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Walking, cycling, and public transport for commuting and non-commuting travels across 5 European urban regions: modal choice correlates and motivations

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Highlights

- A multilevel approach was used to assess individual and contextual correlates of active and public transport in 5 European regions.
- Both individual and contextual characteristics were identified as correlates of commuting and non-commuting walking, cycling and public transport.
- The level of association of individual and contextual characteristics differed according to trip purposes (commuting vs non-commuting).
- For both commuting and non-commuting travels, similar main motivations for mode of transport (walking, cycling and public transport) were observed.

Abstract

The objective of this study was to explore individual and contextual-level characteristics associated with active (walking and cycling) and public transport as main travel modes for both non-commuting and commuting purposes, in residents of five European urban regions. We also described participant-reported motivations for modal choice for each journey purpose. The study used multilevel models to investigate cross-sectional associations of individual (i.e. age, gender, educational level) and contextual (defined by a combination of residential neighbourhood characteristics in typologies) characteristics with the choice of active and public transport as outcome. Based on an online survey of 6,037 residents of Ghent and suburbs (Belgium), Paris and inner suburbs (France), Budapest and suburbs (Hungary), the Randstad (including the cities of Amsterdam, Rotterdam, The Hague and Utrecht in the Netherlands) and Greater London (United Kingdom), we observed associations with both individual and contextual characteristics.

Results of the multilevel modelling show that the probability of using active or public transport as main mode varies depending on both individual and contextual characteristics. At individual level, relations with gender, age, education, weight status and having at least one child varied according to main transport mode and/or purpose. For example, overweight participants reported lower level of cycling for commuting and non-commuting travels than normal-weight participants. In the context of non-commuting travels, participants with one or more child reported less public transport use and more walking (vs participants without children). Among contextual-level variables, urban characteristics of the residential neighbourhood defined by four clusters (according to food environment, recreational facilities and active mobility opportunities) were associated with public transport and walking but not with cycling. For active transport the most important reasons were “I like to travel (on foot or by bike)” and “I want to be physically active” for both travel purposes. “Public transport facilities nearby” was indicated as the most important reason for public transport (for both trip purposes) – the second was “Journey time”.

Our findings highlight the importance of exploring a combination of multiple correlates at individual and contextual level according to journey purposes and suggest that the role of health-related individual characteristics such as weight status need further exploration.

Keywords: modal choice, travel purposes, motivations, multilevel approach, European metropolitan areas

1. Introduction

According to the European Environment Agency (EEA), walking, cycling and public transport stand out as the best options to improve sustainable mobility in urban settings (European Environment Agency., 2020). Promoting active transport modes (i.e. walking and cycling) and the use of public transport has therefore become a main objective of environmental, transport and health policies. Such policies seek to shift individual motorized transport (car, motorbike) to active and public transport to reduce greenhouse gas emissions, air and noise pollution, while increasing physical activity (Goenka and Andersen, 2016). Indeed, walking and cycling are considered as key elements of physical activity promotion for health in everyday life. They can also complement public transport travels that start or end with a short walk or cycle ride.

Choice of transport mode results from a complex process involving the interaction of multiple individual and contextual determinants (De Witte et al., 2013). During the last decade, a large body of research in transport studies, urban planning, social, behavioural sciences and public health has investigated correlates of travel behaviour and more specifically active transport modes (Ewing and Cervero, 2010; Small, 2007). However, most previous studies have focused on just one specific aspect of travel in a specific geographical context. This paper seeks to illustrate the individual and contextual (built and social) determinants that influence active transport (walking, cycling) and public transport for commuting and non-commuting travel (i.e. utility trips such as for shopping) across European urban areas. In this paper, we hypothesized that both individual and contextual correlates of transport mode are likely to vary according to travel purposes with main categories being commuting and non-commuting (Scheepers et al., 2013). Dieleman et al. (2002) showed that the effect of residential context (level of urbanization, center/suburban localization) on travelled distance was stronger for commuting compared to shopping or leisure (Dieleman et al., 2002). This underlines the relevance of splitting models according to travel purposes as adopted in this paper.

In a recent study in the framework of a European research project (SPOTLIGHT), we have explored individual and neighbourhood-level correlates of car driving (in minutes per week) in adults from five urban areas across Europe (den Braver et al., 2020). At individual level, this study showed that higher age, male gender, being employed and having a household of more than 3 persons were associated with higher weekly minutes of car driving. At neighbourhood level, residents engaged in fewer weekly minutes of car driving when they lived in neighbourhoods characterized by both higher residential density and higher land-use mix.

Individual and contextual-level correlates of active and public transport were not addressed in that study.

In addition, we will explore the main reasons for using different modes of transportation according to the study participants in each European urban regions of the study. For example, De Witte et al (2008) observed that the main reason for car users in Brussels Capital Region for using their car was a bad public transport connection (De Witte et al., 2008). For older adolescent (for whom driving a car is not yet an option), the reasons to use cycling was that it is a faster transport mode (than walking) to offer freedom mobility (in place and time) (Simons et al., 2013).

The main aims of the present study were to i) analyze individual and contextual correlates of active transport and public transport use, for commuting and non-commuting purposes in residents of five European urban regions, ii) considering the main reasons reported for their modal choices. There are two main parts in our analyses.

- First, we identified individual- and contextual-level correlates of walking, cycling and using public transport (as main transport mode) for both travel purposes. The question asked is how does the probability of using an active mode or public transport varies depending on individual and environmental characteristics?

