research Institute, Amsterdam, the Netherlands.

Corresponding author:
Erja Portegijs
Gerontology Research Center and Faculty of Sport and Health Sciences
University of Jyvaskyla
P.O. Box 35 (viv)
FI-40014 University of Jyväskylä
Finland
email: erja.portegijs@jyu.fi
phone: +358 40 481 4347

Running headline: Neighborhood resources and active travel

Abstract

Objectives: To study associations between perceived neighborhood resources and time spent by older adults in active travel.

Methods: Respondents in six European countries, aged 65–85 years, reported perceived presence of neighborhood resources (parks, places to sit, public transportation, and facilities) with response options 'a lot', 'some', and 'not at all'. Daily active travel time (total minutes of transport-related walking and cycling) was self-reported at baseline (n=2695) and 12-18 months later (n=2189).

Results: Reporting a lot of any of the separate resources (range B's=0.19-0.29) and some or a lot for all four resources (B=0.22,95%CI=0.09-0.35) was associated with longer active travel time than reporting none or fewer resources. Associations remained over the follow-up, but changes in travel time were similar regardless of neighborhood resources.

Discussion: Perceiving multiple neighborhood resources may support older adults' active travel. Potential interventions, e.g. provision of new resources or increasing awareness of existing resources, require further study.

Keywords: Mobility, Physical activity, Built environment, Aging, Active transport

Introduction

Currently, it is established that even low-intensity activities, such as travel-related walking and cycling, contribute to maintaining health and functioning in old age (Varma et al., 2014). With age, participation in sports and exercise declines, while the relative contribution of time and frequency of active travel increases among individuals able to walk and cycle (Fishman, Bocker, & Helbich, 2015). Grocery shopping and running errands are among the most frequent reasons for leaving the home and using active travel (Chudyk et al., 2015; Davis et al., 2011) and thus contribute to the total amount of physical activity in old age (Schrack et al., 2016; Stel et al., 2004).

When walking or cycling, older adults typically stay rather close to home. Hence neighborhood design may provide support and destinations for active travel (Gauvin et al., 2012; Pucher & Buehler, 2008; Van Cauwenberg et al., 2012). Living in proximity to *destinations* such as parks and public facilities (e.g. supermarkets, post offices, and community centers) is associated with higher levels of physical activity and active travel of older adults according to two recent systematic reviews (Barnett et al., 2017; Cerin et al., 2017). Other neighborhood attributes, such as public transportation and places to sit and rest may *support* older adults' mobility by making it easier to cover longer distances. Previous research has shown that the use of public transportation is associated with higher levels of physical activity and active travel (Davis et al., 2011). Lack of benches is a well-recognized environmental barrier for outdoor mobility (Levasseur et al., 2015; Rantakokko, Iwarsson, Portegijs, Viljanen, & Rantanen, 2015), but the evidence is less clear on whether proximity or presence of benches is associated with more active travel (Cerin et al., 2017). Furthermore, there is some evidence that reporting multiple types of resources in the neighborhood may provide additional benefit over reporting one only (McCormack, Giles-Corti, & Bulsara, 2008; Van Cauwenberg et al., 2013).

To get a deeper understanding of the relationship between the environment and outdoor physical activity it is necessary to study associations using the same measures depicting the environment and physical activity behavior in a variety of settings or countries, rather than the multitude of different measures comprising the current literature (Barnett et al., 2017; Cerin et al., 2017). According to the ecological model of aging (Lawton & Nahemow, 1973), an individual's behavior depends on the balance between individual and environmental factors. The person-environment balance, in turn, is more strongly linked to perceptions of the neighborhood environment than to the objectively assessed physical environment (Portegijs, Keskinen, Tsai, Rantanen, & Rantakokko, 2017; Weden, Carpiano, & Robert, 2008). Prospective studies examining associations between environmental factors related to the physical neighborhood and active travel are rare (Cerin et al., 2017), but could provide information about whether associations found in cross-sectional studies also remain over time, thus providing a rationale for the development and design of interventional studies.

The aim of the current study was to determine whether perceived presence of public facilities, parks and walking areas, places to sit and rest, and public transportation as neighborhood resources separately and jointly was associated with daily active travel time and its change over a 12-18 months follow-up in 65-85-year-old adults in a pooled dataset from six European countries, when controlling for relevant individual and environmental factors.

Methods

Study design and participants

Data from the European Project on OSteoArthritis (EPOSA) were used for these cross-sectional and longitudinal analyses. A detailed description of the study design and data collection is described elsewhere (van der Pas et al., 2013). In summary, random samples were taken from existing population-based cohorts in Germany, the Netherlands, Spain, Sweden and the United Kingdom (UK). In Italy, a new sample was drawn. Data collection took place twice with 12 to 18 months between the baseline and the follow-up assessment. Data of all countries was pooled. A total of 2942 respondents (average response rate 72.8%) with an age range of 65–85 years (in the UK, 71–79 years) were included at baseline. At the follow-up, all willing participants (n=2455) were re-assessed. All participants were interviewed by a trained researcher at home (in the Netherlands, Sweden, and the UK) or in a clinical center (in Germany, Italy and Spain), using a standardized questionnaire and a clinical exam. For all six countries, the study design and procedures were approved by the Ethical Review Boards of the respective institutions. All participants gave written informed consent prior to the start of the study.

Main variables

Perceived presence of neighborhood resources

Perceived presence of neighborhood resources was assessed using three items from a modified version of the Home and Community Environment (HACE) instrument (Keysor, Jette, & Haley, 2005) including items on parks and walking areas, places to sit and rest, public transportations, and an additional, similarly formulated item on public facilities. The HACE is a standardized, self-report instrument designed to assess factors in a person's environment that may influence participation. In the current study, only the items addressing the local community aspect were deemed most relevant. Participants were asked to indicate whether each of the following resources was present in their neighborhood: (1) public facilities such as a daily supermarket, bus stop, post office, bank, community center, (2) parks and walking areas that are easy to get to and easy to use, (3) places to sit and rest at bus stops, in parks, or in other places where people walk, and (4) public transportation close to home. For each resource, response options were ‘a lot’, ‘some’ and ‘not at all’. In addition, as an indicator of *resource variety*, we counted for how many of the resources participants reported at least some (some or a lot) neighborhood resources. Based on the variable distribution we categorized the count for the analyses, and compared those reporting at least some presence for three of the resources, and for four of the resources, with those reporting at least some presence for none to two of the resources. Similarly, we counted for how many of the neighborhood resources participants reported a lot of presence, and we compared those with one or two, and three or four, with those reporting none of the resources to be present a lot.

