What explains public transport use? Evidence from seven European cities

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Abstract

Background: the relationships between the built environment characteristics and personal factors influencing public transport use and the ways they interact are not well understood.

Objective: we aim to advance the understanding of the relationship between built environment and frequency of public transport use in seven European cities, while accounting for other factors, such as individual values and attitudes.

Methods: in this population-based cross-sectional study, we collected information on mobility behaviour including frequency of public transport use, individual characteristics, and attitudes towards transport, environment and health issues (N=9952). Home and work/study built environment characteristics were determined with GIS-based techniques. We also applied factor and principal component analyses to define profiles of potential correlates. Logistic regression analyses for each frequency category of public transport use (1-3 days/month, 1-3 days/week, and daily or almost daily), using as reference "never or less than once a month", were applied. City was included as random effect.

Results: Over all, a large percentage of participants reported daily or almost daily public transport use for travel (40.5%), with a wide range across cities (from 7.1% in Örebro to 59.8% in Zurich). Being female, highly educated, a student, or not working increased the odds of higher frequency of using public transport, while having access to a car and/or a bike reduced the odds. Living or working in high-density areas was associated with higher frequency of public transport use, while living or working in low-density areas was associated with lower frequency (1-3 days/month or 1-3 days/week). We observed interactions between built environment characteristics and having access to a car and/or a bike. For instance, greater distance between the residential and the work or study address increased the odds of higher frequency of public transport use, except among participants who owned a car but not a bike. Regarding individual values and attitudes towards public transport use, valuing lower travel cost and shorter travel time was associated with daily or almost daily public transport use, while valuing low exposure to air pollution, personal health benefits while traveling, as well as flexibility and predictability, were associated with more sporadic use.

Conclusions: We demonstrate, using one of the largest population-based comprehensive multi-city surveys across European cities with varying social and physical contexts, that dense urban environments, reliable and affordable public transport services, and limiting motorized vehicles in high density areas of the cities will help achieve much needed promotion of public transport use.

Keywords: public transport, built environment, urban, travel behaviour, multi-city, European

1. Introduction

The promotion of public transport and active modes of travel (i.e. walking and cycling, and their combination with public transport use) is key to overcoming multiple urban health and environmental challenges such as congestion, traffic injuries, air pollution, greenhouse emissions, and noise (Brand and Preston, 2010; European Environment Agency (EEA), 2018; European Environment Agency (EEA) and European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM), 2018; Guthold et al., 2018; Taipale and Fellini, 2012; The Shift Project, 2019; The World Bank, 2012; United Nations, 2017). People who engage in public transport have also been shown to report higher levels of walking than others (Besser and Dannenberg, 2005; Gascon et al., 2019; Lachapelle and Noland, 2012; Langlois et al., 2016; Morency et al., 2011; Rissel et al., 2012; Sener et al., 2016), and access to public transport was shown to increase levels of walking in natural experiment studies (Brown et al., 2015; Miller et al., 2015; Werner et al., 2016). Thus, beyond sustainability issues, promoting public transport can also help urban population reach the much needed recommended levels of physical activity (WHO, 2018).

Existing research on public transport use has already identified determinants or factors associated with it. These factors include built environment or land use characteristics, usually summarized within the "6 D's" concept (density, diversity, design, destination, distance, and demand) (Agarwal et al., 2019; De Witte et al., 2013; Ogra and Ndebele, 2014; Taylor and Fink, 2013; Yang et al., 2018), individual characteristics of the trip maker (e.g. age, gender, education, income, family size, physical ability, working status) (Agarwal et al., 2019; De Witte et al., 2013; Taylor and Fink, 2013; Yang et al., 2018), characteristics of the trip (e.g. length, time of the day or day of the week, origin and destination) (Agarwal et al., 2019; De Witte et al., 2013; Yang et al., 2018), and characteristics of the service (e.g. affordability, reliability, speed, convenience, comfort, safety and security, ease of access) (Agarwal et al., 2019; Mugion et al., 2018; Taylor and Fink, 2013). Despite the existing evidence, the main determinants are not always consistently associated with public transport use across studies, or might vary across regions or countries (De Witte et al., 2013; Polat, 2012). Importantly, research has also evidenced that some of the identified factors are interconnected; for instance, it is known that as income grows, so does the probability of private vehicle ownership, which is one of the strongest factors associated with a reduction of public transport use (De Witte et al., 2013; Taylor and Fink, 2013). Another example is the high correlation among built environment characteristics like street connectivity, greenness, and richness of facilities (Gascon et al., 2019). Including highly correlated variables in an analysis might lead to overadjustment and difficulties in the interpretation of the results (Schisterman et al., 2009). One of the main limitations of the existing literature is that many studies, including most multi-city analyses, have applied an ecological study design, as observed in previous reviews (De Witte et al., 2013; Polat, 2012; Taylor and Fink, 2013). Ecological studies are those that compare large groups of people instead of individuals for differences in specific outcomes (e.g. use of public transport). The groups can differ by location (e.g. city or country) or time, for instance. Recent examples of ecological studies in the field of public transport research include a cross-sectional ecological study using aggregated city-level data in 48 European cities. The authors observed that network coverage and number of transfer stations were important determinants of public transport ridership (Ingvardson and Nielsen, 2018). In a second study including 25 cities from the USA and Canada, that were observed longitudinally with city level aggregate data, researchers found that revenue vehicle kilometers, average fares and proportion of carless households were important determinants of city-wide public transport ridership (Boisjoly et al., 2018). However, ecological studies are valid for hypothesis generation, but are not considered useful for hypothesis testing because of unmeasured and uncontrolled confounding (Sedgwick, 2014). Thus, for hypothesis testing population-based studies are more suitable (Lieb, 2013).

Despite the breadth and diversity of existing evidence, there is a need for: i) harmonizing protocols and the analysis of modal choice across different regions or countries, ii) conducting population-based studies that control for potential confounding and allow hypothesis testing, iii) studies that consider and analyze multiple factors at the same time and that explore potential interactions between some of these factors (De Witte et al., 2013; Taylor and Fink, 2013). The present work addresses these needs. In addition, for the first time to our knowledge, it incorporates the built environment characteristics of both the home and work or study addresses of the participants in the analysis. With the present population-based cross-sectional study we aim to advance our understanding of the relationship between built environment characteristics and frequency of public transport use in the European context, while considering individual attributes, perceptions and transport habits, as well as potential interactions between built environment characteristics and these other factors.

2. Materials and methods

2.1 Study design and population

Survey data was collected from individuals in seven European cities as part of the "Physical Activity through Sustainable Transport Approaches (PASTA)" EU-funded project (Dons et al., 2015; Gerike et al., 2016; Götschi et al., 2017). Adults (at least 18 years old –or 16 years in the case of Zurich), living, working, studying or regularly travelling (i.e. at least once a week) in one of the seven PASTA cities were eligible to participate, and were recruited following a common protocol (Gaupp-Berghausen et al., 2019). While the PASTA study had a longitudinal design, this analyses uses the baseline questionnaire (http://pastaproject.eu/fileadmin/editor-upload/sitecontent/City_survey/PASTA-questionnaires.pdf), conducted online between November 2014 and December 2016. A comprehensive conceptual framework of active travel behaviour (walking, cycling, public transport use) was developed to guide the questionnaire design (Götschi et al., 2017). Data collected included information on travel habits, individual and household socio-demographic characteristics, and perception and attitudes related to travel. Of the 10691 participants who answered the baseline questionnaire, 713 (6.7%) were excluded because they did not provide information on their home address, and 26 participants because they did not provide information on frequency of public transport use, leaving a total of 9952 participants in the main analyses. A secondary analysis included 8624 participants (86.7% of those included in the main analyses) who reported working or studying. They all provided their work or study address (the working/studying population subsample). The corresponding local ethics committees provided the pertinent permission to collect, store and process data. On enrolment, participants registered and gave informed consent on the PASTA website (see the "Participant information sheet" in http://pastaproject.eu/fileadmin/editor-upload/sitecontent/City_survey/PASTA-questionnaires.pdf) (Dons et al., 2015).

2.2 Outcome assessment

Frequency of public transport (train, tram, metro, underground, bus or coach) use was obtained from the question "*How often do you currently use each of the following methods* *of travel to get to and from places? (walk, bike or e-bike, motorcycle or moped, public transport, car or van)*" (possible answers: never, less than once a month, on 1-3 days/month, on 1-3 days/week, daily or almost daily, don't know). As explained above, those reporting "don't know" were not included in the analysis (N=26).

2.3 Potential correlates of frequency of public transport use

2.3.1 Individual and household characteristics obtained from the questionnaire

Information on a number of individual and household characteristics was collected in the baseline questionnaire (see Table A for a complete list of variables considered for the analysis for the total study population and by city). In 2013 De Witte et al. published a review that analyzed each potential determinant of public transport ridership and the relevance of each determinant (De Witte et al., 2013). Based on this information, but also on the availability of our data (e.g. we do not have information on the need to trip-chain), and with the aim to avoid overadjustment of the models (Schisterman et al., 2009), we chose the following sociodemographic characteristics to be included in a base model (Table 1): age, gender, level of education [high education: education above secondary school (yes/no)], employment status (full-time, part-time, student, not working), and access to car and/or a bike (no access to a car or a bike, only access to a bike, only access to a car, access to both a car and a bike). This last variable was the result of combining the answers to two questions: "Do you have access to a car or van?" (never, sometimes, always) and "Do you have access to a bicycle (private, or through a bike sharing system)" (yes, no).

In addition, participants' values and attitudes towards public transport were determined by asking the level of importance (5-point Likert-type scale from "not important" to "very important", i.e. ordinal variables) attached to each of the following criteria when choosing a mode of transport: short travel time, lower travel cost, higher travel comfort, safer travel (with regard to traffic), safer travel (with regard to crime), lower exposure to air pollution, privacy, personal health benefits, low environmental impact, flexible departure time, more predictable time and journey reliability. Given the very low prevalence in some of the answer categories, we collapsed some of these categories into four or three, instead of the original five possible answers (the prevalence of the original categories are provided in Table A). The criterion to collapse categories was whether the category or the sum of two or more categories reached a prevalence of at least 5% within each city (the original categories are described in Table A).

2.3.2 Built environment characteristics

Using both publicly available and commercial geographic information system (GIS) data [Navteq (2012), Open Street Map (OSM) and local layers (2015-2017), or census/neighbourhood data (2011-2016)] (Dons et al., 2015), we obtained information on the residential and work/study address built environment characteristics at a radial buffer of 300m (Gascon et al., 2019) (Table 2). This buffer size was chosen for three reasons: (i) a 300m buffer is a reasonable walking distance for most of the population, including the elderly, in this case to use public transport; (ii) in the context of high-dense European cities (particularly Barcelona), this buffer size allows for a higher exposure variability among study participants; and (iii) it has been extensively used in previous epidemiological studies on built environment and health based on European data (Nieuwenhuijsen and Khreis, 2019). Extensive information on how each indicator was calculated or defined can be found in Table B. For each participant we additionally calculated Euclidian distance (m), altitude difference (m) and slope between residential and work/study addresses, using R (version R. 3.5.0).