- Second, we described the main reasons reported by participants for both travel purposes to gain a better understanding of active mode or public transport for commuting and non-commuting travels. The question asked is whether there are some specific motivations according to travel purposes?

The paper is organized as follows: Section 2 provides an overview of current literatures on the main individual and contextual correlates that influence travel mode. Section 3 describes the study design, data collection and modeling strategy. Section 4 presents the results of the descriptive analyses and multilevel analyses to assess the individual- and contextual-level correlates of active mode and public transport choice. This part is followed by the description of motivations reported by subjects. The last section (Section 5) discusses results and draws general conclusions.

2. Overview of literature

Understanding how citizens choose a travel mode and which individual and contextual determinants affect travel mode choice are important pre-requisite for the design of transport and urban planning policies. However, literature on these issues present a heterogeneous mix of different designs, measures, methodological approaches, populations studied, scales of study

and geographical contexts which make it difficult at present to draw a comprehensive picture of the topic. Such mixed evidence and inconsistent results reveal the complexity of the process mechanisms at stake and the multiplicity of individual and contextual correlates involved.

Regarding individual-level correlates of active mode of transportation, evidence of (negative) associations with car availability and household composition, especially the presence of children at home, appear to be consistent across studies whereas relations with age, gender, educational level are mixed (De Witte et al., 2013). In other studies, residential self-selection was also identified as an important determinant of travel mode choice (Cao et al., 2009). Individuals who like to walk, cycle, or those who use public transport regularly, may be more likely to choose to live in a neighbourhood with greater access to transport facilities or/and with shorter trip distance to work location. But it has to be noted that only some of these studies addressed residential self-selection (Carse et al., 2013). In addition, very few studies have considered health characteristics such as perceived health or body weight status. Ko et al. (2019) observed that commuters in Seoul, South Korea, who have a negative perception about their health tended to use more active or public transport than others (Ko et al., 2019). The authors suggested that one of the motivations for choosing active modes or public transport would be the desire to improve health. For instance, in cross-sectional studies, walkers and cyclists had lower BMI than car users (Flint and Cummins, 2016; King and Jacobson, 2017). Using a longitudinal approach, car users switching to active travel or public transport experience a significant reduction in self-reported BMI compared to counterparts who still use the car (Dons et al., 2018; Martin et al., 2015; Turrell et al., 2018). Importantly, only few studies have explored the reciprocal relation i.e. little is known about how weight status could influence travel mode choices among commuters and non-commuters. It could be hypothesized that individuals who choose to use walking, cycling, or public transport may be less overweight or obese than car users. Mattisson et al. (2018) observed in Scania (the southernmost county in Sweden) a negative association between the use of active and public travel modes and reported health indicators such as obesity and difficulty of walking (Mattisson et al., 2018).

Regarding contextual-level correlates of active and public transport, significant associations have been found with built environmental characteristics such as high residential density, high mixed land use and high levels of network and accessibility to public transport stops (Ewing and Cervero, 2010; De Witte et al., 2013; Wang and Lin, 2013). In their review, Wang et al.

(2016) assessed built attributes of residential neighborhood that influence both walking and cycling levels (according to transport and leisure purposes) (Wang et al., 2016). These authors noted that a well-maintained footpath would be the most effective built characteristic to promote transport and leisure walking whereas flattened street configuration would be the most effective to encourage cycling. The review of Buehler and Dill (2016), which focused on cycling, showed a consistently positive association with the high-quality, extensiveness, and connectivity of bicycle networks (Buehler and Dill, 2016). In a recent paper, Cervero et al. (2019) analyzed the collective magnitude of effects of built environments, urban amenities, and high-quality bicycle networks on rates of cycling to work for 36 cities and towns in the UK (Cervero et al., 2019). They concluded that “the models reveal a complex web of forces shaping cycling to work, confirming that there is no single, silver-bullet factor even in cities with remarkably high commuter cycling”.

Taken altogether, previous studies have usually considered separately the influence of individual and built environmental dimensions on choice of mode of transport. To better capture the complexity of these relations, we think these dimensions should be considered concurrently. In the present article, we therefore explore the complex and combined influence of such individual and contextual correlates using a multilevel approach. The methodology relies on multilevel regression models to provide accurate estimates of both individual and contextual effects on travel behaviour. As reported in previous studies (Feuillet et al., 2021), the impact of each correlate on the likelihood to use a given mode of transport cannot be correctly considered without integrating the hierarchical structure (at individual AND contextual levels) of the correlates, and thus an appropriate modelling framework such as a multilevel approach. Studies using aggregated data at contextual level could suffer from ecological fallacy leading to the conclusion that relationships observed for geographical area (e.g. neighbourhood level) hold true for behaviours at individual level. Conversely, behaviours analyzed at individual level without considering the context in which this behaviour was performed, could lead to atomistic fallacy. This explain the rapid growth of literature using the multilevel approach to examine the combined effects of individual and contextual correlates on modal choice of transport (Antipova et al., 2011; Arbués et al., 2016; Ding et al., 2017, 2014; Loo and Lam, 2013; Rachele et al., 2015; Shuttleworth and Gould, 2010)”.

3. Data and methods

Data were collected in a cross-sectional survey conducted as part of the European Commission-funded SPOTLIGHT ('Sustainable prevention of obesity through integrated strategies') project. This project was established to increase and combine knowledge on overweight and obesity-related determinants (at individual and contextual levels) to support effective health promotion approaches (Lakerveld et al., 2012).