Active travel time

Active travel time was assessed at baseline and follow-up using two activity categories, i.e. daily walking, and daily cycling, from the validated Longitudinal Aging Study Amsterdam (LASA) Physical Activity Questionnaire (Stel et al., 2004), a questionnaire specifically developed to assess physical activities of older people. Daily walking and cycling were related to transportation and everyday activities (e.g. shopping), but not sports (separate question). Frequency and duration of participation in the respective activities during the previous two weeks was estimated by the participant. Total walking and cycling times (frequency*duration for each activity) were summed and divided by 14 to obtain the daily active travel time expressed in minutes. Separate analyses of walking and cycling were not possible because cycling as a means of transportation was rather uncommon in several countries, but considering only walking would underestimate transport-related physical activity in other countries (Pucher & Buehler, 2008). The change in active travel time over the follow-up was computed by subtracting the baseline from the follow-up time, thus negative values indicating a decline and positive values indicating an increase in active travel time.

Covariates

Covariates were selected because of previously reported associations with the study outcome (Ding et al., 2014; Fishman et al., 2015; Hinrichs et al., 2019; Klenk et al., 2012; Lubs, Peplies, Drell, & Bammann, 2018; Van Cauwenberg et al., 2012). Participants' **age**, **sex** and **country of residence** were obtained from the cohort registers. The date of the assessments were used to create a variable for astronomical **season** at baseline (winter as reference), and the **study duration**, that is, the number of months between the baseline and follow-up assessments. **Level of urbanization** was categorized based on population size and density into urban (>300 persons/km^2 and >5000 inhabitants (n=1622)), intermediate (5000–30000 inhabitants (n=851)) and rural (<300 persons/km^2 or <5000 inhabitants (n=217)) areas (van der Pas et al., 2016). To avoid small group sizes, rural and intermediate areas were merged together into 'other areas'. Self-reported number of **chronic diseases** was calculated from a list of chronic diseases or symptoms that lasted for at least three months or for which the participant had been treated or followed by a physician. The list included: chronic non-specific lung disease, cardio-vascular diseases, peripheral arterial disease, diabetes mellitus, stroke, cancer, and osteoporosis. In addition, the count included osteoarthritis, which was asked with the question 'Do you have osteoarthritis?'. **Physical performance** was assessed with a modified version of the Short Physical Performance Battery (SPPB) consisting of a walking test, repeated chair stands and a tandem stance test (Edwards et al., 2014; Guralnik et al., 1994). Walking speed over a distance of 3m was assessed with a stopwatch (Italy, Netherlands, Spain, Sweden, and the UK) or using a GAITRite® walkway system (Germany) at maximal (Germany, Italy, Netherlands, Spain, and Sweden) or habitual pace (UK). Use of assistive devices was permitted if required. Five chair stands were conducted at habitual (Italy, Netherlands, Spain, and Sweden) or maximal pace (Germany and UK) with the participants' arms folded across their chest. Standing balance was assessed with a ten-second tandem stance test, which was scored 0 (unable to stand or able to manage <4s in the position), 2 (maintained balance between 4 and <10s) or 4 (balance maintained for 10s). For the walking test and chair stands, those who could not complete the test were given a score of 0 and scores of 1 (slowest) – 4 (fastest) were assigned based on country-specific quartiles of the times to account for the specific methodology used in each country. Scores of the walking test, chair rises and balance test were summed, and if necessary, when only two out of three tests were conducted (n=140), scaled from 0 to 12. Higher SPPB scores indicate better performance. **Sense of mastery** was assessed with the Pearlin Mastery Scale (Pearlin & Schooler, 1978). It consists of five negative and two positive items with response options ranging from 1 (strongly disagree) to 5 (strongly agree). Sum scores range from 7 to 35, with higher scores indicating a higher sense of mastery. **Partner status** was assessed by asking the marital status of the participant and categorizing responses into having no partner (single/never married, divorced and widowed) versus having a partner (married or cohabiting, registered partnership and living apart together). **Educational level** was derived from the highest level of education completed by the participant and categorized into at most elementary school (elementary school completed or not completed) versus vocational or higher education (vocational education/general secondary education, and college or university education). The question on **car use** of the HACE questionnaire (Do you drive a car?) was used as a covariate in the analyses (yes, no).

Statistical analyses

At baseline, overall 1.1% of participants (n=32) had no data on any of the neighborhood resources (range from 0.4% in Spain to 3.3%% in Sweden), and 6.8% of participants (n=198) had missing data on walking and cycling (range from 3.7% in Germany to 13.2% in Sweden), and were thus excluded from all analyses. The active travel time variable was skewed to the right with values of 0 and higher and it displayed clear outliers. Scores of ≥360 minutes (Germany n=1 and Italy n=8) or individual scores deviating >1 standard deviation (SD) from their closest neighbor within the same country (cut-off 267.6 for Netherlands n=4, 283.9 for Spain n=1, and 296.4 for the UK n=3) were considered as outliers and dropped from all analyses. From the 2695 participants included in the baseline analyses, 18.4% (n=497) did not respond to the follow-up questions on active travel (range from 9% in UK to 34% in Italy) and another 9 were dropped from the analyses due to the defined cut-off values for active travel time (Italy n=4, Netherlands, n=1, Spain n=3, UK n=1), thus leaving 2189 participants for the prospective observational analyses.

Participants were dropped list wise from the respective analyses in case of missing scores for a neighborhood resource (1.5% of participants with one or two missing resources) and/or covariate (0-0.6% of participants depending on the variable; in total 1.0% in the fully adjusted models) other than sense of mastery. For 2.6% of participants, mastery scores were missing and subsequently imputed by the country-specific mean (n=71; mostly from UK and Italy).

Descriptive variables, neighborhood resources, and physical activity were compared among those included and not included in the cross-sectional and prospective analyses using Chi-square and Mann-Whitney U tests. The change in active travel time from baseline to follow-up was tested using the related-samples Wilcoxon Signed Rank Test. Descriptive analyses of none-categorical variables were weighted by sex and 5-yr age category based on European population averages in 2010 (van der Pas et al., 2013).