2.4 Statistical Analysis

2.4.1 Multiple imputation of the data

We applied multiple imputation procedures (Royston, 2005) to address missing variables and avoid reducing the sample size in our analysis. Missing values ranged from 0 to 19.5% across variables except for household income which reached 32.6% (see Table A and Table C for further information on the percentage of missing data, and Table D for information on the imputation process and the variables considered). Multiple imputations were conducted by chained equations carrying out 20 imputations with 10 cycles for each imputation generating 20 complete datasets. Imputation procedures were undertaken separately for each city, and resulting databases then merged into one. Standard combination rules for multiple imputations were applied (Marshall et al., 2009; Rubin, 1987).

2.4.2 Logistic regression analysis

The prevalence of participants reporting to never use public transport (3.9%) being low, we combined the category with that of participants using public transport less than once a month (15.2%). This combined category ("Never or less than once a month") was then used as our reference category in remaining analyses. Because a command for multinomial logistic regression analysis with random effect and with imputed data was not available, we generated binomial outcomes for each of the three remaining categories of frequency of public transport use (1-3 days/month, 1-3 days/week, daily or almost daily) versus the category of reference. We thus conducted logistic regression models including city as random effect for each of the frequency combinations, obtaining Odds Ratios (OR) for each frequency contrasts. This approach is less efficient than conducting multinomial logistic regression models, as it tends to have larger standard errors, but previous research has provided evidence of its validity (Agresti, 2002). All built environment characteristic variables were scaled to the mean (i.e. ORs were derived using the standard deviation (SD) as the exposure contrast), except surrounding greenness, for which we used the interquartile range (IQR), and the binary variables access to green spaces and access to blue spaces.

All potential correlates of frequency of public transport use were each individually added to the base model in separate models to explore their individual effect on the frequency of public transport use. The same procedures were applied for the full sample (N=9952) and the working/studying population subsample (N=8624). For the latter, models additionally included information on the built environment characteristics of work or study address, following the same procedure.

2.4.3 Factor and principal component analyses

In a second step, and in order to reduce the number of variables and capture patterns of built environment characteristics and values and attitudes towards public transport use (i.e. criteria when choosing a mode of transport), we created factors and principal components for the different sets of variables, following the same procedure applied in a recent study based on PASTA data (Gascon et al., 2019). Briefly, three sets of factors were constructed for the built environment characteristics: i) only including residential built environment characteristics (N=9952), ii) only including work/study built environment characteristics (N=8624) and, iii) including both the residential and the work/study built environment characteristics (N=8624). Principal components were derived for the values variables (indicating importance of criteria when choosing a mode of transport). As in our previous study, we combined the use of the eigenvalue as a value of reference with the application of subjective criteria (e.g., whether the factors obtained made sense or provided new information with respect to other factors) to decide the final number of factors and principal components. The aim was to detect profiles that were of interest for the purpose and aim of the present study (Gascon et al., 2019). The derived factors and principal components were separately included to the base model and, in a second step, altogether at the same time. In this second step we assessed collinearity among the variables of the base model, city, and the principal components and factors obtained by calculating the variance inflation factors (VIFs).

2.4.4 Sensitivity analyses

We additionally explored the influence of each city in the association between built environment characteristics and frequency of public transport use by conducting a sensitivity analysis excluding each city one by one from the model. Because owning a car or a bike is a strong determinant of public transport use, and at the same time the probability of owning these vehicles can be influenced by the characteristics of the residential built environment, we also explored the interaction between having "access to a car and/or a bike" and the built environment characteristics. If interactions were statistically significant ($p \leq 0.05$), we stratified the association between built environment characteristics and frequency of public transport use by the four categories of the variable "access to a car and/or a bike". Data analysis was conducted with STATA 14.0.

Table 1. Description of the variables included in the base model[a] of the associations between individual factors of public transport use and frequency of public transport use (whole study population, N=9952). Category of reference is "Never or less than once a month" (N=1904, 19.1%).

	Description	1-3 days/month N=1874 (18.8%)		1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
		OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Age (mean years, min-max)	40.1 (16.1, 91.4)	1.00 (0.99, 1.01)	0.37	1.00 (0.98, 0.99)	0.02	1.00 (0.98, 0.99)	0.007
Gender (%)							
Male	46.0	1		1		1	
Female	54.0	0.97 (0.84, 1.13)	0.72	0.99 (0.90, 1.16)	0.90	1.35 (1.15, 1.58)	<0.001
High level of education (%)[b]							
No	27.3	1		1		1	
Yes	72.7	1.31 (1.11, 1.55)	0.002	1.39 (1.14, 1.70)	0.001	1.34 (1.11, 1.62)	0.002
Employment status (%)							
Full-time worker	60.7	1		1		1	
Part-time worker	16.7	1.10 (0.89, 1.35)	0.37	1.32 (1.06, 1.65)	0.02	0.87 (0.70, 1.09)	0.23
Student	13.9	1.61 (1.18, 2.20)	<0.001	2.41 (1.73, 3.37)	<0.001	1.95 (1.43, 2.66)	0.000
Not working[c]	8.7	1.43 (1.09, 1.87)	0.007	2.09 (1.55, 2.81)	<0.001	0.79 (0.58, 1.10)	0.16
Access to a car and/or bike (%)							
Never to car or bike	6.7	1		1		1	
Only bike	16.3	1.58 (0.78, 3.18)	0.20	0.70 (0.35, 1.42)	0.32	0.25 (0.14, 0.47)	<0.001
Only car	13.0	0.57 (0.29, 1.16)	0.12	0.20 (0.10, 0.41)	<0.001	0.15 (0.08, 0.27)	<0.001
Both car and bike	64.1	0.75 (0.38, 1.48)	0.41	0.27 (0.14, 0.53)	<0.001	0.08 (0.05, 0.15)	<0.001

See Table A for further information on the characteristics of the study population

[a]All variables are included in the model at the same time (base model)

[b]No: no degree, primary school or secondary school, Yes: education above secondary school

[c]Home duties/ unemployed/ retired/sickness leave/ parental leave

3. Results

3.1 Characteristics of the study population

Our sample population (N=9952) varied by city (Table A). Average age was 40.1 years, varying from 36.7 mean in Barcelona to 45 in Örebro. We had a higher representation of females across cities (54% overall), except in Rome (38.6%), and reaching up to 62.5% in Örebro. Our sample was highly educated, with 72.7% reporting having secondary school at least, ranging from 62.3% in Zurich to 84.7% in London. In most cities the majority of participants were full-time workers (60.7% on average), except in Vienna (46.6%) and Zurich (49.6%). Having access to a car and a bike was most prevalent in our sample in Antwerp (87.6%) and least so in London (37.8%), with an overall 64.1% prevalence across the sample. Daily or almost daily use of public transport varied from 7.1% in our Orebro sample to close to 60% in Zurich and Vienna, with an average across the sample of 40.5%.

The percentage of excluded participants due to lack of information on their home address (N=713) ranged from 3.4% (in Rome) to 12.4% (in Örebro), with statistically significant differences across cities ($p<0.001$). Regarding covariates, we observed that the main difference between included and excluded participants was the percentage of missing values for high level of education (15.8% vs. 80.2%, respectively), employment status (2.6% vs. 74.8%) and car or bike access (0% vs. 15.7%). This considered, these were also the three variables for which we observed statistically significant differences between the included and the excluded participants; excluded participants had lower education (62.4% vs. 72.7% among included, $p<0.001$), lower percentage of full-time workers (54.4% vs. 60.7%, $p<0.001$), and higher access to a bike (20.3% vs. 16.3%), but less access to both a car and a bike (60.4% vs. 64.1%, $p<0.02$).

3.2 Correlates of frequency of public transport use

3.2.1 Results for the whole study population (N=9952)

Results of the base model showed being a female is an important correlate of daily or almost daily public transport use [OR (95%CI)=1.35 (1.15, 1.58)] (Table 1). Having a high level of education was similarly positively associated with frequency of public transport use across all three categories of frequencies [e.g. OR (95%CI) for daily or almost daily use = 1.34 (1.11, 1.62)] (Table 1). In reverse, having access to a car or a bike, or to both of them, significantly decreased the odds of frequent public transport ridership [e.g. OR (95%CI) for daily or almost daily use when having access to both car and bike = 0.08 (0.05, 0.15)] in comparison to those not having access to either (Table 1). As compared to full-time workers, positive associations with public transport use were found for students across all frequencies, with the strongest association for the 1-3 days/week frequency [OR (95%CI)=2.41 (1.73, 3.37)], and for those working part time or not working workers only for sporadic public transport use (1-3 days/weeks for both groups, 1-3 days/month for those not working) (Table 1).

3.2.1.1 Residential built environment characteristics

Residential built environment characteristics around participant addresses differed widely across our seven PASTA cities. On average participants had 21/km^2 public transport stations/stops within a 300m buffer around their home address, but participants in Barcelona had the densest supply of public transport stations/stops with 30 stations/km^2 and Örebro the lowest with nearly a third of that (11 stations/km^2) (Table C). Participants lived on average 145m away from the nearest public transport station/stop, with distances ranging from 111m in Rome to188m in Örebro (Table C).

Table 2. Associations between residential built environment characteristics (300 m buffer) and frequency of public transport use (whole study population, N=9952). Category of reference is "Never or less than once a month" (N=1904, 19.1%).