3.1 Study design and sampling

A total of 60 administrative neighbourhoods were randomly selected in 5 urban regions across Europe (i.e. 12 administrative neighbourhoods per region): Ghent and suburbs (Belgium), Paris and inner suburbs (France), Budapest and suburbs (Hungary), the Randstad (including the cities of Amsterdam, Rotterdam, The Hague and Utrecht in the Netherlands), and Greater London (United Kingdom). As described in detail elsewhere (Lakerveld et al., 2015), sampling of administrative neighbourhoods was based on two environmental obesity-related characteristics to ensure variability of environmental contexts: residential density and neighbourhood median income, as a proxy for socioeconomic position (SEP). Residential density data were obtained from the Urban Atlas database distributed by the European Environmental Agency, based on a compilation of satellite photographs covering Europe providing high-resolution data on land use (European Environment Agency., 2002). This Urban Atlas includes a measure of density of residential areas (calculated as the percentage of coverage of buildings devoted to residential facilities) that is comparable across European countries. Data on residential density were defined using two classes - high and low residential density - corresponding to >80% and <50% of areas covered by residential buildings respectively. Median income data were derived from national census databases from all five countries, with two classes used: low and high (i.e. the first and third tertiles). The combination of residential density and neighbourhood-level income classes allowed four neighbourhood types to be defined (high residential density/high SEP, high residential density/low SEP, low residential density/high SEP and low residential density/low SEP). In addition, sampled neighbourhoods had to contain a minimum threshold of adult inhabitants. For a target sample of about 100 residents in each neighbourhood, with an estimate of 10% response rate, approximately 1,000 residents were sampled in each neighbourhood. We anticipated that response rates would vary according to neighbourhood SEP, so we sampled 1,200 adults in low SEP neighbourhoods and 800 in high SEP neighbourhoods. Neighbourhoods were randomly selected from within administrative areas in each country, generating a total of 60 neighbourhoods. Neighbourhood was defined according to small-scale local administrative boundaries as used in each country

except for Hungary. Budapest is divided into districts and suburbs that are highly heterogeneous in terms of population and much larger than the equivalent administrative areas in the other study countries. In order to ensure comparability, areas within 1 km² were defined to represent neighbourhoods in Budapest and suburbs (Lakerveld et al., 2015).

3.2 Study participants and questionnaire

Adult inhabitants (≥ 18 years) within the 60 selected neighbourhoods were invited to participate in an online survey with a similar approach in each country. The study design and sampling approach have been described previously (Lakerveld et al., 2015). Briefly, in the selected neighbourhoods, a random sample of residential addresses was drawn from postal companies (the Netherlands), Yellow Pages (France), electoral rolls (the UK) or public administration services (Belgium, Hungary). Since we expected lower response rates from participants in low-SEP neighbourhoods, we oversampled adults from low-SEP neighbourhoods (1,200 adults per neighbourhood) relative to high-SEP neighbourhoods (800 adults per neighbourhood). The aim was to recruit at least 100 participants per neighbourhood (6,000 in total), with an anticipated response rate of around 10%. Between February and September 2014, participants were recruited via postal invitation using the Dillman method (Dillman, 2007). In order to increase response rates, a prize (one or more bicycles) was offered for participants in the Netherlands, Belgium and Hungary. In the Netherlands and France, in the neighbourhoods with lowest response rates, researchers also randomly visited people at home to encourage study participation. Response rates per country and neighbourhood type have been described in a previous paper (Lakerveld et al., 2015). A total of 55,893 postal invitations was sent, and 6,037 (10.8%) individuals participated in the study.

The online survey included questions on demographics, mode of transport (commuting and non-commuting travels), as well as weight and height. The study was approved by the corresponding local ethics committees of participating countries and all participants in the survey provided informed consent.

3.3 Modal choice - variable of interest

Participants were asked to provide information about the mode of transport they used to travel to/from workplace (commuting purpose) and/or to/from other places (non-commuting purpose). Four transport mode alternatives were proposed for the dependent variable: motorized individual transport, walking, cycling and public transport. Each participant reported on how many days per week and how much time on an average day he/she spent travelling with each

mode of transport during the last seven days for commuting and non-commuting travels. We estimated the main mode of travel based on the number of days and time reported (total weekly minutes) by each participant during the previous seven days for both travel purposes. We included participants who provided data on number of days and time for at least one mode of transport for commuting or non-commuting travels (n=3,070 and n=5,058, respectively).

3.4 Individual characteristics

Individual characteristics of adult participants included sex, age (into 4 classes: ≤ 35 years; 36-45 years; 46-55 years; > 55 years), educational level [input as a dichotomous variable defined in each country by lower - from less than primary to higher secondary education - or higher level - college or university level - allowing comparison between country-specific education systems] and body mass index (BMI), calculated by dividing self-reported weight in kilograms by the square of the self-reported height in meters (< 25 kg/m² normal weight; ≥ 25 kg/m² overweight). Participants were asked if they were owner of at least one car (yes or no). Respondents were also asked about the factors that influenced their decision to live in their residential neighbourhood. In our analysis, we used items “distance to work or school” and “there is easy access to transport facilities” (yes/no) as an indicator of residential self-selection.