Intraclass Correlation Coefficient (ICC) (variance due to country / total variance), depicting the dependency of active travel time of participants within countries, e.g. due to shared factors such as culture, amounted to ICC=0.08 and combined with marked improvement of the model fit (reduction of the Bayesian Information Criterion of >14500), justified the use a mixed modeling approach including country as a random effect (Vajargah & Nikbakht, 2015). Generalized linear mixed models with gamma log link transformation were used to study associations between the perceived neighborhood resources and active travel time (with the value of one added to all scores to eliminate zeros). Each neighborhood resource separately and the counts were analyzed in separate models. All models were adjusted for fixed factors age and sex (model 1) and additionally adjusted for urbanization grade, season, chronic conditions, SPPB score, mastery score, partner status, educational level, and car use (model 2). For the prospective analyses, a repeated measures design was used for the generalized linear mixed models with gamma log link transformation. The previously described protocol was used for the analyses with the addition of ‘assessment’ (follow-up versus baseline) and ‘assessment by neighborhood resource interaction’ in each model. In addition, an interaction term of ‘study duration’ and ‘season at baseline’ was created, and added to the prospective mixed models. However, based on the statistical contribution of ‘duration’ ($p \geq .263$) and ‘duration-season interaction’ (variable redundant), and the reduced model fit (BIC increase >8), only baseline season was maintained as covariate in the final model.

Results

At baseline, participants were on average 74.1 (± standard deviation (SD) 5.1) years old. Table 1 shows that over half of the participants were female and lived in urban areas. Participants not included in the cross-sectional analyses were older, more often lived alone and in other than urban areas, and reported fewer resources in their neighborhood than those included in the analyses. Furthermore, those not included had lower SPPB (6.0±4.1 vs. 8.4±2.8, $p<.001$) and mastery (25.9±5.6 vs. 26.3±4.9, $p=.749$) scores and more chronic diseases (2.0±1.3 vs. 1.6±1.1, $p<.001$) than those included in the analyses.

Cross-sectional analyses

For participants included in the baseline analyses, the perceived presence of public facilities, parks and walking areas, places to sit and rest, and public transportation was generally reported more frequently in the Netherlands, Spain and Sweden and most limited in Italy (Appendix 1). The majority of participants reported that all neighborhood resources were present (at least some) in their neighborhood (overall 73.5%), and about one third of participants reported 'a lot' for at least three out of four resources (Table 1 and Appendix 1), except in Italy where the respective percentages were markedly lower. Table 2 shows that the active travel time varied between countries, with the highest values in Germany and Spain and the lowest in Italy and Sweden. The overall median active travel time was 28.9 minutes (interquartile range 48.6).

Perceived presence of neighborhood resources associated with active travel time at baseline

Overall, reporting a lot of public facilities (B=0.24, 95%CI=0.09-0.38) was associated with longer active travel times than reporting no such facilities at all (Table 3). Similarly, reporting some (B=0.18, 95%CI=0.05-0.32) or a lot (B=0.31, 95%CI=0.17-0.45) of parks and walking areas was associated with longer active travel times than reporting no parks and walking areas at all. Reporting a lot of, not some, places to sit and rest (B=0.29, 95%CI=0.15-0.43) and public transportation stops (B=0.27, 95%CI=0.12-0.42) was associated with longer walking and cycling times than when no such places were reported. In terms of variety in perceived neighborhood resources, reporting 'at least some' presence for all four of the neighborhood resources (B=0.26, 95%CI=0.12-0.39) was associated with longer active travel time than reporting 'at least some' presence for two or fewer of the resources. Reporting the presence of 'a lot' for one to two (B=0.16, 95%CI=0.06-0.27) or for three to four (B=0.36, 95%CI=0.25-0.47) of the perceived resources was associated with longer active travel time than not reporting 'a lot' for any of the resources. In general, adjustment of these models for covariates slightly attenuated the strength of the relationships, but did not affect their statistical significance.

Prospective analyses

Participants not included in the prospective analyses were older, had attained a lower level of education, more often did not drive a car, more often lived in urban areas, and reported fewer resources in their neighborhood than those included in the analyses (Table 1). In addition, participants not included in the analyses had lower SPPB (7.4±3.3 vs. 8.6±2.7, $p<.001$) and mastery (25.1±4.8 vs. 26.6±4.8, $p<.001$) scores and more chronic diseases (1.8±1.2 vs. 1.5±1.1, $p<.001$) than those included.

Perceived presence of neighborhood resources associated with active travel time over the follow-up

There was high variability between participants with large declines and increases in active travel time occurring over the follow-up (median change 0.0 minutes, p=.684; Table 2). Moreover, active travel time declined significantly in Germany, Sweden, and the UK, while it increased over the follow-up in Spain, and did not change statistically significantly in Italy and the Netherlands. Table 4 shows that the overall change in active travel time and the assessment by resource interaction effects were not statistically significant in any of the models, as indicated by 95%CIs not including 0 (representing p>.169), indicating that the change over the follow-up period was not associated with perceived neighborhood resource presence. However, in line with the cross-sectional findings, participants reporting a lot of the same neighborhood resource (public facilities, parks and walking areas, places to sit and rest, and public transportation) overall spent more time in active travel compared to participants not reporting the respective resource (range of B's=0.23-0.30). For parks and walking areas reporting some presence was also associated with longer overall active travel times (B=0.17, 95%CI=0.02-0.32). In terms of neighborhood resource variety, reporting 'at least some' presence for all four of the neighborhood resources (B=0.23, 95%CI=0.07-0.39) was associated with longer active travel time than reporting only two or fewer of them. Reporting 'a lot' for one to two resources (B=0.14, 95%CI=0.03-0.24) and for three to four resources (B=0.27, 95%CI=0.12-0.41) was associated with longer active travel time than not reporting 'a lot' for any of the perceived resources. Generally, adjusting the models for covariates slightly attenuated the strength of the associations. Ancilliary analyses did not reveal any systematic differences when grouping countries based on average change over time.