	Exposure contrast[a]	1-3 days/month N=1874 (18.8%)		1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
		OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Built environment correlates (300 m buffer)[b]							
Street length density (m/km^2)[c]	7040	1.30 (1.19, 1.42)	<0.001	1.47 (1.33, 1.62)	<0.001	1.14 (1.04, 1.25)	0.004
Street connectivity (intersections/km^2)[c]	110	1.26 (1.14, 1.39)	<0.001	1.39 (1.25, 1.54)	<0.001	1.13 (1.03, 1.24)	0.01
Building area density (m^2/km^2)[c]	157383	1.26 (1.16, 1.37)	<0.001	1.43 (1.30, 1.57)	<0.001	1.12 (1.02, 1.23)	0.01
Population density (inhabitants/km^2)[c]	12789	1.47 (1.29, 1.66)	<0.001	1.64 (1.44, 1.87)	<0.001	1.20 (1.07, 1.34)	<0.001
Facilities[d] density (nº facilities/km^2)[c]	257	1.07 (0.98, 1.17)	0.11	1.14 (1.04, 1.25)	0.01	1.06 (0.98, 1.15)	0.17
Facilities[d] richness (nº facilities types/nº facilities)[c]	0.09	1.28 (1.17, 1.39)	<0.001	1.41 (1.28, 1.55)	<0.001	1.13 (1.04, 1.24)	0.004
Density of public transport stations or stops (nºstations/km^2)[c]	16.0	1.24 (1.14, 1.35)	<0.001	1.34 (1.22, 1.47)	<0.001	1.16 (1.07, 1.26)	<0.001
Distance to the 1st public transport station or stop (m)	117	0.88 (0.82, 0.94)	<0.001	0.79 (0.73, 0.86)	<0.001	0.92 (0.86, 0.99)	0.03
$PM_{2.5}$ ($\mu g/m^3$)	3.6	1.79 (1.52, 2.11)	<0.001	2.25 (1.93, 2.63)	<0.001	1.41 (1.19 1.66)	<0.001
NO_2 ($\mu g/m^3$)	10.7	1.60 (1.44, 1.68)	<0.001	1.92 (1.69, 2.19)	<0.001	1.17 (1.06, 1.29)	0.001
Surrounding greenness (NDVI)	0.26	0.72 (0.63, 0.84)	0.001	0.58 (0.49, 0.69)	<0.001	0.86 (0.73, 1.01)	0.06
Distance to the closest major GS (m)	1194	1.01 (0.93, 1.09)	0.81	1.03 (0.95, 1.13)	0.46	1.09 (1.01, 1.17)	0.02
Area of the closest GS (km^2)	222	1.01 (0.95, 1.06)	0.41	1.05 (0.99, 1.12)	0.09	1.06 (0.99, 1.13)	0.11
Access to major GS (within 300m)	Yes	0.74 (0.61, 0.89)	0.002	0.67 (0.54, 0.82)	<0.001	0.78 (0.64, 0.95)	0.02
Distance to the closest major BS (m)	2716	0.97 (0.89, 1.05)	0.43	0.82 (0.75, 0.90)	<0.001	1.04 (0.97, 1.12)	0.24
Area of the closest BS (km^2)	38245	1.02 (0.88, 1.16)	0.80	1.00 (0.89, 1.12)	0.96	0.97 (0.87, 1.08)	0.60
Access to major BS (within 300m)	Yes	0.81 (0.62, 1.07)	0.14	1.18 (0.88, 1.59)	0.27	0.98 (0.72, 1.34)	0.91
Factors for built environment correlates obtained through factor analysis[e]							
1) *High density residential area*: high street length density and connectivity, population density, density and richness of facilities, density of public transport stations/stops and high air pollution but low surrounding greenness		1.46 (1.32, 1.61)	<0.001	1.74 (1.55, 1.95)	<0.001	1.22 (1.12, 1.34)	<0.001
2) *Low density residential area*: low street length density and connectivity and low density of public transport stations/stops, moderate air pollution		1.20 (1.06, 1.36)	0.04	1.18 (1.03, 1.35)	0.02	1.06 (0.94, 1.19)	0.32

IQR=interquartile range

See Tables B and C for further information on the built environment characteristics.

GS: green spaces, BS: blue spaces; NDVI: normalized difference vegetation index.

[a]All variables were scaled based on the mean and standard deviation (SD) (all cities together) and therefore the unit of contrast is the SD, with the exception of access to green and blue spaces (binary variables) and surrounding greenness (we used the interquartile range - IQR).
[b]Variables were included one by one in the base model. All variables except access to green and blue spaces, and surrounding greenness were scaled based on the mean and standard deviation (all cities together).
[c]Street length, connectivity, building area, population, facilities, and public transport stations/stops are expressed per km^2 (density). However, in terms of interpretation, the reader might wish to use the indicators per area of the buffer (area of a 300m buffer=0.2809 km^2). In this case the SD of each of these variables has to be multiplied by 0.2809 [e.g. if SD of street length density is 7040 m/km^2, then the new value for area of the buffer is 1978 m].
[d]Definition of "facilities": private and public points of interest including shops, schools, theatres and leisure activities, supermarkets, administration offices, banks, hospitals…motorized vehicle related points were excluded (e.g. parking lots, petrol stations…).
[e]*Variables (none scaled) included in the factor analysis:* Residential street length density, connectivity, built area density, population density, density and richness of facilities, public transport station/stop distance and density, $PM_{2.5}$, NO_2, surrounding greenness and area of and distance to the closest green and blue spaces. See Table E for further information on the factor analysis for the residential built environment characteristics.

A number of residential built environment characteristics were associated with public transport use, but following non-monotonic trends across increasing frequencies of public transport use as compared to those who never or less than once a month use public transport (Table 2); for all built environment characteristic that associated with public transport use, whether positively (e.g. street connectivity, public transport station/stop density, or population density) or negatively (e.g. distance to public transport station/stop or access to green spaces), the largest effects were found for the 1-3 days/week frequency, mostly often followed by 1-3 days a month, and with least influence on the daily or almost daily frequency (each in comparison to "never or less than once a month") (Table 2).

The same two main factors derived in the previous study following the same methodology (Gascon et al., 2019) were obtained to characterize the residential built environment (Table E): Factor 1 labelled "high density residential area" (explaining 75% of the total variance) and Factor 2 labelled "low density residential area" (explaining 10% of the total variance). Similar to the individual built environment contributions examined above, a non-monotonic trend across frequencies of public transport use was observed in association with the factor "high density residential area", with statistically significant positive associations across all three frequency categories, and the highest odds obtained for the 1-3 days/week [OR (95%)=1.74 (1.55, 1.95)] compared to never or less than once a month use (Table 2). On the other hand, increasing values of "low density residential area" had similar associations with sporadic public transport use (1-3 days a month [1.20 (1.06, 1.36)] and 1-3 days/week [1.18 (1.03, 1.35)]), but no effect on the daily or almost daily frequency [1.06 (0.94, 1.19)]. Sensitivity analyses excluding each city one-by-one provided results with the same direction as when including all cities in the model (Table F).

3.2.1.2 Values and attitudes

Valuing lower travel cost, low exposure to air pollution, safer travel with regards to traffic, and low environmental impact when choosing a travel mode were each associated with an increased frequency in public transport use [e.g. the association with "daily or almost daily public transport" use if these criteria were considered very important were: OR (95%CI)=1.70 (1.30, 2.21), 1.46 (1.14, 1.87), 1.25 (0.95, 1.64) and 1.89 (1.44, 2.49), respectively] (Table G). On the contrary, importance ("very important") given to travel comfort [0.50 (0.38, 0.66)], safer travel with regard to crime [0.74 (0.54, 1.00)], privacy [0.25 (0.18, 0.36)], and flexible departure time [0.24 (0.19, 0.31)] were associated with a decreased frequency of public transport use (Table G). Other variables, such as short travel time, personal health benefits, or predictable time and journey reliability were not associated with frequency of public transport use or did not show a clear pattern across levels of importance and frequencies of use (Table G).

The PCA yielded the same four principal components (Table H) previously described in Gascon et al. (2019). The first (PC1), explaining 26% of the variance and labelled "Safe, healthy, sustainable and private travel", describes participants who value safety (from traffic and crime), low exposure to air pollution, privacy, personal health benefits, and low environmental impact. Associations between this principal component and frequency of public transport use were non-statistically significant or weak [OR (95%) for 1-3 days/month=0.98 (0.94, 1.03), for 1-3 days/week=0.94 (0.89, 0.98), and for daily or almost daily use=0.97 (0.93, 1.02)] (Table 3). PC2 was labelled "Short, flexible and predictable travel, do not care about health or environment" and accounting for 15% of the total variance, describes those who value short travel time, predictability, reliability and flexibility, but do not value health and the environment. We observed a strong inverse association between this principal component and frequency of public transport use [OR (95%) for 1-3 days/month=0.92 (0.87, 0.97), for 1-3 days/week=0.83 (0.78, 0.88), and for daily or almost daily use=0.79 (0.75, 0.84)] (Table 3). PC3, labelled "Flexible and predictable travel. Health and environment are relevant, but not comfort or safety", and explaining 12% of the total variance, included participants who value flexibility, predictability, low exposure to air pollution and personal health benefits, but felt that comfort, safety or privacy were not important. This principal component was associated with a non-daily use of public transport [e.g. 1-3 days/week; 1.18 (1.10, 1.27)], but not with a daily or almost daily use [1.03 (0.96, 1.10)] (Table 3). PC4, labelled "Cheap and short travel" and explaining 9% of the total variance, included those who value lower travel cost and a short travel time, but not flexibility, privacy and predictability. We observed an increasing association between this principal component and a higher frequency of public transport use [e.g. 1.04 (0.97, 1.12) for those reporting to use the public transport 1-3 days/week and 1.50 (1.38, 1.62) for those reporting to use public transport daily or almost daily] (Table 3).

3.2.1.3 All correlates in the full model

After evaluating each single set of correlates of frequency of public transport use, we introduced all the different factors and principal components into one single model (Table 4). The associations remained similar as compared to the models including only the built environment characteristics or only the values. There was no evidence of collinearity among the variables included in the models (mean VIF value obtained=1.11; the highest individual VIF was 1.22 for the variable age).

3.2.2 Results for the working/studying subpopulation (N=8624)

3.2.2.1 Residential built environment characteristics and other correlates

When including only those participants who reported to be working or studying (N=8624), the frequencies of public transport use did not vary with respect to the total study population (N=9952), nor did the associations reported above (data not shown).

3.2.2.2 Work/study built environment characteristics and other correlates

We observed a different pattern of associations between the work/study built environment characteristics and frequency of public transport use compared to associations with the residential built environment characteristics. In this case, monotonic trends across increasing frequencies of public transport use were found with increasing street length density, street connectivity, building area density, facilities density and richness and density of public transport stations/stops around work/study addresses (Table I). Similar monotonic trends were shown for associations with the "high density work/study area" factor derived from the work/study address factors analyses (explaining 68% of the total variance), but not for the "low density work/study area" factor (12% of the total variability, Table J). The increasing trends led to higher odds of daily or almost daily use of public transport for increasing "high density in the work/study area" factor [OR (95%CI)=1.46 (1.32, 1.62)], compared to the residential area factor [1.22 (1.12, 1.24)]. The impacts of increasing low density factor in the work/study area were all slightly higher than of increasing the low density factor in the residential area (Table I). Results of the full model with all co-variates, including principal components on values, yielded similar results (Table L).

Table 3. Associations between principal components obtained for the importance of different aspects when travelling (*"How important are the following criteria for you when choosing a method of travel?"*) and frequency of public transport use (whole study population, N=9952). Category of reference is "Never or less than once a month" (N=1904, 19.1%).

Principal component[b]	On 1-3 days/month N=1874 (18.8%)		On 1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
	OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
1) Safety (traffic and crime), low exposure to air pollution, privacy, health benefits, and low environmental impact	0.98 (0.94, 1.03)	0.47	0.94 (0.89, 0.98)	0.008	0.97 (0.93, 1.02)	0.19
2) Short travel time, predictable travel time and journey reliability, and flexible departure time. Health benefits and low environmental impact are not important	0.92 (0.87, 0.97)	0.002	0.83 (0.78, 0.88)	<0.001	0.79 (0.75, 0.84)	<0.001
3) Low exposure to air pollution and health benefits are important, as well as flexibility and predictability, but not being comfortable, safe or providing privacy	1.20 (1.13, 1.27)	<0.001	1.18 (1.10, 1.27)	<0.001	1.03 (0.96, 1.10)	0.44
4) Cost and short travel are very important, but not flexibility, privacy or predictability	1.04 (0.97, 1.12)	0.27	1.19 (1.10, 1.29)	<0.001	1.50 (1.38, 1.62)	<0.001

PCA: principal component analysis.
[a]*Variables included in the PCA:* "importance of" short travel time, lower travel cost, higher travel comfort, safer travel with regards to traffic, safer travel with regards to crime, lower exposure to air pollution, privacy, personal health benefits, low environmental impact, flexible departure time, more predictable time and journey reliability. See Table H for further information on this PCA.