In addition, participants were asked in the survey about their main reasons to use a mode of transport through the question “*Why did you choose this mode of transport (indicate the most important reason)*”. A list of 10 to 12 items (including “other”, in which case respondents were asked to state the other reason) was proposed for each mode of transport. Two items “Journey time” and “I like to travel by....” were available for each mode of transport. The other items varied according to the mode of transport. For instance, “I want to be physically active” was proposed only for walking and cycling and “price” only for using public transport.

3.5 Contextual characteristics

Recent studies have demonstrated that remote sensing tools such as Google Street View (GSV) are feasible, affordable and valid means to assess built environmental characteristics at street level in urban areas, on a large scale and at low cost (Aghaabbasi et al., 2018; Bethlehem et al., 2014; Charreire et al., 2014; Gullón et al., 2015). To assess neighbourhood-level built environment in the five European urban regions, we developed a virtual audit instrument using GSV (Bethlehem et al., 2014). Based on this virtual audit, 40 neighbourhood items were

assessed in all streets of 59 neighbourhoods (one Hungarian neighbourhood was not covered by GSV at the time of the virtual audit), resulting in 4,486 street segments audited. The virtual audit was carried out in 2014 in each country by trained researchers from the SPOTLIGHT project team. All built neighbourhood features were then aggregated from street segment level to neighbourhood level by taking the percentage of street segments in each neighbourhood that contained them (Bethlehem et al., 2014; Feuillet et al., 2016). For instance, if 100 of the 500 street segments of a neighbourhood were qualified as ‘pedestrian friendly’, then the feature ‘pedestrian friendly street’ was quantified as 0.20 in this neighbourhood.

Based on these virtual audit measures, using multiple factor analysis and hierarchical clustering on principal components, four neighbourhood clusters were identified according to food environment, recreational facilities and active mobility opportunities (Feuillet et al., 2016). This typology was used to define contextual characteristics in the present study:

- The cluster named “green/low residential density” neighbourhoods is characterized by high level of percentage of streets with residential gardens, trees or green areas and by a low level of residential density.
- The cluster named “street opportunities/low residential density” is characterized by a low level of residential density but with a high level of percentage of traffic calming devices, zebra crossings, well-maintained sidewalks, and traffic lights.
- The cluster named “recreational and food facilities/high residential density” is defined by a high level of residential density and had a high level of public transport facilities, cycle lanes and food facilities.
- The cluster named “low level of aesthetics/high residential density” is composed of neighbourhoods with high residential density but with a low aesthetic dimension (high level of percentage of graffiti and abandoned building).

3.6 *Statistical analysis*

Given the distribution of the dependent variable and the hierarchical structure of the data (individuals nested within administrative neighbourhoods nested within countries), we applied a two-level logistic multilevel analysis model, with the levels being the individual (level-1) and the residential neighbourhood (level-2) to explore individual and contextual correlates of transport behaviour. We also initially performed three-level multilevel analysis with urban European region as level-3 but the variance of region (level 3) was never found significant (data not shown). To propose the most parsimonious model, we therefore decided to only keep the two-level multilevel analysis model. All models used the dependent variable as a

dichotomous one (yes/no) with no (it is not the main transport choice) as the reference category. So, in all cases the dependent variable was the main mode of transport (e.g., walking [coded 1] vs. all other modes [coded 0]).

Models were implemented using individual-level characteristics of participants: age, gender, and educational level, having at least one child, BMI, residential neighbourhood self-selection (distance to work and access to public transport facilities) at level-1. Contextual characteristics (neighbourhood clusters and income level) were added at level-2.

For each of the two travel purposes (commuting and non-commuting), three models were fitted separately for each mode of transport. First, an intercept-only (null) model which did not include any independent variable (i.e. only including a random intercept) was fitted with the random intercept for residential neighbourhood to assess the variance components within residential neighbourhoods. In other words, this model served as a baseline model to assess whether there was a significant variation between neighbourhoods in terms of modal choice. Individual variables (level 1) were then added to the null model to control for individual characteristics of respondents (Model 1). Then, contextual characteristics (level 2) were added to fit the fully adjusted model including both level-1 and level-2 covariates (Model 2).

All results are reported as odds ratios (OR) with their 95% confidence intervals (CI) which indicated the probability of reporting a given mode of transport as main mode (e.g. walking) compared to the others. The change in variance components between models was examined. The amount of explained variance (between the null model and both Model 1 and Model 2 at individual and contextual levels) was calculated by the proportional change in variance (PCV, in %). Finally, in order to explore motivations for choosing walking, cycling or public transport, a descriptive analysis was performed to assess potential differences in motivation according to journey purposes (non-commuting and commuting). Analyses were carried out with SAS version 9.3 (SAS Institute Inc., Cary, NC, USA).

4. Results

4.1. *Characteristics of the study population*

Characteristics and main transport mode of study participants according to commuting status are described in Table 1. In each sample, around 55% of participants were women. About two thirds of participants had at least one child (70%) and at least one car (71.5%). The mean (SD) age was 43.3 (12.1) and 51.8 (16.4) years, for commuters and non-commuters respectively.

More than a third of participants was overweight. A majority of participants reported distance to work and easy access to transport facilities as criteria to choose their residential neighbourhood.

Table 1.

4.2. Relations between individual and contextual characteristics and main mode of transport

Results from the multilevel analyses to explore correlates (at both individual and contextual level) of walking, cycling and public transport (as dependent variables) for commuting and non-commuting travels are presented in Tables 2a and 2b, respectively.

Table 2a.

Table 2b.