Discussion

The current European wide study, using the exact same variables in all countries, showed that reporting a lot of neighborhood resources of the same nature – that is, public facilities, parks and walking areas, places to sit and rest, or public transportation – or a variety of these different neighborhood resources, was associated with longer active travel times reported by older adults. These results suggest that multiple favorable neighborhood resources may need to be perceived to induce older adults to travel actively, but it may be of less importance whether the resources are of the same or a different nature. The prospective analyses showed that associations between perceived neighborhood resources and active travel time remained over time, but that changes in active travel time over the follow-up were similar regardless of reported neighborhood resources presence.

Based on the current study results it remains unclear whether the associations between neighborhood resources and active travel found are due to differences in the actual environment or differences in awareness of resources (Portegijs et al., 2017). In the current study, only perceptions of the presence of neighborhood resources were available. Perceptions of neighborhood resources provide important information about preferences and neighborhood resources used, but less about the actual physical environment (Cerin et al., 2017). While correlations between perceived and actual features of the environment tend to be rather poor, perceptions are more proximal determinants of an individual's behavior (Weden et al., 2008). Consequently, in terms of practical application, further study is needed to determine whether strategies to increase active travel should target the actual physical environment or people by increasing their awareness of neighborhood resources. Possibly, interventions may need to be designed in a country-specific way due to potential differences in factors underlying associations found.

It has been suggested that the availability of supportive attributes and destinations for physical activities in the neighborhood may have a cumulative effect on activity behavior (Van Dyck et al., 2012). The current, as well as earlier studies, showed positive associations between a higher number of neighborhood resources and older people's activity behavior (McCormack et al., 2008; Portegijs et al., 2017; Van Cauwenberg et al., 2013). The current study furthermore showed that reporting more of the same or multiple different neighborhood resources both were associated with longer active travel time. Reporting at least three out of four resources to be present a lot in the neighborhood was most beneficial in terms of active travel, potentially because diversity and quality aspects contribute to the attractiveness of these destinations (McCormack et al., 2008; Van Cauwenberg et al., 2013). Environments offering a lot of resources may provide a wider variety and thus more likely include one suitable for the older adult to use in light of their preferences and capacity (Portegijs et al., 2017; Satariano et al., 2016). Yet, in the current study, perceiving a greater presence of any of the neighborhood resources separately was also found to be beneficial for active travel.

Associations between the presence of public facilities and active travel have been shown rather consistently based on objectively assessed and perceived environmental variables (Cerin et al., 2017) and are confirmed by the current study. In the context of the current societal trend to foreclose local facilities and centralize them (Buffel & Phillipson, 2018), it is important to emphasize the importance of providing a wide variety of public facilities locally. Although based on perceptions of the neighborhood resources, the current study shows that maintaining only a few facilities may not be sufficient for older people to be drawn to active travel, which may have important health benefits in old age. The question on public facilities covered a diverse range of facilities (e.g. supermarket, bank, community center), which may not all be equally important to the older person (Chudyk et al., 2015). For example, grocery shopping may be a much more frequently occurring event than visiting a bank or post office, and a person may chain different errands or destinations into one trip (Davis et al., 2011). Consequently, associations between varying public facilities and active travel may differ accordingly.

Consistent with existing research (Cerin et al., 2017), reported presence of parks and walking areas was associated with higher active travel time compared to when parks and walking areas were not present. Parks and walking areas were the only neighborhood resource for which reporting some parks and walking areas was beneficial in terms of active travel behavior, indicating that reporting any green space is of importance. A 'dose-response relationship' indicated that more parks and walking areas present were associated with longer active travel times. Quality aspects of parks and walking areas (e.g. natural diversity and facilities) have been associated with physical activity behavior (Keskinen, Rantakokko, Suomi, Rantanen, & Portegijs, 2018; Schipperijn, Bentsen, Troelsen, Toftager, & Stigsdottir, 2013), but are not captured by measures assessing presence only, but to some extent may be aligned with the ability to choose from multiple available options, suiting their preferences and capacity (Keskinen et al., 2018). This is further supported by a recent study showing that parks were relevant for active travel, but that it made no difference whether or not these parks were spatially located between the home and a frequently visited grocery store (Hinrichs et al., 2019).

So far, associations between benches and active travel behavior have been less consistent (Cerin et al., 2017). In the current study, longer active travel times were found among those reporting a lot of places to sit and rest in the neighborhood than among those reporting no such places. Different types of benches were included in the same question (at bus stops, parks, and other places), while destinations and infrastructural elements in the environment may affect physical activity behavior differently according to their facilitating or supportive nature (Cerin et al., 2017). Benches as a supportive feature may be especially important for those with mobility limitations and fear of falls (Van Cauwenberg et al., 2016). Benches of a mobility facilitating nature may be located at places with an attractive view (e.g. in green or near blue spaces) or provide opportunities for social interaction (Ottoni, Sims-Gould, Winters, Heijnen, & McKay, 2016). Consequently, not every bench is valued equally and thus the likelihood of it promoting active travel increases with a higher provision of benches in an area. To the best of our knowledge, we are not aware of studies making such a distinction.

Mobility is essential to function in daily life and opportunities to use different modes of transportation enable an older person to go wherever and whenever one wants to go (Satariano et al., 2012). Presence of public transportation options has been associated with the level of physical activity and active travel (Cerin et al., 2017), potentially due to the need to travel to and from the transit stops. In the current study, reporting a lot of public transportation stops in the neighborhood was associated with active travel time. Presence of any transportation stop may be important especially in more remote areas (Van Cauwenberg et al., 2012) and when no other transportation options are available (Ding et al., 2014). In more densely populated areas, the coverage and directions of public transportation lines may be relevant (Zeitler, Buys, Aird, & Miller, 2012).