3.2.2.3 Residential and work/study built environment characteristics and other correlates

On average, participants worked or studied 4.9 km away from their home; only 353 participants lived 300 m or less from their work/study place, and only 48 had a distance of 100 km or greater. Altitude difference and slope between home and work/study address were not statistically significantly associated with frequency of public transport use in separate models (data not shown). Increasing distances between both addresses, on the other hand, was statistically significantly associated with associated with a daily or almost daily use of the public transport [for each SD= 24561 m the OR (95%) =2.08 (1.74, 2.51)], although not for the other frequency categories [OR (95%) for 1-3 days/month=0.96 (0.90, 1.03) and for 1-3 days/week=1.02 (0.93, 1.12)]. Thus, this variable was included in further analyses.

As in Gascon et al. 2019, the factor analysis combining residential and work/study built environment characteristics yielded two main factors. The "high density residential and work/study areas" factor explained 48% of the total variability, and the "low density residential areas, but high density work/study areas" factor explained 19% of the total variability (Table K). When solely these two factors were added on to the base model, they both provided a non-monotonic trend with the frequency of public transport use. Increasing "high density in the residential and work/study areas" maintained a positive effect on public transport use across frequency categories: [OR (95%) for 1-3 days/month=1.47 (1.31, 1.64), for 1-3 days/week=1.82 (1.60, 2.07), and for daily or almost daily use=1.54 (1.39, 1.70)]. On the other hand, "low density residential areas, but high density work/study areas" had a deterring impact on sporadic public transport use [OR (95%) for 1-3 days/month=0.82 (0.75, 0.89), for 1-3 days/week=0.80 (0.72, 0.88)] and a positive impact on daily or almost daily use [OR (95%) =1.16 (1.07, 1.26)].

Table 4. Associations between the different correlates and frequency of public transport use (whole study population, N=9952) for the full model (all variables included). Category of reference is "Never or less than once a month" (N=1904, 19.1%).

Population characteristics, and factor or principal component[a]	On 1-3 days/month N=1874 (18.8%)		On 1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
	OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Age	1.00 (0.99, 1.00)	0.48	1.00 (0.98, 1.00)	0.04	0.99 (0.98, 1.00)	0.007
Gender (female)	0.99 (0.86, 1.16)	0.95	1.04 (0.86, 1.24)	0.63	1.37 (1.17, 1.61)	<0.001
High level of education (yes)[a]	1.23 (1.04, 1.47)	0.02	1.29 (1.05, 1.58)	0.02	1.35 (1.11, 1.64)	0.002
Employment status (full-time worker is reference)						
Part-time worker	1.08 (0.88, 1.33)	0.48	1.26 (0.98, 1.58)	0.05	0.87 (0.69, 1.09)	0.22
Student	1.71 (1.24, 2.34)	0.001	2.24 (1.59, 3.15)	<0.001	1.89 (1.38, 2.59)	<0.001
Not working[b]	1.42 (1.08, 1.86)	0.01	1.91 (1.41, 2.58)	<0.001	0.66 (0.50, 0.95)	0.02
Access to a car and/or bike						
Only bike	1.34 (0.66, 2.71)	0.42	0.62 (0.31, 1.25)	0.18	0.22 (0.12, 0.41)	<0.001
Only car	0.70 (0.35, 1.41)	0.32	0.27 (0.13, 0.55)	<0.001	0.16 (0.09, 0.29)	<0.001
Both car and bike	0.76 (0.38, 1.50)	0.42	0.29 (0.15, 0.57)	<0.001	0.08 (0.05, 0.15)	<0.001
Factors of the residential built environment characteristics (300 m buffer)						
High density residential area[c]	1.43 (1.30, 1.58)	<0.001	1.71 (1.52, 1.91)	<0.001	1.23 (1.12, 1.34)	<0.001
Low density residential area[d]	1.19 (1.05, 1.35)	0.006	1.18 (1.03, 1.35)	0.02	1.06 (0.95, 1.20)	0.30
PCs of importance of criteria						
Safe, healthy, sustainable and private travel	0.98 (0.94, 1.02)	0.38	0.93 (0.89, 0.98)	0.005	0.97 (0.93, 1.02)	0.23
Short, flexible and predictable travel, do not care about health or environment	0.92 (0.87, 0.97)	0.002	0.83 (0.78. 0.88)	<0.001	0.80 (0.75, 0.85)	<0.001
Flexible and predictable travel. Health and environment are relevant, but not comfort or safety	1.18 (1.11, 1.25)	<0.001	1.16 (1.08, 1.25)	<0.001	1.02 (0.95, 1.10)	0.56
Cheap and short travel	1.04 (0.97, 1.12)	0.25	1.18 (1.09, 1.28)	<0.001	1.49 (1.38, 1.61)	<0.001

[a]No: no degree, primary school or secondary school, Yes: education above secondary school
[b]Home duties/ unemployed/ retired/sickness leave/ parental leave
[c]High street length density and connectivity, population density, density and richness of facilities, density of public transport stations/stops and high air pollutants but low surrounding greenness (see Table E).
[d]Low street length density and connectivity and low density of public transport stations/stops, moderate air pollution (see Table E).

Distance between the residential and the work addresses was negatively, but not strongly, correlated with the factor "high density residential and work/study areas" (spearman r=-0.27), whereas the correlation was positive for the factor "low density residential areas" (r=0.19). Adding distance, the factors for the built environment (combining residential and work/study addresses) and the values' principal components to the model (full model Table 5), strengthened the associations between the "high density residential and work/study areas" factor and a daily or almost daily public transport use [1.82 (1.62, 2.05)] and between distance and a daily or almost daily public transport use [2.60 (2.12, 3.20)] (Table 5). All other associations in the full model remained largely unchanged (and those that changed a little remained in the same direction as the previous full models) (Table 5).

3.3 Interaction analyses

We observed statistically significant interactions ($p \leq 0.05$) between access to a car and/or a bike and some of the factors of the built environment and therefore we stratified the analyses of the association between built environment characteristics and frequency of public transport use by access to a car and/or a bike (Table 6).

3.3.1 Residential built environment

Among participants who did not have access to a car or a bike, increasing values of the "low density residential areas" was statistically associated with the use of the public transport (all categories), but the "high density residential areas" factor had no effect. (Table 6). Among participants having access only to a bike, both high and low density residential area were associated with lower odds of daily or almost daily use of the public transport system, but it was not associated with a sporadic use (1.3 days/month or 1-3 days/week). Finally, among those having access to a car, or to a car and a bike, we observed higher odds of using the public transport with increasing values of the "high density residential areas" factor, while the association with "low density residential areas" factor was only statistically significant with a sporadic use of the public transport for those owning both a car and a bike (Table 6).

3.3.2 Work/study built environment

In relation to the work/study built environment, we did not observe associations among those not having access to a car or a bike, or among those having a bike, with any of the built environment factors (Table 6). Among car or car and bike owners we observed that increasing values of "high density work/study areas" was associated with increased odds of using the public transport system, while increasing values of "low density work/study areas" was associated with increased odds of using the public transport system sporadically, but not daily or almost daily (Table 6).

3.3.3 Residential and work/study built environments

When considering both the residential and the work/study built environment, we observed that, practically for all groups, increasing distance from home to work/school increased the odds of using public transport, except among those who were only car owners (Table 6). Those who do not have access to a car or a bike are not shown to be affected by any of the combined home and work/study built environment factors, and those who only have access to a bike are barely affected (the only statistically significant association is with "high density residential and high density work/study areas" for the 1-3 days/week use of public transport). Among car and car and bike owners we observed an association between increasing values of the "high density residential and high density work/study areas" and the use of public transport, while there was an inverse association between the factor "low density residential area and high density work/study area" and a sporadic public transport use, and a small increase of the odds of using the public transport daily or almost daily (Table 6).

4. Discussion

4.1 Key findings

The present study, one of the largest observational studies and most varied, with 9000 participants from seven different European cities, considers a wide range of correlates of public transport use, including built environment characteristics and individual characteristics. Moreover, to our knowledge, we are the first to incorporate the built environment characteristics of both the residential and the work/study addresses, thus going a step further in terms of obtaining richer information on built environment exposure. The findings of our study can be summarized in three main themes: built environment, sociodemographic characteristics, and individual values and attitudes.

Regarding the built environment characteristics, the present study observed that 1) living or working in high density areas was associated with increased general use of the public transport system (all frequencies as compared to "never or less than a month"), while living or working in low density areas was associated with sporadic use (1-3 days/month or 1-3 days/week); 2) when considering both the residential and work/study built environments jointly in the models, increasing values of the factor "high density residential and high density work/study areas" were associated with increasing odds of public transport use, while increasing values of the factor "low density residential area

Table 5. Associations between the different correlates, including the residential and the WOS built environment characteristics and the distance between both addresses, and frequency of public transport use (working/studying population, N=8624). Category of reference is “Never or less than once a month” (N=1634, 19.0%).