Overall, at individual level, relations with gender, age, education, weight status and having at least one child varied according to main transport mode and purpose. Having a car was significantly negatively associated with public transport, walking, and cycling for both travel purposes. Gender and educational level were not significant except for those who reported walking for commuting. Women reported more walking as principal mode (*vs.* men), as did participants with low educational level (*vs.* high educational level). In the context of non-commuting travel, participants with one or more child reported less public transport use and more walking *vs.* participants without children. Overweight participants reported lower level of cycling for commuting and non-commuting travels *vs.* normal-weight participants. Compared to participants over 55 years, the probability of reporting walking as the main mode for non-commuting travels was lower in younger subjects. Except for public transport and for those between 18-35 years, age was non-significant in associations with walking and cycling for commuting travel.

We observed indications for residential self-selection, as distance to work was reported to be a factor when choosing the place of residence, and this was positively associated with active modes of transport (walking and cycling) for commuting travels (but not significant for non-commuting travels). In addition, respondents who reported that they considered their accessibility to transport facilities when choosing their place of residence more often used public transport as main means of transportation (for the two purposes).

Overall, among contextual-level variables, neighbourhood income level was non-significant for all reported modes of transport for the two trip purposes. Built environmental characteristics of the residential neighbourhood as defined by clusters were associated with public transport and walking but not with cycling. For instance, the probability of using public transport was lower in low residential density neighbourhoods in comparison to neighbourhoods characterized by “low aesthetic/high residential density” for both travel purposes.

Table 3a.

Table 3b.

Values of variance components of the two-level models showed significant differences for walking, cycling and public transport reported for both non-commuting and commuting travel (Table 3a and 3b, respectively). In other words, these results confirmed that there were significant variations between individual characteristics (Model 1) and between residential neighbourhoods (Model 2) in terms of mode of transport used for the two travel purposes.

For non-commuters, individual characteristics (Model 1) explained between 49.3% (cycling) and 13.8% (walking) of the differences in main mode of transport between residential neighbourhoods. At this step, the between-neighbourhood variance remained significant, indicating that there is still unexplained variance between neighbourhoods for all modes of transport. In final models (Model 2) with combination of individual and environmental characteristics, models explained between 76.1% (cycling) and 35.1% (public transport) of differences in mode of transport between residential neighbourhoods. The between-neighbourhood variances remained significant meaning that there is still unexplained variance in all models (Table 3a and 3b).

4.3. Main motivations

Overall, the main reasons for walking, cycling, and public transport were similar between non-commuting and commuting travels (Table 4). For active transport (walking and cycling) the most important motivations were “I like to travel (on foot or by bike)” and “I want to be physically active” for both travel purposes. The fact that the environment was “pleasant or convenience” was also cited by participants. “Public transport facilities nearby” was indicated as the most important reason for public transport (for both trip purposes) – the second was “Journey time”. Price of public transportation was ranked third for both trip purposes.

Table 4.

5. Discussion and conclusion

In this study, we identified correlates of walking, cycling and public transport use as main mode of transport for commuting and non-commuting travels in five European urban regions. We additionally explored main reasons, reported by participants, to use a mode of transport to better understand the choice of using active or public transport.

Our main findings indicated that both individual and contextual characteristics were significant correlates of walking, cycling, and using public transport but differed across trip purposes. We also described the reasons of participants underlying the choice of active transport modes. For walking and cycling, pleasure concerns and the willingness to be physically active were the most important reported reasons. “Public transport facilities nearby” was the first reason for public transportation.

5.1 Individual dimensions

Not unexpectedly, car ownership was found to be a negative correlate to walking, cycling and using public transport (De Witte et al., 2013; Driscoll et al., 2013). However, individual and contextual correlates remained significant even after inclusion of the variable “having a car” in the models, which confirms that travel modal choice is a complex combination of various factors.

As emphasized by De Witte (2013), there is no real consensus on the influence of age on travel modal choice. For instance, in our study, we observed a negative relation between age and walking during non-commuting travels but not during commuting travels. The relation between age and recreational walking has been described previously in other geographical contexts (Van Dyck et al., 2013).

Along the same lines, evidence on gender and educational level as correlates of modal choice remains inconsistent in the literature (De Witte et al., 2013, Pollard and Wagnild, 2017), except for feeling unsafe in public transport (Vanier and d’Arbois de Jubainville, 2017). In our study in five European urban regions, women were more likely than men to report walking as main mode for commuting. In France, an inverse association was observed: being a woman was significantly and positively associated with walking for leisure and errands but was not for commuting (Feuillet et al., 2018; Menai et al., 2015). Van Dyck et al. (2013, 2012) found no significant gender difference in walking for both leisure and transportation (in weekly minutes) in metropolitan areas in the USA, Australia, and Belgium. Comparing the impact of

gender and educational level on modal choice between studies remains difficult given differences in urban contexts and types of travel purposes. For instance, in our study, commuting travel was defined by the whole trip from home to workplace and non-commuting travels included leisure and errands. In contrast, in a recent review on gender differences in walking, associations were reported according to leisure, transportation and total walking; errand travels were included in the transportation dimension of walking (Pollard and Wagnild, 2017).

Whilst the role of car ownership, and to a lesser extent socio-demographic characteristics, has been studied previously (Driscoll et al., 2013), our results show that the relation between health-related characteristics such as weight status and travel behaviours would require further investigation. In our study, participants with higher BMI (overweight) reported less cycling even after adjustment on individual and contextual factors. In Cambridge (UK), a previous study found that adults with obesity reported travelling by car instead of cycling for leisure trips but not for shopping or commuting purposes (Carse et al., 2013). High BMI could impact the individual capacity for physical activity and active mobility.