Prospective cohort studies provide evidence of potential long-term effects of factors underlying behavior. Overall the time spent on active travel did not change during the 12-18 month follow-up and was not associated with the duration of follow-up. Associations between neighborhood resources and active travel time remained over time as reported earlier (Gauvin et al., 2012; Portegijs et al., 2017; Sugiyama, Cerin, Mridha, Koohsari, & Owen, 2018). However, reporting some or a lot of any of the neighborhood resources did not prevent or reduce declines in active travel time, indicated by the lack of statistically significant time by resource interactions. Nevertheless, causal relationships cannot be established. Individuals with a physically active lifestyle may choose to live in an environment that is supportive to their physical activity. This self-selection bias may distort associations found between neighborhood resources and physical activity (Cao, 2014), although it may persist even when accounting for self-selection (Christiansen, Madsen, Schipperijn, Ersboll, & Troelsen, 2014). Thus, interventional studies are needed to determine whether changes in the environment lead to changes in active travel. In addition, exposure to the environment, which is reflected in a higher level of physical activity or active travel in the neighborhood, creates awareness of environmental features, which in turn affects what is reported by participants in self-reports (Keysor et al., 2005), thus, suggesting that interventions targeting better awareness of neighborhood resources may also be useful. Moreover, participants more active at baseline may have been more active at follow-up, thus explaining the associations found between perceived neighborhood resources and active travel time at baseline and follow-up. Alternatively, the relatively short length of follow-up may not have been optimal to capture systematic changes. Possibly changes in the environment or related policies between baseline and follow-up may have affected the study findings, but information on such potential changes was not available. Such changes may have been favorable or unfavorable to active travel, so that it is not clear how they may have affected our results.

This is a unique study conducted using similar methods in samples of older adults from six European countries, and allowing prospective analyses. In this study, population-based samples were drawn and pooled, and thus comprised residents of multiple neighborhoods with a large variety in social and physical environments. Limitations of this study are that the main dependent and independent variables were self-reported, which do not provide exact estimates of active travel time or the physical environment, but they are time- and cost-efficient for use in correlational studies and large cohorts (Cerin et al., 2017; Schrack et al., 2016). Validity and reliability of validated questionnaires may not apply to a selection of questions, but unfortunately, in the current study, could not be re-established. Over time, neighborhood resources and preferences and needs of older adults may change, but in this study, the perceived presence of neighborhood resources was assessed once only. Furthermore, environmental needs are not fully identical for walking and cycling (Van Cauwenberg et al., 2012; Van Dyck et al., 2012), but it was not possible to look at them separately. Sensitivity analyses showed associations of similar direction for both walking and cycling. As is common in aging studies, participants in the study had better health and function due to selective non-participation and drop-out, thus compromising the generalization of the results. Our analyses were adjusted for a range of individual and environmental factors to determine whether these factors could explain the associations between perceived neighborhood resources and active travel time, but it is possible that not all relevant factors were accounted for and some residual effects remain, including effects related to country-specific factors. Research has shown that active travel behavior may differ according to the season (Klenk et al., 2012), but in the prospective analyses, we were not able to identify any systematic trend in how changes in season between the baseline and follow-up assessments (as occurred in 54.6% of participants) affected associations between perceived presence of neighborhood resources and active travel behavior over time.

Conclusions

This European study shows that older adults reporting more neighborhood resources of the same nature or a variety of different resources in the neighborhood spent more time on active travel. Perceived presence of public facilities, parks and walking areas, places to sit and rest, and public transportation in the neighborhood were all separately associated with longer active travel time when a lot of them were reported in the neighborhood compared to them not being reported at all at baseline and 12-18 months later. For parks and walking areas only, reporting some presence was also beneficial in terms of active travel. Being able to pool the data from European countries provided a unique opportunity to show that associations exist within the broader context of Europe, despite large differences between the environments and cultures. In light of the importance of maintaining mobility and the potential health benefits of active travel especially in old age, these results suggest that it is important to promote the provision of neighborhood resources locally within walking or cycling distance from older adults' homes. However, considering that we studied perceived presence of neighborhood resources rather than actual availability of neighborhood resources, further study is needed to determine whether environmental modifications or promoting awareness of existing neighborhood resources is more effective in facilitating active travel. Furthermore, it is possible that the mechanisms of action and strategies to facilitate active travel may differ between different countries. In future studies, temporal changes in the environment, in mobility behaviors of older adults and in policy should be studied using prospective study designs including multiple assessments over time and incorporating also objective measures such as accelerometry, GPS and geographical information enabling for more detailed analyses.

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Table 1. Participant characteristics at baseline according to inclusion in the cross-sectional and prospective analyses.

		Cross-sectional			Prospective		
		Not included (n=247) % (n)	Included (n=2695) % (n)	Chi²-test P	Not included (n=506) % (n)	Included (n=2189) % (n)	Chi²-test P
Country	Germany	7.3 (18)	14.4 (389)	<.001	14.8 (75)	14.3 (314)	<.001
	Italy	19.4 (48)	15.6 (420)		28.9 (146)	12.5 (274)	
	Netherlands	18.6 (46)	19.6 (528)		18.2 (92)	19.9 (436)	
	Spain	12.6 (31)	18.8 (508)		18.8 (95)	18.9 (413)	
	Sweden	33.2 (82)	15.9 (428)		11.7 (59)	16.9 (369)	
	UK	8.9 (22)	15.7 (422)		7.7 (39)	17.5 (383)	
Age group	65-74	46.6 (115)	56.9 (1533)	.002	51.0 (258)	58.2 (1275)	.003
	75-85	53.4 (132)	43.1 (1162)		49.0 (248)	41.8 (914)	
Sex	Male	45.3 (112)	48.4 (1304)	.396	44.9 (227)	49.2 (1077)	.087
	Female	54.7 (135)	51.6 (1391)		55.1 (279)	50.8 (1112)	
Urbanization grade	Other areas	47.8 (118)	39.6 (1068)	.016	34.8 (176)	40.7 (892)	.015
	Urban areas	52.2 (129)	60.3 (1625)		65.2 (330)	59.2 (1295)	
	Missing	0.0 (0)	0.1 (2)		0.0 (0)	0.1 (2)	
Season	Spring	45.3 (112)	42.1 (1134)	.434	40.9 (207)	42.3 (927)	.354
	Summer	21.5 (53)	21.9 (591)		21.3 (108)	22.1 (483)	
	Autumn	18.6 (46)	17.4 (470)		20.2 (102)	16.8 (368)	
	Winter	14.6 (36)	18.6 (500)		17.6 (89)	18.8 (411)	
Education level	Elementary school only	48.6 (120)	43.9 (1182)	.177	55.3 (280)	41.2 (902)	<.001
	Vocational or higher education	51.4 (127)	56.0 (1510)		44.5 (225)	58.7 (1285)	
	Missing	0.0 (0)	0.1 (3)		0.2 (1)	0.1 (2)	
Partner status	Alone	42.1 (104)	31.2 (840)	.001	34.0 (172)	30.5 (668)	.142
	Together	57.9 (143)	68.8 (1855)		66.0 (334)	69.5 (1521)	
Drives car	No	33.2 (82)	35.1 (946)	.644	41.5 (210)	33.6 (736)	.001
	Yes	56.3 (139)	64.3 (1733)		57.7 (292)	65.8 (1441)	
	Missing	10.5 (26)	0.6 (16)		0.8 (4)	0.5 (12)	