Population characteristics, and factor or principal component[a]	On 1-3 days/month N=1623 (18.8%)		On 1-3 days/week N=1808 (21.0%)		Daily or almost daily N=3559 (41.3%)	
	OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Age	0.99 (0.99, 1.00)	0.18	0.99 (0.98, 0.99)	0.002	0.99 (0.98, 0.99)	0.001
Gender (female)	1.02 (0.87, 1.20)	0.82	1.08 (0.89, 1.30)	0.42	1.41 (1.18, 1.69)	<0.001
High level of education (yes)[a]	1.22 (1.01, 1.49)	0.04	1.37 (1.08, 1.73)	0.01	1.33 (1.07, 1.65)	0.011
Employment status (full-time worker is reference)						
Part-time worker	1.07 (0.86, 1.33)	0.53	1.22 (0.96, 1.55)	0.1	0.93 (0.74, 1.19)	0.58
Student	1.73 (1.24, 2.40)	0.001	2.19 (1.53, 3.14)	<0.001	1.97 (1.42, 2.74)	<0.001
Access to a car and/or bike						
Only bike	1.91 (0.73, 5.01)	0.19	0.66 (0.26, 1.66)	0.38	0.18 (0.08, 0.40)	<0.001
Only car	0.92 (0.35, 2.42)	0.87	0.29 (0.12, 0.73)	0.009	0.11 (0.05, 0.25)	<0.001
Both car and bike	1.02 (0.40, 2.61)	0.97	0.32 (0.13, 0.78)	0.012	0.06 (0.03, 0.13)	<0.001
Factors of the residential and WOS built environment characteristics (300 m buffer)						
High density residential and high density WOS areas[b]	1.43 (1.28, 1.60)	<0.001	1.84 (1.61, 2.09)	<0.001	1.82 (1.62, 2.05)	<0.001
Low density residential area and high density WOS area[c]	0.82 (0.75, 0.89)	<0.001	0.80 (0.73, 0.89)	<0.001	1.12 (1.03, 1.23)	0.01
Distance between both addresses[d]	1.00 (0.93, 1.07)	0.98	1.12 (1.00, 1.25)	0.04	2.60 (2.12, 3.20)	<0.001
PCs of importance of criteria						
Safe, healthy, sustainable and private travel	1.00 (0.95, 1.04)	0.83	0.94 (0.89, 0.99)	0.03	0.98 (0.93, 1.03)	0.47
Short, flexible and predictable travel, do not care about health or environment	0.89 (0.84, 0.95)	<0.001	0.80 (0.74. 0.86)	<0.001	0.79 (0.73, 0.84)	<0.001
Flexible and predictable travel. Health and environment are relevant, but not comfort or safety	1.18 (1.10, 1.26)	<0.001	1.16 (1.07, 1.26)	<0.001	1.04 (0.96, 1.12)	0.32
Cheap and short travel	1.03 (0.96, 1.12)	0.42	1.17 (1.07, 1.28)	0.001	1.54 (1.41, 1.69)	<0.001

WOS=work or study

[a]No: no degree, primary school or secondary school, Yes: education above secondary school

[b]High street length density and connectivity, population density, density and richness of facilities, high air pollutants but low surrounding greenness for both residential and work/study addresses. Public transport density is better at residential than at work/study address (see Table K).

[c]Low street length density and connectivity, population density, density and richness of facilities, low air pollutants and moderate-high surrounding greenness for residential address. But high street length density and connectivity, building area density (not population), density and richness of facilities, moderate density of public transport stations/stops but low surrounding greenness for work/study address, where NO_2 levels are moderately high but not $PM_{2.5}$ (see Table K).
[d]Results for each SD increase of 24561 meters.

Table 6. Associations between the built environment factors and frequency of public transport use stratified by access to a car and/or a bike.

Category of reference is "Never or less than once a month" (N=1904, 19.1%).	On 1-3 days/month N=1874 (18.8%)		On 1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
	OR (95%CI)	**p-val**	**OR (95%CI)**	**p-val**	**OR (95%CI)**	**p-val**
RESIDENTIAL ADDRESS (N=9952)						
High density residential area						
No access to car or bike	3.12 (0.69, 14.0)	0.14	0.98 (0.48, 2.02)	0.97	1.29 (0.51, 3.29)	0.59
Only bike	1.20 (0.85, 1.69)	0.31	1.15 (0.80, 1.66)	0.44	0.72 (0.53, 0.99)	0.04
Only car	1.53 (1.19, 1.96)	<0.001	1.78 (1.24, 2.57)	0.002	1.37 (1.02, 1.84)	0.03
Both car and bike	1.47 (1.32, 1.64)	<0.001	1.83 (1.60, 2.09)	<0.001	1.25 (1.11, 1.41)	<0.001
Low density residential area						
No access to car or bike	5.13 (1.30, 20.3)	0.02	2.04 (0.98, 4.21)	0.06	3.19 (1.30, 7.83)	0.01
Only bike	0.79 (0.54, 1.16)	0.24	0.75 (0.51, 1.10)	0.14	0.64 (0.45, 0.92)	0.02
Only car	1.19 (0.88, 1.61)	0.25	1.31 (0.89, 1.93)	0.17	1.13 (0.81, 1.59)	0.47
Both car and bike	1.26 (1.11, 1.43)	<0.001	1.21 (1.03, 1.42)	0.02	1.05 (0.90, 1.23)	0.54

Category of reference is "Never or less than once a month" (N=1634, 19%).	On 1-3 days/month N=1623 (18.8%)		On 1-3 days/week N=1808 (21.0%)		Daily or almost daily N=3559 (41.3%)	
	OR (95%CI)	**p-val**	**OR (95%CI)**	**p-val**	**OR (95%CI)**	**p-val**
WOS ADDRESS (N=8624)						
High density WOS area						
No access to car or bike	NA		0.53 (0.14, 1.95)	0.34	0.47 (0.14, 1.56)	0.22
Only bike	1.11 (0.78, 1.58)	0.56	1.09 (0.77, 1.54)	0.74	0.92 (0.67, 1.27)	0.61
Only car	1.39 (1.04, 1.85)	0.02	1.23 (0.86, 1.76)	0.25	2.45 (1.81, 3.32)	<0.001
Both car and bike	1.11 (1.00, 1.24)	0.05	1.33 (1.17, 1.50)	<0.001	1.52 (1.34, 1.72)	<0.001
Low density WOS area						
No access to car or bike	NA		1.37 (0.38, 4.99)	0.64	1.15 (0.33, 4.01)	0.83
Only bike	1.43 (0.90, 2.28)	0.13	1.20 (0.73, 1.95)	0.48	1.19 (0.74, 1.93)	0.47
Only car	1.43 (1.01, 2.02)	0.04	1.35 (0.82, 2.22)	0.24	1.48 (0.93, 2.33)	0.10
Both car and bike	1.35 (1.16, 1.57)	<0.001	1.38 (1.15, 1.67)	0.001	1.06 (0.86, 1.32)	0.56

RESIDENTIAL & WOS ADDRESSES (N=8624)						
High density residential and high density WOS areas						
No access to car or bike	NA		0.39 (0.11, 1.41)	0.15	0.50 (0.18, 1.37)	0.18
Only bike	1.24 (0.80, 1.92)	0.33	1.60 (1.02, 2.52)	0.04	1.11 (0.72, 1.72)	0.65
Only car	1.73 (1.29, 2.31)	<0.001	1.74 (1.12, 2.69)	0.01	2.70 (1.81, 4.04)	<0.001
Both car and bike	1.45 (1.28, 1.64)	<0.001	1.98 (1.69, 2.31)	<0.001	1.89 (1.62, 2.21)	<0.001
Low density residential area and high density WOS area						
No access to car or bike	NA		0.93 (0.31, 2.77)	0.89	0.79 (0.23, 2.70)	0.70
Only bike	0.82 (0.60, 1.13)	0.23	0.80 (0.58, 1.10)	0.18	0.98 (0.71, 1.36)	0.91
Only car	0.84 (0.63, 1.12)	0.24	0.79 (0.58, 1.08)	0.14	1.35 (1.07, 1.71)	0.01
Both car and bike	0.81 (0.73, 0.90)	<0.001	0.79 (0.71, 0.89)	<0.001	1.11 (1.00, 1.24)	0.05
Distance between both addresses						
No access to car or bike	NA		1.81 (0.00, 7798)	0.89	13308 (0.44, 4.0e+08)	0.07
Only bike	0.15 (0.02, 1.10)	0.06	1.96 (0.99, 3.87)	0.05	16.6 (4.5, 61.6)	<0.001
Only car	1.04 (0.84, 1.28)	0.74	0.99 (0.81, 1.20)	0.90	1.62 (0.91, 2.87)	0.10
Both car and bike	0.99 (0.92, 1.07)	0.82	1.12 (0.99, 1.26)	0.06	2.58 (2.05, 3.25)	<0.001

WOS=work or study

All models adjusted by age, gender, education, employment status and the four principal components for the importance of different criteria when choosing a method of travel.

[a]NA=we could not obtain results within this category because of the small study population.

and high density work/study area" were inversely associated with sporadic use of the public transport system, and a small increase of daily or almost daily use; and 3) increasing distance between the residential and the work or study addresses increased the odds of using public transport.

Regarding sociodemographic correlates, we observed that being female, highly educated or a student increased the odds of using public transport, with independent effects of each other. In the case of females, the association was only observed with a daily or almost daily public transport use. Not working was associated with a sporadic public transport use, and having access to a car and/or a bike reduced the odds of using public transport. Also, we observed interactions between built environment characteristics and having access to a car and/or a bike.

Finally, regarding values and attitudes (in our study represented by importance of certain criteria when choosing a mode of transport), we observed that valuing lower travel cost and shorter travel time was associated with a daily or almost daily public transport use, while valuing low exposure to air pollution and personal health benefits, as well as flexibility and predictability, was associated with more sporadic use. However, valuing shorter travel time, predictable travel time and journey reliability, and not caring about health or environmental benefits was associated with reduced public transport use.

Based on our findings, and on those obtained by previous studies, we provide recommendations for planners and policy makers to develop strategies to promote the use of public transport in Table 7. Policies can be implemented at different scales, particularly cities and regions, but with the support of states and, in the case of Europe, the European Commission (EC). We think that these recommendations can be applied anywhere in the world, while considering the uniqueness of each place (Buehler, 2011).

4.2 Theme 1: Built environment matters

Previous ecological studies have suggested that public transport use is associated with built environment characteristics (e.g. population density and the number of (transfer) public transport stations/stops) (De Witte et al., 2013; Ingvardson and Nielsen, 2018; Ogra and Ndebele, 2014; Polat, 2012), which makes sense as one of the main criteria used by transport authorities to decide the location of new public transport stations/stops is the population density of an area. Now, for the first time, we can simultaneously evaluate, in a study with a cross-sectional design and using data from more than 9000 individuals of seven European cities, the role of the residential and the work/study addresses. Our results confirm the importance of built environment characteristics, as we observed that higher density (in our study defined as areas with high street length density and connectivity, population density, density and richness of facilities, density of public transport stations/stops and high air pollution but low surrounding greenness) of the residential area, the work/study area or the combination of both clearly increased the odds of using public transport, although in some cases we observed non-monotonic trends between these characteristics of the built environment and the frequency of public transport use. Meanwhile, in low density (in our study defined as areas with low street length density and connectivity and low density of public transport stations/stops, moderate air pollution) residential area and working/study area we observed associations with a more sporadic public transport use, but not with a daily or almost daily use. In addition, the factor "low density residential area and high density work/study area" had a particular pattern of association with public transport use; although "low density residential area" was associated with a sporadic public transport use, when combined with a "high density working/study area" the associations were totally the opposite. One explanation could be that those living in "low density residential area" use the public transport for needs other than going to work or to study, which might require a more sporadic public transport use. Meanwhile, for going to work or study they might prefer using other means of transport if they need to do it sporadically, and only use the public transport if they need to go to work or study every day. It is important to note that although there was an association between "low density residential area and high density work/study area" and daily or almost daily public transport use, this association [OR (95%CI)=1.12 (1.03, 1.23)] was weaker than the association observed between "high density residential and high density work/study areas" and the daily or almost daily public transport use [1.82 (1.62, 2.05)]. In conclusion, our results confirm that promoting cities with the characteristics of "high density areas", as opposed to "low density areas", is associated with public transport use for everyday mobility, in addition to other needs that require a more sporadic use of the public transport system. "High density areas" may not only pull people towards public transport by providing proximity to stops and destinations, but also because high density often means congestion and high parking prices, which discourages the use of private vehicle in these areas (Taylor and Fink, 2013). Overall, our results support "Transit oriented development", an urban planning development that promotes mix-land uses and maximizes the amount of residential, business and leisure space within walking distance of public transport.