In addition, the location of the place of residence within the urban system hierarchy (urban centre *vs.* suburbanized area) could reflect this interdependency of socio-demographic correlates such as educational level, income, or household composition. Indeed, residential location may well not be neutral, as some households are likely to decide where to live based on preferences (e.g. housing cost, aesthetic and social atmosphere) including preferred travel behaviour (Cao, 2014; Cao et al., 2009; Ettema and Nieuwenhuis, 2017). For instance, some individuals whose proximity to their workplace is important will choose to reside close to their workplace to minimize travel time and commuting by walking or cycling. It follows that residential self-selection is an important issue to explain modal choice and is also a potential confounding element in the relation between contextual dimension and travel behaviours (Cao, 2014). In line with these studies, in our analyses, commuters who reported “distance to work/school” as factors influencing the decision to live in their neighbourhood performed more active transport. “Easy access to transport facilities” as a factor influencing the decision to live in the residential neighbourhood was associated with public transport for non-commuting trips.

5.2 Contextual dimension

At contextual level, greener neighbourhoods with low residential density have been characterized by both low presence of active transport facilities and low density of destinations (e.g.

local store, food outlets, physical activity facilities) (Feuillet et al., 2016). The combination of these characteristics could explain, in part, the lower likelihood of using public transport and walking in this cluster (*vs.* cluster of high residential density and low aesthetic).

Our study did not show any relation between income level of the residential neighbourhood and using active modes or public transport as main modes of transport. In the few previous studies which investigated the influence of the social environment, associations between mode of transport and neighbourhood SEP levels remained unclear. Walking was significantly higher in low SEP neighbourhoods in Brisbane, Australia (Rachele et al., 2015). In Eindhoven (The Netherlands), residents living in the most disadvantaged neighbourhoods (compared to the most advantaged) reported higher levels of walking and cycling to shops or work, but an inverse relation was found for leisure time activities (van Lenthe et al., 2005). In addition, our results may reflect the fact that the financial dimension is more sensitive (as a constraint) at individual level than at contextual level. In our study, “price” was the second most frequent reason reported by the participant to explain the choice of public transport. Furian et al. (2012) previously explored a range of seven possible motivations for walking, cycling and using public transport in 4,290 respondents from 19 European countries (Furian et al., 2012). The most common reasons selected by respondents were “no necessity to use motorized vehicles” and “financial reasons” followed by “the need of more physical exercise”, “health reasons”, “environmental reasons”, “fear of driving” and “driving license withdrawal/ban”.

5.3 Limitations and future research

The present study has some limitations. Due to the cross-sectional design of the SPOTLIGHT survey, it is not possible to draw conclusions about causation. Walking, cycling, and using public transport were self-reported, thus may be subject to recall error. These self-reported modes of transport were assessed without information of where it took place. A part of these could have occurred outside the local areas for which environmental attributes were measured. The study did not measure additional potentially relevant variables, especially about distance or time of travel especially for commuting which has been reported as an important factor in journey planning (De Witte et al., 2013) and about representation of mode of transport, mobility culture, or more generally, socio-psychological factors were not collected in our study (De Witte et al., 2013; Haustein and Nielsen, 2016). Analyses based on main mode of transport is another potential limitation of our study as it fails to take account of the complexity of daily mobility, specifically multimodality and trip chaining. The design of the SPOTLIGHT questionnaire, which was not designed as an activity travel diary, did not allow

the collection of data on combination of different modes of transport used for each trip in a specific journey.

Conclusion

Overall, our paper contributes to the body of literature on correlates of walking, cycling, and using public transport as main mode of transport, by providing information and analysis considering both individual and contextual (at residential neighbourhood) levels for commuting and non-commuting purposes in European urban areas. The results suggest that trip purposes (e.g. commuting *vs.* non commuting) should be taken into account when promoting a shift from motorized transport use to active mode or public transport. Future studies of this nature will assist in improving our understanding of how main modes of transport are used according to travel purposes, assisting urban planners and policy makers.

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TABLES

Table 1. Characteristics of the study participants according to non-commuting/commuting travels

	Non-commuting		Commuting	
	N	%	N	%
Gender				
Male	2631	44.0	1523	43.5
Female	3346	56.0	1976	56.5
<i>Missing</i>	60		18	
Age (y)				
18-35	1136	19.0	985	28.2
36-45	1129	18.9	970	27.8
46-55	1118	18.7	909	26.1
>55	2592	43.4	623	17.9
<i>Missing</i>	62		30	
Educational level				
Higher	2909	53.5	2002	62.4
Lower	2532	46.5	1207	37.6
<i>Missing</i>	596		308	
Have child				
Yes	3820	70.0	1877	58.4
No	1639	30.0	1338	41.6
<i>Missing</i>	578		302	
BMI (kg/m²)				
Overweight (≥ 25)	2433	46.0	1233	35.1
No overweight (< 25)	2862	54.0	2284	64.9
<i>Missing</i>	742		407	
Have a car				
Yes	4089	71.5	2438	72.2
No	1633	28.5	937	27.8
<i>Missing</i>	315		142	
Factors - choice of residential neighbourhood				
Distance to work				
Yes	3062	65.4	2120	71.5
No	1622	34.6	845	28.5
<i>Missing</i>	1353		552	
Easy access to transport facilities				
Yes	3700	76.0	2198	74.4
No	1167	24.0	757	25.6
<i>Missing</i>	1170		562	
Principal mode of transport				
Walking	1432	28.3	223	7.3
Cycling	851	16.8	567	18.5
Public transport	838	16.6	998	32.5
Individual motorized transport	1937	38.3	1282	41.7