Table 1 continues		Cross-sectional			Prospective		
		Not included (n=247) % (n)	Included (n=2695) % (n)	Chi²-test P	Not included (n=506) % (n)	Included (n=2189) % (n)	Chi²-test P
Public facilities	A lot	20.2 (50)	42.7 (1152)	<.001	34.8 (176)	44.6 (976)	<.001
	Some	49.4 (122)	46.9 (1263)		49.6 (251)	46.2 (1012)	
	Not at all	16.6 (41)	10.2 (274)		15.6 (79)	8.9 (195)	
	Missing	13.8 (34)	0.2 (6)		0.0 (0)	0.3 (6)	
Parks & walking areas	A lot	29.1 (72)	47.1 (1270)	<.001	36.2 (183)	49.7 (1087)	<.001
	Some	37.7 (93)	41.4 (1116)		45.5 (230)	40.5 (886)	
	Not at all	19.8 (49)	11.4 (307)		18.0 (91)	9.9 (216)	
	Missing	13.4 (33)	0.1 (2)		0.4 (2)	0.0 (0)	
Places to sit & rest	A lot	19.4 (48)	33.5 (902)	<.001	27.1 (137)	34.9 (765)	<.001
	Some	40.1 (99)	51.5 (1387)		51.2 (259)	51.5 (1128)	
	Not at all	25.1 (62)	14.4 (388)		21.3 (108)	12.8 (280)	
	Missing	15.4 (38)	0.7 (18)		0.4 (2)	0.7 (16)	
Public transportation	A lot	21.5 (53)	39.9 (1076)	<.001	32.8 (166)	41.6 (910)	<.001
	Some	44.9 (111)	48.9 (1319)		50.4 (255)	48.6 (1064)	
	Not at all	20.2 (50)	10.7 (288)		16.6 (84)	9.3 (204)	
	Missing	13.4 (33)	0.4 (12)		0.2 (1)	0.5 (11)	
Count ’at least some’ resources	4	45.7 (113)	73.5 (1980)	<.001	63.8 (323)	75.7 (1657)	<.001
	3	16.6 (41)	13.9 (375)		16.2 (82)	13.4 (293)	
	0-2	37.7 (93)	12.6 (340)		20.0 (101)	10.9 (239)	
Count ’a lot’ resources	3-4	12.1 (30)	31.4 (846)	<.001	25.3 (128)	32.8 (718)	<.001
	1-2	32.8 (81)	34.3 (924)		27.5 (139)	35.9 (785)	
	0	55.1 (136)	34.3 (925)		47.2 (239)	31.3 (686)	

Table 2. Proportion of participants reporting transport-related walking or cycling, and median amount of time spent in total active travel (minutes) at baseline and follow-up, and its change over the 12-18-month follow-up, overall and stratified by country.

	Walking	Cycling	**Baseline**			**Follow-up**			**Absolute change**			
	%	%	n	Median (IQR)	Range	n	Median (IQR)	Range	n	Median (IQR)	Range	P [a]
Overall	90.5	32.6	2695	28.9 (48.6)	0.0 - 325.0	2189	28.6 (47.1)	0.0 - 329.0	2189	0.0 (33.2)	-293.0 - 267.0	.684
Germany	91.3	48.3	389	42.9 (58.6)	0.0 - 325.0	314	34.3 (42.7)	0.0 - 240.0	314	-6.4 (42.9)	-290.0 - 165.0	<.001
Italy	75.7	42.1	420	17.1 (40.7)	0.0 - 309.0	274	20.7 (34.3)	0.0 - 329.0	274	2.1 (39.4)	-293.0 - 267.0	.936
Netherlands	90.3	56.8	528	21.4 (32.4)	0.0 - 214.0	436	25.7 (38.3)	0.0 - 240.0	436	0.7 (26.6)	-214.0 - 159.0	.128
Spain	96.2	1.6	508	42.9 (38.6)	0.0 - 240.0	413	60.0 (60.0)	0.0 - 270.0	413	12.9 (60.0)	-171.0 - 210.0	<.001
Sweden	90.0	2.6	428	20.0 (24.3)	0.0 - 180.0	369	15.0 (22.9)	0.0 - 174.0	369	-1.4 (22.9)	-177.0 - 135.0	.001
UK	98.6	6.9	422	25.7 (43.8)	0.0 - 240.0	383	21.4 (31.3)	0.0 - 289.0	383	-0.7 (26.4)	-227.0 - 178.0	.005

Note: Analyses weighted by sex and age based on European population averages in 2010.

IQR= interquartile range

[a] Related-Samples Wilcoxon Signed Rank Test

Table 3. Cross-sectional mixed models to determine associations between presence of neighborhood resources and active travel time at baseline (n=2652–2695).