Table 7. Policy recommendations based on our results and previous literature

Main findings in our study	Recommendations
Theme 1: Built environment matters	
• Living in areas with the characteristics of "high density areas", as opposed to "low density areas", is associated with public transport use for everyday mobility, in addition to other needs that require a more sporadic use of the public transport system. • Increasing distance between the residential and the work or study addresses increased the odds of using public transport	• Our results support "Transit oriented development", an urban planning development that promotes mixed land use and maximizes the amount of residential, business and leisure space within walking distance of public transport. For instance, other studies have observed that there is a higher propensity to use transit if trip origins and destinations are located within close proximity to transit (within 400 metres of a bus stop with frequent transit service or within 800 metres of a rapid transit station) (Translink, 2010). This requires the coordination of different areas, including transportation, urban planning, housing or land-use management (Agarwal et al., 2019; Translink, 2010) and a collaborative work of different administrations at city, metropolitan and regional level.
Theme 2: Who we are and what we do matters	
• Being female, highly educated or a student increased the odds of using public transport, with independent effects of each other	• Our results indicate that a good and affordable public transport helps reducing gender and social inequalities. Thus, interventions to ensure a reliable, safe and affordable public transport - the latter particularly for specific groups (e.g. students) - are needed.
• Having access to a car and/or a bike reduced the odds of using public transport. • There was an interaction between built environment characteristics and access to a car and/or a bike. For instance, car (or car and bike) owners preferred using the public transport if living and/or working/studying in "high density areas". • Having access to only a bike reduced the odds of using the public transport daily or almost daily, independently of the characteristics of the built environment.	• Our results indicate the need of densifying the nearby residential (and also the work/study) built environment, together with a reliable and affordable public transport service, and limiting motorized vehicles in specific areas of the cities. • The "competition" between the bike and public transport should not be considered a problem. Both should be supported when pursuing policies to increase the levels of physical activity among the general population, and reduce air pollution levels in the cities. Moreover, as pointed by Friman et al. biking cannot substitute public transport, as many commuters may not desire or cannot ride a bike (Friman et al., 2018). Indeed, our results suggest that certain profiles of bike owners might combine bike and public transport use.
Theme 3: Our attitudes and perceptions matter, too	
• Public transport users mainly value lower travel cost and short travel time for their daily or almost-daily mobility.	• Providing a fast and reliable service at reasonable (affordable) prices, together with highlighting the environmental and health benefits, should be the strategy to follow based on our results. The need to provide a good quality service and reasonable prices has been highlighted by previous studies (De Witte et al., 2013; Mugion et al., 2018; Taylor and Fink, 2013). A better service can be provided by adopting new

• Two profiles of people valued flexibility and predictability, one of the profiles also valued low exposure to air pollution and personal health benefits; this profile was associated with sporadic public transport use. However, the other profile, which did not care about low exposure to air pollution and personal health benefits, was associated with a decreased public transport use. • Valuing low exposure to air pollution and personal health benefits, as well as flexibility and predictability, was associated with more sporadic use.	technologies to increase the efficiency and effectiveness of transit operations (Taylor and Fink, 2013) and make traditional transit modes safer, more secure, and more efficient, convenient, and attractive (Agarwal et al., 2019). These improvements might help changing perceptions regarding public transport among certain sections of the population.

4.3 Theme 2: Who we are and what we do matters

We also observed that having access to a bike and/or a car reduced the odds of using public transport. Particularly for access to a car, our results are in line with results from previous studies, which found that household car ownership is a strong determinant for not using public transport (Boisjoly et al., 2018; De Witte et al., 2013, 2008; Kitamura, 1989). In addition, we observed that the patterns of the relationship between the built environment and the use of the public transport varied depending on whether the participant had access to a car and/or a bike. Interestingly, among those not having access to a car or a bike we only observed an association between "low density residential area" and public transport use (any frequency as compared to using the public transport "never or less than a month"), which probably is a reflection that these participants are forced to use public transport as they do not have access to a vehicle, and walking is not an option given the long distances or the characteristics of the built environment. However, in "high density areas" (residential and/or work/study), these subjects might choose to walk for their mobility needs rather than using the public transport (Marquet and Miralles-Guasch, 2015, 2014), which explains that we did not find an association between "high density areas" and public transport use within this group. Nevertheless, our results need to be considered with caution given the small percentage of participants without access to car or a bike (less than 7% of the total study population), which limits our statistical power, as our results show (Table 5). Secondly, having access to only a bike (16.3% of the total study population) reduced the odds of using the public transport daily or almost daily, independently of the characteristics of the built environment. This competition between bike and public transport was already reported by a previous study conducted in Barcelona (Braun et al., 2016). However, in our study bike ownership did not influence the use of the public transport system in relation to the characteristics of the work or study built environment. This might indicate that those with access to only a bike (and not a car) are subjects that choose to use the bike as their everyday mode of transport due to reasons (e.g. environmental concerns) other than the characteristics of the built environment or independently of the purpose (e.g. going to work, doing the groceries, etc). In fact, within this group 34.9% of the participants considered a low environmental impact as very important when choosing the mode of travel, in the other groups this percentage was lower [between 20.5% (access to only a car) and 28.8% (access to a car and a bike)]. Thus, within this group of people we observed substitution of public transport by bike for their daily mobility which, in terms of pursuing policies to increase the levels of physical activity among the general population and reduce air pollution in the cities, these findings are encouraging. In addition, in cities with crowded public transport systems, this might help to reduce the demand. Finally, despite that in the main models having access to a car – 13% of the total study population - (or to a car and a bike – 64.1%) reduced very significantly the odds of using public transport, once we stratified the analyses, we observed that car (or car and bike) owners preferred using the public transport if living and/or working/studying in "high density areas". However, among participants who only owned a car no associations were observed between "low density areas" (either residential or work/study addresses) and public transport use, while among those who owned a car and a bike we observed an association with a sporadic public transport use. Among car and bike owners we observed similar associations between "low density residential area and high density work/study area" and public transport use to those obtained before stratifying.

In terms of the profile of public transport users, our results are also in line with previous publications that indicate that women are more willing to adopt more sustainable transport means (e.g. public transport, walking or cycling) than men (European Institute for Gender Equality, 2017; Garcia-Sierra et al., 2018; Soria-Lara et al., 2017), although a study from 2015 conducted in Barcelona observed that women are less likely to use the bike for commuting (Cole-Hunter et al., 2015); this may explain the greater use in public transport as an alternative to bicycling. In addition, research shows that another reason for women to use public transport more often is that they have more diversified activities and less access to a car (European Institute for Gender Equality, 2017). In our study, being female is associated with a daily or almost daily use of the public transport system, but not with a sporadic use. Also, highly educated participants used public transport more often (all frequencies) compared to their peers with a lower education level, results that are in line with previous studies conducted in the European context (Garcia-Sierra et al., 2018; Limtanakool et al., 2006).

4.4 Theme 3: Our attitudes and perceptions matter, too

With regards to values and attitudes towards public transport use, we observed that public transport users mainly value lower travel cost and short travel time for their daily or almost-daily mobility, which is in accordance with results obtained by previous studies, despite using different study designs or approaches (e.g. qualitative interviews or ecological studies) (Agarwal et al., 2019; De Witte et al., 2013; Mugion et al., 2018; Taylor and Fink, 2013). In fact, perceptions and attitudes are among the factors less studied in the literature (De Witte et al., 2013). Interestingly, while we observed two profiles of people that valued flexibility and predictability, one of the profiles also valued low exposure to air pollution and personal health benefits; this profile was associated with sporadic public transport use. However, the other profile, which did not care about low exposure to air pollution and personal health benefits, was associated with a decreased public transport use. These results should be considered in terms of promoting public transport use: providing a fast and reliable service at reasonable (affordable) prices, together with highlighting the environmental and health benefits, should be the strategy to follow based on our results. Indeed, Mugion et al., observed through qualitative interviews that public transport service quality had a direct effect both on the intention to use public transport more often, and on the intention to use one's own car less and other sustainable means of transportation, such as car-sharing, more often (Mugion et al., 2018).

4.5 Strengths and limitations

One of the strengths of our study is having data from more than 9000 participants from seven European cities; moreover, we could include built environment information of the residence and the work/study addresses. However, there are some limitations that need to be considered. First, with the cross-sectional design of the study and the risk of self-selection (e.g. those who prefer using public transport decide to live in areas that facilitate its use) we cannot discard reverse causality. However, even if participants of the present study would have moved to areas with these desired characteristics so that they could easily use public transport, the results of the present study indicate that these built environment characteristics in a neighbourhood do in fact facilitate public transport use. Secondly, we could not include information on access to a motorbike in the models because this information was not collected. This variable might be relevant in cities where daily use of motorbike is common (e.g. Barcelona – 7.8% - or Rome – 11.8%, Table A). Thirdly, for the reasons explained in the methods, we used a buffer with a radius of 300m. However, in other countries, with different urban designs (e.g. Australia or the US), this distance might not be relevant or representative as it might be too small (James et al., 2014; Knuiman et al., 2014; Sugiyama et al., 2012). Nevertheless, in our study the characteristics of the built environment between buffers of 300m and 500m were highly correlated (correlations were above r=0.75). Fourth, and probably one of the most important limitations, compared to the cities census data, the composition of the PASTA sample is broadly representative in terms of gender distribution, but it includes younger and more highly educated participants than in the general population (Gaupp-Berghausen et al., 2019). Moreover, those participants excluded due to lack of information on their home address were less likely to be highly educated or full-time working, and more likely to have access to a bike but not to a car. It is unlikely that this has led to spurious associations, but it means that the non-highly educated population is under-represented in our sample. Fifth, unfortunately, we could not include information on public transport cost, service frequency, diversity (e.g. number bus stops, train stations, etc.), or other objective data, and this limits our analyses and interpretation of the results. In addition, we did not have information on whether participants lived or worked in areas with a restriction for motorized vehicles or if these working had workplace incentives for taking public transport. Sixth, creation of factors or principal components (PCs) facilitates the reduction of the number of variables included in a model and the creation of profiles. However, in terms of interpretation, a one-unit increase of a PC or factor might not be very informative. In this sense, what the analyses are reflecting is that for each unit increase of a specific PC or factor (so, the more adherent to a specific profile of commuter), the odds of using public transport with a specific frequency are increased or decreased by XX%. For example, for each unit increase of PC 1 [subjects that value safety (traffic and crime), low exposure to air pollution, privacy, health benefits, and low environmental impact], the odds of using public transport 1-3 days/week are reduced by 6% (Table 3). Finally, because the PASTA project focused on walking and cycling, information on attitudes about public transport was not collected. Indeed, the role of the public transport service quality through qualitative interviews (Mugion et al., 2018) would be interesting to collect in future studies.