<i>Missing</i>	979		447	
Neighbourhood clusters				
Green/low density	3385	65.1	1798	59.6
Active mobility/low density	1289	24.8	835	27.7
Recreational, food facilities/high density	327	6.2	242	8.0
Low aesthetic/high density	204	3.9	141	4.7
<i>Missing</i>	832		501	
Neighbourhood income level				
High	2914	49.1	1707	49.3
Low	3022	50.9	1759	50.7
<i>Missing</i>	101		51	
Regions				
Paris and suburbs (France)	844	14.0	541	15.4
The Randstad (The Netherlands)	1609	26.6	912	25.9
Ghent and suburbs (Belgium)	1849	30.6	972	27.6
Greater London (United Kingdom)	860	14.2	554	15.7
Budapest and suburbs (Hungary)	875	14.6	538	15.4

Table 2a. Results of the multilevel binary logistic models for selecting walking, cycling or using public transport as main means of transport or not, for non-commuting travels

	WALKING			CYCLING			PUBLIC TRANSPORT		
	OR*	95% CI**		OR	95% CI		OR	95% CI	
INDIVIDUAL LEVEL									
Have a car									
Yes	0.64	0.51	0.80	0.68	0.51	0.92	0.34	0.25	0.45
No	1	Ref		1	Ref		1	Ref	
Gender									
Female	1.18	1.00	1.40	0.88	0.72	1.07	1.12	0.89	1.42
Male	1	Ref		1	Ref		1	Ref	
Age (years)									
18-35	0.52	0.40	0.68	0.86	0.64	1.16	1.88	1.37	2.59
36-45	0.59	0.45	0.78	0.94	0.68	1.27	1.00	0.69	1.45
46-55	0.71	0.55	0.91	0.97	0.73	1.28	1.04	0.73	1.48
>55	1	Ref		1	Ref		1	Ref	
Educational level									
Higher	1.04	0.86	1.26	0.95	0.77	1.17	0.83	0.64	1.06
Lower	1	Ref		1	Ref		1	Ref	
BMI (kg/m²)									
Overweight (>=25)	0.90	0.75	1.07	0.74	0.60	0.91	1.10	0.86	1.39
No overweight (<25)	1	Ref		1	Ref		1	Ref	
Have child									
Yes	1.36	1.09	1.68	1.04	0.81	1.33	0.57	0.43	0.77
No	1	Ref		1	Ref		1	Ref	
Distance to work as a reason for choosing the neighbourhood									
Yes	0.89	0.75	1.07	1.23	0.99	1.52	0.95	0.74	1.21
No	1	Ref		1	Ref		1	Ref	
Easy access to transport facilities as a reason for choosing the neighbourhood									
Yes	1.09	0.89	1.35	1.12	0.89	1.41	1.54	1.12	2.11
No	1	Ref		1	Ref		1	Ref	
CONTEXTUAL LEVEL									
Neighbourhood clusters									
Green/low density	0.37	0.18	0.75	1.26	0.44	3.62	0.28	0.09	0.87
Street opportunities/low density	0.60	0.29	1.24	1.57	0.54	4.59	0.28	0.08	0.91
Recreational, food facilities/high density	0.61	0.27	1.41	0.44	0.12	1.67	0.65	0.18	2.40
Low aesthetic/high density	1	Ref		1	Ref		1	Ref	
Income level									
High	0.76	0.55	1.05	0.83	0.57	1.20	0.90	0.53	1.53
Low	1	Ref		1	Ref		1	Ref	

*OR: Odds ratio; **CI: Confidence Intervals

Table 2b. Results of the multilevel binary logistic models for selecting walking, cycling or using public transport as main means of transport or not, for non-commuting travels

	WALKING			CYCLING			PUBLIC TRANSPORT		
	OR*	95% CI**		OR	95% CI		OR	95% CI	
INDIVIDUAL LEVEL									
Have a car									
Yes	0.56	0.32	0.98	0.70	0.50	0.99	0.32	0.24	0.44
No	1	Ref		1	Ref		1	Ref	
Gender									
Female	1.77	1.16	2.71	0.99	0.78	1.25	1.20	0.96	1.49
Male	1	Ref		1	Ref		1	Ref	
Age (years)									
18-35	0.76	0.38	1.51	0.97	0.66	1.43	1.92	1.34	2.75
36-45	1.02	0.49	2.09	1.04	0.69	1.56	1.25	0.85	1.83
46-55	1.18	0.59	2.35	1.10	0.75	1.61	1.08	0.74	1.57
>55	1	Ref		1	Ref		1	Ref	
Educational level									
Higher	0.46	0.29	0.72	1.02	0.78	1.33	1.14	0.89	1.46
Lower	1	Ref		1	Ref		1	Ref	
BMI (kg/m²)									
Overweight (>=25)	0.93	0.60	1.44	0.77	0.59	0.99	0.92	0.73	1.16
No overweight (<25)	1	Ref		1	Ref		1	Ref	
Have child									
Yes	0.79	0.49	1.28	1.01	0.77	1.32	0.89	0.70	1.14
No	1	Ref		1	Ref		1	Ref	
Distance to work as a reason for choosing the neighbourhood									
Yes	2.65	1.51	4.64	2.35	1.75	3.16	0.65	0.51	0.82
No	1	Ref		1	Ref		1	Ref	
Easy access to transport facilities as a reason for choosing the neighbourhood									
Yes	1.28	0.68	2.41	0.83	0.63	1.10	1.75	1.32	2.32
No	1	Ref		1	Ref		1	Ref	
CONTEXTUAL LEVEL									
Neighbourhood clusters									
Green/low density	0.24	0.07	0.79	1.28	0.39	4.18	0.19	0.07	0.54
Street opportunities/low density	0.65	0.19	2.18	1.88	0.56	6.32	0.22	0.08	0.65
Recreational, food facilities/high density	3.37	0.93	12.26	0.48	0.12	1.96	0.19	0.06	0.60
Low aesthetic/high density	1	Ref		1	Ref		1	Ref	
Income level									
High	0.98	0.54	1.78	0.78	0.46	1.31	1.06	0.67	1.68
Low	1	Ref		1	Ref		1	Ref	