	Age & Sex Adjusted		**Fully Adjusted [a]**	
	Estimate	95%CI	Estimate	95%CI
Public facilities	7763.33 [b]		7722.39 [b]	Δ 40.94 [c]
Intercept	4.78	4.14 - 5.41	3.43	2.66 - 4.20
Resource (a lot)	**0.24**	**0.09 - 0.38**	**0.19**	**0.04 - 0.33**
Resource (some)	0.04	-0.09 - 0.18	0.03	-0.10 - 0.07
Resource (no)	0.00		0.00	
Random variance (country)	0.09	0.02 - 0.31	0.08	0.02 - 0.30
Parks & walking areas	7781.73 [b]		7745.70 [b]	Δ 36.02 [c]
Intercept	4.55	3.91 - 5.20	3.21	2.44 - 3.99
Resource (a lot)	**0.31**	**0.17 - 0.45**	**0.29**	**0.14 - 0.43**
Resource (some)	**0.18**	**0.05 - 0.32**	**0.17**	**0.04 - 0.31**
Resource (no)	0.00		0.00	
Random variance (country)	0.09	0.02 - 0.31	0.09	0.02 - 0.32
Places to sit & rest	7739.66 [b]		7687.79 [b]	Δ 51.87 [c]
Intercept	4.71	4.06 - 5.35	3.33	2.56 - 4.11
Resource (a lot)	**0.29**	**0.15 - 0.43**	**0.24**	**0.10 - 0.38**
Resource (some)	0.08	-0.05 - 0.21	0.05	-0.08 - 0.18
Resource (no)	0.00		0.00	
Random variance (country)	0.09	0.02 - 0.30	0.09	0.02 - 0.31
Public transportation	7722.03 [b]		7685.28 [b]	Δ 36.75 [c]
Intercept	4.71	4.06 - 5.35	3.32	2.55 - 4.10
Resource (a lot)	**0.27**	**0.12 - 0.42**	**0.22**	**0.07 - 0.38**
Resource (some)	0.02	-0.12 - 0.16	0.00	-0.14 - 0.15
Resource (no)	0.00		0.00	
Random variance (country)	0.09	0.02 - 0.32	0.09	0.02 - 0.32
Count 'at least some' resources	7788.83 [b]		7758.12 [b]	Δ 30.71 [c]
Intercept	4.62	3.98 - 5.62	3.27	2.49 - 4.04
Count (4)	**0.26**	**0.12 - 0.39**	**0.22**	**0.09 - 0.36**
Count (3)	0.10	-0.05 - 0.25	0.08	-0.07 - 0.24
Count (0-2)	0.00		0.00	
Random variance (country)	0.08	0.02 - 0.29	0.08	0.02 - 0.30

Table 3 continues	**Age & Sex Adjusted**		**Fully Adjusted [a]**	
	Estimate	95%CI	Estimate	95%CI
Count 'a lot' resources	7768.36 [b]		7725.54 [b]	∆ 42.82 [c]
Intercept	4.64	4.01 - 5.28	3.32	2.55 - 4.08
Count (3-4)	**0.36**	**0.25 - 0.47**	**0.31**	**0.20 - 0.43**
Count (1-2)	**0.16**	**0.06 - 0.27**	**0.14**	**0.03 - 0.24**
Count (0)	0.00		0.00	
Random variance (country)	0.10	0.03 - 0.35	0.10	0.03 - 0.35

Generalized mixed model with gamma log link transformation.

95%CI= 95% confidence interval

[a] Adjusted for age, sex, urbanization grade, season, chronic conditions, physical performance score, mastery score, partner status, educational level, and car use.

[b] Bayesian Information Criterion (BIC) – an indicator of model fit, lower scores are better.

[c] BIC change compared to previous model, indicating improved model fit by full adjustment.

Table 4. Prospective mixed models to determine associations between presence of neighborhood resources at baseline and active travel time over the follow-up (n=2154–2189).

	Age & Sex Adjusted		Fully Adjusted [a]	
	Estimate	95%CI	Estimate	95%CI
Public facilities	12252.31 [b]		12094.47 [b]	Δ 157.84 [c]
Intercept	4.78	4.24 - 5.32	3.53	2.91 - 4.16
Resource (a lot)	**0.23**	**0.07 - 0.39**	**0.19**	**0.03 - 0.35**
Resource (some)	0.05	-0.10 - 0.21	0.05	-0.10 - 0.21
Resource (no)	0.00		0.00	
Assessment (follow-up)	0.03	-0.17 - 0.22	0.06	-0.13 - 0.26
Assessment (baseline)	0.00		0.00	
IA assessment*resource (a lot)	-0.10	-0.32 - 0.11	-0.13	-0.34 - 0.08
IA assessment *resource (some)	-0.04	-0.25 - 0.17	-0.07	-0.28 - 0.14
IA assessment *resource (no)	0.00		0.00	
Random variance (country)	0.11	0.03 - 0.39	0.12	0.03 - 0.41
Parks & walking areas	12255.34 [b]		12115.22 [b]	Δ 144.12 [c]
Intercept	4.61	4.07 - 5.15	3.42	2.79 - 4.04
Resource (a lot)	**0.30**	**0.15 - 0.45**	**0.27**	**0.12 - 0.42**
Resource (some)	**0.17**	**0.02 - 0.32**	**0.16**	**0.01 - 0.31**
Resource (no)	0.00		0.00	
Assessment (follow-up)	-0.06	-0.25 - 0.12	-0.04	-0.22 - 0.14
Assessment (baseline)	0.00		0.00	
IA assessment*resource (a lot)	0.00	-0.20 - 0.20	-0.01	-0.21 - 0.19
IA assessment *resource (some)	0.06	-0.14 - 0.27	0.04	-0.16 - 0.24
IA assessment *resource (no)	0.00		0.00	
Random variance (country)	0.12	0.03 - 0.40	0.12	0.03 - 0.43
Places to sit & rest	12191.25 [b]		12031.11 [b]	Δ 160.14 [c]
Intercept	4.74	4.20 - 5.28	3.51	2.89 - 4.14
Resource (a lot)	**0.29**	**0.14 - 0.44**	**0.26**	**0.11 - 0.41**
Resource (some)	0.11	-0.03 - 0.24	0.09	-0.04 - 0.23
Resource (no)	0.00		0.00	
Assessment (follow-up)	-0.10	-0.26 - 0.06	-0.08	-0.24 - 0.08
Assessment (baseline)	0.00		0.00	
IA assessment*resource (a lot)	0.06	-0.13 - 0.25	0.05	-0.14 - 0.24
IA assessment *resource (some)	0.08	-0.11 - 0.26	0.07	-0.11 - 0.24
IA assessment *resource (no)	0.00		0.00	
Random variance (country)	0.11	0.03 - 0.40	0.12	0.03 - 0.43