Despite these limitations, the PASTA project is a unique opportunity to explore a number of correlates of public transport use in different urban and cultural contexts. Following the PASTA theoretical framework, the study considers individual characteristics, information on the values towards mobility options, and the characteristics of the built environment (Götschi et al., 2017). Moreover, to our knowledge, in terms of assessing the correlates of frequency of public transport use, this is the first study to incorporate not only the characteristics of the residential built environment but also those of the work/study built environment, which provides richer information about the built environment to which participants are exposed. It also incorporates the analysis of values and attitudes, often not considered in the existing literature (De Witte et al., 2013). A similar approach has been followed in previous studies using PASTA data (Cole-Hunter et al., 2015; Gascon et al., 2019). Finally, the PASTA project has follow-up data of a large part of the initial participants, so future studies can focus on longitudinal use of the public transport system and assess changes in modes of transport for travel.

5. Conclusions

The promotion of public transport use is among the key actions to overcome challenges related to road transport in the urban context. We show that key elements of strategies to promote public transport use should include the improvement of the nearby residential (and also the work/study) built environment, promotion of and planning for more densely populated urban areas, investment in and promotion of high quality, reliable and affordable public transport services, and the curtailment of private motorized vehicles in high density areas of the cities.

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Supplemental material

What explains public transport use? Evidence from seven European cities

Table A. Characteristics of the study population by city, for the whole study population (N=9952) and for those participants working or studying (N=8624)

	% missing (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)	Whole population (N=9952)	Workers or students (N=8624)
Age	0.03									
Mean (min, max)		42.2 (18.3, 91.4)	36.7 (18.0, 87.8)	40.0 (18.0, 84.3)	45.0 (18.8, 81.0)	39.6 (18.1, 78.7)	38.8 (18.0, 87.7)	39.6 (16.1, 82.2)	40.1 (16.1, 91.4)	38.5 (16.1, 77.9)
Gender (%)	0									
Male		48.0	40.8	41.1	36.6	61.4	46.3	43.0	46.0	46.2
Female		52.0	59.2	58.9	63.4	38.6	53.8	57.0	54.0	53.8
BMI (%)	15.4									
<18.5		2.0	4.2	4.9	1.3	3.1	4.1	4.9	3.5	3.5
18.5 - 24.9		67.2	70.8	58.6	55.3	67.0	67.1	68.0	65.4	66.6
25 - 29.9		25.3	20.9	19.6	32.8	25.1	23.0	21.5	24.0	23.0
≥30		5.5	4.1	16.9	10.6	4.9	5.8	5.7	7.2	6.9
High level of education[a] (%)	15.8									
No		16.3	19.5	15.3	32.5	34.6	34.8	37.7	27.3	26.3
Yes		83.7	80.5	84.7	67.5	65.4	65.2	62.3	72.7	73.7
Employment status (%)	2.6									
Full-time employed		69.0	61.4	62.6	65.2	68.4	46.6	49.6	60.7	66.6
Part-time employed		20.4	12.5	13.9	8.9	10.9	20.1	32.6	16.7	18.0
Student		2.3	17.9	12.0	11.5	16.7	22.2	13.0	13.9	15.4
Home duties/ unemployed/ retired/ sickness leave/ parental leave		8.3	8.3	11.5	14.4	4.0	11.1	4.8	8.7	NA
Household income (%)	32.6									
≤24999 €		16.6	39.3	16.9	22.3	76.0	41.7	9.5	31.0	29.5
25000-74999 €		76.5	55.0	51.9	67.9	21.0	53.3	45.1	53.6	54.8
75000 € or more		6.8	5.7	31.2	9.8	3.0	5.0	45.4	15.1	15.7
Health (%)	14.8									
Excellent		8.5	8.5	12.5	9.2	5.3	12.7	9.3	9.1	9.5
Very good		37.7	38.7	40.1	34.5	31.1	43.5	42.0	37.9	39.0
Good		42.1	39.1	33.1	41.0	46.0	34.7	39.9	39.8	39.5
Fair		10.4	11.7	11.9	13.6	15.9	8.5	8.4	11.6	10.9
Poor		1.3	2.0	2.4	1.8	1.8	0.7	0.6	1.5	1.1
Smoke (%)	14.5									
Yes		7.1	17.0	7.7	6.5	19.7	14.4	14.8	13.0	13.2
No, but used to smoke		27.4	24.7	28.2	29.2	24.5	27.0	25.8	26.5	25.3
No, never smoked		65.5	58.4	64.1	64.4	55.8	58.7	59.4	60.5	61.6

	% missing (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)	Whole population (N=9952)	Workers or students (N=8624)
Alcohol consumption (glasses per week) (%)	14.5									
0		19.7	28.8	28.5	30.0	25.8	26.6	23.0	26.0	24.9
≤7		53.7	60.8	49.6	62.8	62.5	59.6	64.3	59.2	60.4
≥8		26.5	10.5	21.9	7.2	11.8	13.8	12.8	14.8	14.7
Children 0-6 years at home (%)	18.8									
No		77.3	83.2	82.4	81.2	79.0	87.1	83.8	81.9	81.7
Yes		22.7	16.8	17.6	18.8	21.0	12.9	16.2	18.1	18.3
Children 7-17 years at home (%)	18.8									
No		71.7	81.8	80.2	75.6	75.0	83.3	81.4	78.3	77.3
Yes		28.3	18.2	19.8	24.4	25.0	16.7	18.6	21.7	22.7
Nº of adults (%)	19.5									
One		19.5	13.5	18.8	24.0	21.8	26.5	23.4	20.5	19.9
Two		60.7	51.2	53.3	65.0	43.6	53.2	57.4	54.3	54.8
Three		9.0	19.5	12.7	8.0	13.8	13.9	10.9	12.8	13.0
Four or more		10.7	15.8	15.2	3.0	20.8	6.4	8.4	12.1	12.3
Days of physical activity (at least 30 min)/week (%)	0									
0 days/week		4.2	5.2	7.3	4.4	10.4	8.1	2.3	6.2	6.1
1 day/week		4.7	6.6	5.3	7.3	9.2	14.8	8.7	8.1	8.3
2 or 3 days/week		23.4	30.8	28.5	30.4	40.5	42.1	40.9	34.0	34.2
4 or more days/week		67.7	57.5	59.0	57.9	39.9	35.1	48.1	51.7	51.2
Access to a car or van (%)	0									
Never		11.3	28.9	45.5	13.2	12.6	26.3	25.1	23.0	22.0
Sometimes		25.7	26.9	19.2	19.3	28.1	32.6	32.2	26.5	27.3
Always		63.0	44.2	35.3	67.5	59.3	41.2	42.8	50.5	50.7
Access to a bike (%)	0									
No		1.6	29.2	37.0	5.8	33.2	10.0	13.6	19.7	18.2
Yes		98.4	70.8	63.0	94.2	66.8	90.0	86.4	80.3	81.8
Access to a car and/or a bike (%)	0									
Never to car or bike		0.5	10.4	20.3	1.2	5.1	4.1	5.1	6.7	5.8
Only bike		10.8	18.6	25.2	12.1	7.5	22.2	20.0	16.3	16.1
Only car		1.1	18.8	16.7	4.7	28.1	6.0	8.5	13.0	12.4
Both car and bike		87.6	52.3	37.8	82.1	59.3	67.8	66.4	64.1	65.7

	% missing (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)	Whole population (N=9952)	Workers or students (N=8624)
How often you use…										
How often walk to get to and from places (%)	0.4									
Never		1.4	1.0	1.0	2.4	3.5	0.9	0.6	1.6	1.5
Less than once/month		5.3	1.0	1.3	4.1	3.8	0.6	1.3	2.5	2.7
1-3 days/month		13.2	2.5	3.7	6.6	7.8	2.5	3.2	5.7	6.3
1-3 day/week		28.4	10.5	12.2	21.2	14.8	8.7	10.5	15.0	15.7
Daily or almost daily		51.7	85.0	81.8	65.7	70.1	87.4	84.4	75.3	73.8
How often use (electric) bike to get to and from places (%)	0.6									
Never		1.6	36.9	39.2	7.6	33.4	15.6	18.2	22.8	21.5
Less than once/month		2.4	13.9	13.8	10.5	13.5	18.9	15.5	12.7	12.9
1-3 days/month		4.0	7.0	5.8	9.7	11.9	15.0	12.0	9.4	9.4
1-3 day/week		15.0	16.1	11.8	20.2	16.2	18.2	18.7	16.5	16.4
Daily or almost daily		77.0	26.1	29.4	52.0	25.0	32.4	36.0	38.6	39.8
How often use motorbike or moped to get to and from places (%)	0.5									
Never		96.0	80.1	96.6	94.4	71.8	91.9	88.9	87.6	87.2
Less than once/month		2.0	3.7	1.5	2.5	4.3	3.5	3.8	3.1	3.1
1-3 days/month		1.0	3.1	0.6	1.8	6.1	1.9	2.9	2.7	2.9
1-3 day/week		0.7	4.6	0.6	0.8	6.7	1.8	2.0	2.7	2.8
Daily or almost daily		0.2	7.8	0.8	0.5	11.2	0.9	2.5	3.9	4.1
How often use public transport to get to and from places (%)	0									
Never		6.2	0.6	1.0	17.8	3.1	0.6	0.4	3.9	3.8
Less than once/month		35.2	5.7	5.2	44.6	10.9	6.0	4.1	15.2	15.1
1-3 days/month		29.6	15.1	16.0	20.3	24.2	12.3	13.4	18.8	18.8
1-3 day/week		15.2	30.1	33.1	10.3	17.0	22.1	22.3	21.6	21.0
Daily or almost daily		13.9	48.6	44.8	7.1	44.8	59.0	59.8	40.5	41.3
How often use car or van to get to and from places (%)	0.5									
Never		6.5	17.1	20.8	6.7	9.6	17.1	16.5	13.5	12.8
Less than once/month		8.6	21.8	27.1	11.4	7.6	25.3	28.5	18.3	18.5
1-3 days/month		21.8	29.9	18.0	15.5	24.7	26.4	22.5	23.1	23.4
1-3 day/week		48.5	22.3	23.5	39.8	33.0	22.4	24.1	30.3	30.2