*OR: Odds ratio; **CI: Confidence Intervals

Table 3a. Variance component of the multilevel binary logistic models (non-commuting travels)

Random effects (Variance components)	Non-commuting travels								
	Null model			Model 1			Model 2		
WALKING									
Between residential neighbourhoods (coef (SE))	0.39	0.09	<.0001	0.34	0.09	<.0001	0.24	0.08	0.0008
Proportional Change in Variance* (PCV) %				13.77			38.66		
CYCLING									
Between residential neighbourhoods (coef (SE))	1.00	0.24	<.0001	0.51	0.19	0.003	0.24	0.12	0.02
Proportional Change in Variance* (PCV) %				49.25			76.09		
PUBLIC TRANSPORT									
Between residential neighbourhoods (coef (SE))	1.17	0.25	<.0001	0.82	0.21	<.0001	0.76	0.20	<.0001
Proportional Change in Variance* (PCV) %				29.28			35.12		

*[initial variance–actual variance]/initial variance: percentage of initial variance of transport behaviours explain by the model; Coef: estimated regression coefficient; PCV: proportional change in variance; SE: standard error.

Table 3b. Variance component of the multilevel binary logistic models (commuting travels)

Random effects (Variance components)	Commuting travels								
	Null model			Model 1			Model 2		
WALKING									
Between residential neighbourhoods (coef (SE))	1.38	0.35	<.0001	1.26	0.44	0.007	0.44	0.26	0.04
Proportional Change in Variance* (PCV) %				8.88			67.85		
CYCLING									
Between residential neighbourhoods (coef (SE))	0.68	0.17	<.0001	0.53	0.17	0.001	0.34	0.13	0.004
Proportional Change in Variance* (PCV) %				22.73			49.66		
PUBLIC TRANSPORT									
Between residential neighbourhoods (coef (SE))	0.97	0.21	<.0001	0.64	0.16	<.0001	0.54	0.15	0.0001
Proportional Change in Variance* (PCV) %				34.09			44.38		

*[initial variance–actual variance]/initial variance: percentage of initial variance of transport behaviours explain by the model; Coef: estimated regression coefficient; PCV: proportional change in variance; SE: standard error.

Table 4. Main reasons reported by participants for each principal mode of transport (non-commuting and commuting travels)

Motivations	Non-commuting		Commuting	
	N	%	N	%
WALKING				
I like to travel on foot	490	35.8	77	41.6
I want to be physically active	446	32.6	40	21.6
The environment is pleasant to walk in	134	9.8	16	8.6
It is convenient to walk	112	8.2	14	7.6
I care about the environment	56	4.1	6	3.2
I don't have a car / it's not convenient to use a car	48	3.5	3	1.6
Walk dog	21	1.5	-	-
No public transport facilities nearby	16	1.2	4	2.2
Close destination	1	0.1	18	9.7
Others	23	1.7	7	3.1
<i>Missing</i>	65		38	
CYCLING				
I like to travel by bike	359	42.4	236	41.8
I want to be physically active	268	31.7	188	33.3
The environment is pleasant to cycle in	60	7.1	21	3.7
I care about the environment	57	6.7	45	8.0
I don't have a car / it's not convenient to use a car	45	5.3	18	3.2
Easy, comfortable, do other tasks while travelling	28	3.3	29	5.1
Two or more reasons*	14	1.6	16	2.8
No public transport facilities nearby	2	0.2	2	0.3
No choice	2	0.2	2	0.3
Others	11	1.3	7	0.9
<i>Missing</i>	5		3	
PUBLIC TRANSPORT				
Public transport facilities nearby	430	53.7	431	44.0
Journey time	128	16.0	227	23.2
Price	102	12.7	119	12.2
No choice	50	6.2	75	7.7
High price of parking	28	3.5	19	1.9
Lack of parking spaces	20	2.5	21	2.1
Easy, comfortable, do other tasks while travelling	16	2.0	26	2.7
The environment is unpleasant or unsafe to walk/cycle	5	0.6	12	1.2
Two or more reasons*	4	0.5	14	1.4
Environmentally friendly	3	0.4	11	1.1
To walk, to exercise	1	0.1	-	-
Others	13	1.6	24	2.4
<i>Missing</i>	38		19	

*Participant reported more than one reasons even though the question read "indicate the most important reason"

**Not relevant for commuting travels