Table 4 continues	**Age & Sex Adjusted**		**Fully Adjusted** [a]	
	Estimate	95%CI	Estimate	95%CI
Public transportation	12208.39 [b]		12055.62 [b]	Δ 152.77 [c]
Intercept	4.68	4.14 - 5.23	3.44	2.81 - 4.07
Resource (a lot)	**0.28**	**0.12 - 0.44**	**0.24**	**0.09 - 0.40**
Resource (some)	0.06	-0.09 - 0.21	0.05	-0.10 - 0.21
Resource (no)	0.00		0.00	
Assessment (follow-up)	-0.06	-0.25 - 0.13	-0.04	-0.23 - 0.15
Assessment (baseline)	0.00		0.00	
IA assessment*resource (a lot)	0.00	-0.21 - 0.20	-0.01	-0.22 - 0.19
IA assessment *resource (some)	0.06	-0.15 - 0.26	0.04	-0.17 - 0.24
IA assessment *resource (no)	0.00		0.00	
Random variance (country)	0.11	0.03 - 0.39	0.12	0.03 - 0.42
Count ‘at least some’ resources	12284.84 [b]		12140.50 [b]	Δ 144.34 [c]
Intercept	4.63	4.09 - 5.17	3.40	2.77 - 4.02
Count (4)	**0.27**	**0.12 - 0.41**	**0.25**	**0.10 - 0.39**
Count (3)	0.15	-0.03 - 0.32	0.16	-0.01 - 0.33
Count (0-2)	0.00		0.00	
Assessment (follow-up)	-0.05	-0.23 - 0.12	-0.01	-0.19 - 0.16
Assessment (baseline)	0.00		0.00	
IA assessment*count(4)	0.01	-0.17 - 0.20	-0.01	-0.20 - 0.17
IA assessment*count (3)	0.02	-0.22 - 0.25	-0.02	-0.25 - 0.21
IA assessment*count (0-2)	0.00		0.00	
Random variance (country)	0.11	0.03 - 0.38	0.12	0.03 - 0.43
Count ‘a lot’ resources	12264.13 [b]		12112.12 [b]	Δ 152.01 [c]
Intercept	4.71	4.18 - 5.24	3.51	2.89 - 4.12
Count (3-4)	**0.33**	**0.21 - 0.44**	**0.28**	**0.17 - 0.39**
Count (1-2)	**0.14**	**0.03 - 0.24**	**0.11**	**0.01 - 0.22**
Count (0)	0.00		0.00	
Assessment (follow-up)	0.01	-0.09 - 0.11	0.02	-0.08 - 0.12
Assessment (baseline)	0.00		0.00	
IA assessment*count (3-4)	-0.10	-0.24 - 0.04	-0.09	-0.24 - 0.05
IA assessment*count (1-2)	-0.03	-0.17 - 0.11	-0.03	-0.17 - 0.11
IA assessment*count (0)	0.00		0.00	
Random variance (country)	0.12	0.03 - 0.42	0.11	0.04 - 0.44

Generalized mixed model with gamma log link transformation.

95%CI= 95% confidence interval, IA=interaction

[a] Adjusted for age, sex, urbanization grade, season, chronic conditions, physical performance score, mastery score, partner status, educational level, and car use.

[b] Bayesian Information Criterion (BIC) – an indicator of model fit, lower scores are better.

[c] BIC change compared to previous model, indicating improved model fit by full adjustment.

Appendix 1.

Table. Presence of neighborhood resources reported by participants in each country (n=2695).

	Germany	Italy	Netherlands	Spain	Sweden	UK
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Public facilities						
A lot	41.4 (161)	4.3 (18)	68.4 (361)	42.3 (215)	46.3 (198)	47.2 (199)
Some	46.3 (180)	65.7 (276)	21.6 (114)	54.5 (277)	50.9 (218)	46.9 (198)
No	12.1 (47)	30.0 (126)	9.8 (52)	3.0 (15)	2.1 (9)	5.9 (25)
Missing	0.3 (1)	0.0 (0)	0.2 (1)	0.2 (1)	0.7 (3)	0.0 (0)
Parks & walking areas						
A lot	46.8 (182)	6.4 (27)	64.4 (340)	47.6 (242)	70.6 (302)	41.9 (177)
Some	41.4 (161)	55.5 (233)	25.6 (135)	48.0 (244)	27.8 (119)	53.1 (224)
No	11.8 (46)	38.1 (160)	9.7 (51)	4.3 (22)	1.6 (7)	5.0 (21)
Missing	0.0 (0)	0.0 (0)	0.4 (2)	0.0 (0)	0.0 (0)	0.0 (0)
Places to sit & rest						
A lot	29.3 (114)	2.4 (10)	46.2 (244)	42.5 (216)	47.0 (201)	27.7 (117)
Some	62.0 (241)	41.9 (176)	41.1 (217)	54.1 (275)	49.5 (212)	63.0 (266)
No	7.5 (29)	55.7 (234)	11.4 (60)	2.8 (14)	3.0 (13)	9.0 (38)
Missing	1.3 (5)	0.0 (0)	1.3 (7)	0.6 (3)	0.5 (2)	0.2 (1)
Public transportation						
A lot	30.8 (120)	1.7 (7)	62.7 (331)	52.4 (266)	49.3 (211)	33.4 (141)
Some	66.3 (258)	56.7 (238)	24.2 (128)	45.9 (233)	47.4 (203)	61.4 (259)
No	2.8 (11)	41.7 (175)	12.1 (64)	0.8 (4)	3.0 (13)	5.0 (21)
Missing	0.0 (0)	0.0 (0)	0.9 (5)	1.0 (5)	0.2 (1)	0.2 (1)
Count ‘at least some’ resources						
4	74.3 (289)	25.2 (106)	70.8 (374)	90.9 (462)	92.1 (394)	84.1 (355)
3	18.5 (72)	27.6 (116)	17.6 (93)	6.5 (33)	6.1 (26)	8.3 (35)
0-2	7.2 (28)	47.1 (198)	11.6 (61)	2.6 (13)	1.9 (8)	7.6 (32)
Missing	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
Count ‘a lot’ resources						
3-4	22.4 (87)	1.2 (5)	50.4 (266)	40.9 (208)	41.1 (176)	24.6 (104)
1-2	48.6 (189)	9.5 (40)	40.0 (211)	21.7 (110)	43.9 (188)	44.1 (186)
0	29.0 (113)	89.3 (375)	9.7 (51)	37.4 (190)	15.0 (64)	31.3 (132)
Missing	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)

UK= United Kingdom