	% missing (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)	Whole population (N=9952)	Workers or students (N=8624)
Daily or almost daily		14.8	9.0	10.0	26.5	25.0	8.8	8.5	14.8	15.3
Importance of… [b]										
Short travel time (%)	0									
Not important		2.8	2.3	2.4	3.5	2.4	1.5	2.1	2.4	2.1
Less important		8.3	3.1	4.3	11.0	4.7	5.5	6.6	6.0	5.4
Neutral		10.7	7.6	10.0	15.2	5.4	11.8	10.8	9.9	9.0
Important		50.4	42.2	41.5	45.3	40.6	43.1	46.7	44.0	44.3
Very important		27.8	44.9	41.8	25.0	46.9	38.2	33.8	37.7	39.3
Lower travel cost (%)	0									
Not important		3.5	2.1	3.8	5.5	4.2	2.0	4.8	3.7	3.5
Less important		9.1	5.3	6.9	12.0	7.0	6.0	13.4	8.3	8.4
Neutral		21.4	12.9	11.4	22.3	15.6	15.4	23.4	17.2	17.4
Important		49.5	47.4	40.1	44.9	45.8	45.2	40.5	45.0	45.2
Very important		16.4	32.3	37.8	15.3	27.4	31.4	18.0	25.9	25.6
Higher travel comfort (%)	0									
Not important		4.9	3.7	5.2	6.6	5.9	3.4	3.8	4.8	4.7
Less important		27.1	12.3	18.1	24.9	18.1	17.5	19.8	19.3	19.7
Neutral		33.2	27.1	31.4	35.6	34.7	35.3	30.8	32.5	32.5
Important		30.5	43.0	35.0	26.1	32.6	34.7	37.2	34.4	34.3
Very important		4.4	13.9	10.4	6.7	8.8	9.1	8.4	9.0	8.8
Safer travel (traffic) (%)	0									
Not important		2.4	6.4	5.3	3.0	2.1	1.8	3.4	3.5	3.6
Less important		7.9	14.4	12.7	9.7	7.0	8.1	9.5	9.9	10.5
Neutral		18.9	29.2	24.5	20.9	17.6	21.6	23.8	22.3	23.0
Important		47.5	36.5	36.9	45.7	43.8	41.0	41.1	41.7	41.1
Very important		23.3	13.6	20.6	20.8	29.5	27.6	22.2	22.6	21.9
Safer travel (crime) (%)	0									
Not important		8.4	18.3	10.7	10.1	7.3	7.9	16.7	11.4	11.7
Less important		14.7	17.3	14.8	15.4	11.7	13.8	14.7	14.6	15.1
Neutral		32.0	29.7	26.3	26.4	23.9	25.1	25.1	26.9	27.3
Important		34.9	22.3	28.4	31.7	31.0	28.9	27.4	29.1	28.8
Very important		10.0	12.4	19.8	16.4	26.1	24.3	16.1	18.1	17.0
Lower exposure to air pollution (%)	0									
Not important		6.7	10.4	9.6	12.1	3.9	3.4	7.0	7.5	7.8
Less important		17.2	19.9	17.5	19.4	10.1	9.7	15.0	15.4	16.0
Neutral		28.5	31.4	30.9	31.2	25.1	22.4	26.6	27.9	28.4

	% missing (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)	Whole population (N=9952)	Workers or students (N=8624)
Important		32.6	26.4	27.7	27.6	36.2	41.7	33.3	32.3	31.9
Very important		15.0	12.0	14.3	9.8	24.7	22.8	18.1	17.0	15.9
Privacy (%)	0									
Not important		24.3	27.6	27.5	21.7	27.9	13.2	16.8	23.1	24.0
Less important		29.7	25.1	25.5	28.4	23.7	28.3	29.4	26.9	27.5
Neutral		29.8	32.2	31.7	34.5	32.7	35.8	32.1	32.7	32.4
Important		13.4	12.0	10.7	12.6	11.4	16.3	16.7	13.2	12.5
Very important		2.8	3.1	4.7	3.0	4.3	6.4	5.1	4.2	3.6
Personal health benefits (%)	0									
Not important		1.5	4.0	4.2	2.7	1.4	2.9	4.1	2.9	2.9
Less important		3.7	8.3	7.2	7.5	5.1	10.8	13.7	7.9	8.0
Neutral		14.9	23.2	20.8	24.2	16.4	27.4	30.2	22.1	22.4
Important		53.2	43.4	44.8	46.3	41.9	40.9	38.6	44.0	44.4
Very important		26.8	21.2	23.0	19.4	35.3	18.0	13.4	23.0	22.3
Low environmental impact (%)	0									
Not important		1.6	3.1	5.0	3.6	2.3	1.9	3.0	2.9	2.9
Less important		4.8	7.8	8.2	9.3	4.6	5.5	7.0	6.6	6.6
Neutral		15.8	22.1	24.2	23.8	14.8	17.2	23.8	20.0	20.4
Important		45.3	43.0	39.5	43.6	39.8	42.0	42.2	42.1	42.2
Very important		32.5	24.0	23.2	19.7	38.5	33.5	23.9	28.4	27.9
Flexible departure time (%)	0									
Not important		0.8	1.4	1.5	1.3	0.9	0.7	1.2	1.1	1.0
Less important		3.1	2.9	4.0	2.7	3.8	5.5	6.5	4.0	3.7
Neutral		7.3	11.0	13.8	10.3	13.3	13.1	15.4	12.1	11.6
Important		42.5	49.8	51.5	44.9	41.5	42.2	43.2	45.0	44.9
Very important		46.4	34.9	29.3	40.8	40.6	38.5	33.8	37.8	38.8
More predictable time and journey reliability (%)	0									
Not important		0.7	0.4	0.7	1.5	0.3	0.3	0.7	0.6	0.6
Less important		2.4	2.0	0.8	4.9	1.2	2.5	3.6	2.4	2.2
Neutral		7.7	10.4	6.9	13.7	5.5	9.1	14.6	9.5	9.2
Important		50.0	51.0	50.1	48.6	37.7	51.1	53.9	48.5	48.3
Very important		39.1	36.3	41.5	31.3	55.3	37.1	27.2	39.1	39.8

[a] No: no degree, primary school or secondary school, Yes: education above secondary school

[b] The question is "*How important are the following criteria for you when choosing a method of travel?*"

Table B. Description on how each built environment indicator was defined.

Indicator	Source
Street length density - length of streets **(m/km²)**	Navteq[a] street data (2012)
Connectivity - number of junctions with node degree >1 (in order to exclude the cul-de-sac) **(nº/km²)**	Navteq[a] street intersections data (2012)
Building area density (m²/km²)	OSM / local layers (2015-2017)[b]
Population density (inhabitants/km²)	Census / neighbourhood data (2011-2016)[c]
Facility density index - number of points of interest (POI) **(nº facilities/km²)**	Navteq[a] POI dataset (2012). For full list of POIs see https://tinyurl.com/PASTA-POI
Facility richness index - number of different facility types (POI) present, divided by the maximum potential number of facility types specified **(nº facility types/74)**	Navteq[a] POI data (2012). For full list of POIs see https://tinyurl.com/PASTA-POI
Density of public transport stations or stops (nº of public transport stations/km2)	OSM (and local data if available; 2015-2017)[d]
Distance to the 1st public transport station or stop (m)	OSM (and local data if available; 2015-2017)[d]
$PM_{2.5}$ (µg/m³)	$PM_{2.5}$ land use regression models incorporating satellite-derived and chemical transport modelling data (de Hoogh et al. 2016)[e]
NO_2 (µg/m³)	NO_2 land use regression models incorporating satellite-derived and chemical transport modelling data (de Hoogh et al. 2016)[e]
Surrounding greenness (NDVI)	Landsat Satellite Images (2015-16)[f]
Green and blue spaces indicators	Land-cover map Corine 2006 (available for the whole of Europe for both urban and rural areas)

OSM: Open Street Maps (https://www.openstreetmap.org/export)

[a]Navteq is licensed data under ArcGIS software. This data is prepared for routing analysis over Europe. It contains data on Streets and Points of Interest (POI) so it identifies a wide range of categories in which the different POI (e.g. schools, libraries, cinemas, banks, restaurants, etc) are included. Motorized vehicle related points (e.g. parking lots, petrol stations…). See the full list in this link: https://tinyurl.com/PASTA-POI.

[b]The source of information varied across cities: Antwerp: Local layer (2015) for city center and OSM (2016) for addresses outside the city, Barcelona: local layer (2013) and OSM (2017) for addresses outside the city, London: local layer (2016), Orebro, Rome, Vienna and Zurich: OSM (2017).

[c]The source of information varied across cities: Antwerp, Barcelona, London, Rome and Vienna: National Census (2011), Orebro: Local layer (2015) and Zurich Local and Regional layer (2016).

[d]The source of information varied across cities: Antwerp: OSM (2016), Barcelona: local layer (2011) and OSM (2017) for addresses outside the city, London: local layer (2011), Orebro: OSM (2017) but local layer (2015) for bus stations/stops, Rome: OSM (2017), Vienna: OSM (2017), and Zurich: OSM (2017).

[e]The NO_2 and $PM_{2.5}$ air pollution grids (100m resolution; annual means, µg/m3) used are from the European wide models for these pollutants, developed for 2010. Models are based on routine air pollution monitoring data (AIRBASE database) incorporating satellite-derived and chemical transport model estimates, and road and land use data. Both NO_2 and $PM_{2.5}$ models explained ~60% of spatial variation in measured NO_2 and $PM_{2.5}$ concentrations (de Hoogh et al. 2016)(de Hoogh et al. 2016). Website: http://www.sahsu.org/content/data-download

[f]We followed the PHENOTYPE project (Nieuwenhuijsen et al. 2014) protocol to select the images from LANDSAT within the greenest period and having the lowest cloud cover. Green season was considered from March to July 2015. However, if there was the need to get additional usable images, these were obtained from the following year, 2016. Different images were merged to cover all the study area, and if different images overlapped in the same area, we selected the one without clouds and having the highest pixel value. Following this process, we were able to completely cover the area of study.

Table C. Built environment characteristics of the residential address (300 m buffer) for the total population and by city (N=9952)

Mean (min, max) or %	% missing (N=9952)	Whole population (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)
Street length density (m/km^2)	0.1	18262 (536, 54584)	14963 (1241, 33107)	26406 (2877, 54584)	17529 (2163, 33707)	12466 (898, 25392)	17901 (1078, 35275)	17889 (536, 30534)	18541 (2416, 36954)
Connectivity (intersections/km^2)	0.3	166 (4, 1007)	123 (4, 501)	281 (7, 1007)	161 (7, 666)	79 (4, 292)	163 (4, 527)	139 (4, 413)	181 (4, 694)
Building area density (m^2/km^2)	3.3	269984 (13, 678837)	262825 (45, 659249)	442181 (16930, 678837)	240468 (30382, 614782)	132270 (13, 501850)	209903 (28, 611566)	342786 (1137, 616034)	199481 (257, 436123)
Population density (inhabitants/km^2)	3.7	13500 (2, 69643)	7126 (24, 25801)	33388 (5, 69643)	11025 (747, 23821)	3785 (2, 12175)	13205 (8, 47497)	14220 (232, 32538)	4742 (85, 14145)
Facilities density (nº facilities/km^2)	0	135 (0, 2470)	106 (0, 2470)	306 (0, 975)	129 (0, 2420)	20 (0, 359)	102 (0, 1954)	178 (0, 2442)	65 (0, 890)
Facilities richness (nº facilities types/nº facilities)	0	0.1 (0, 0.4)	0.1 (0, 0.4)	0.2 (0, 0.4)	0.1 (0, 0.5)	0 (0, 0.3)	0.1 (0, 0.4)	0.1 (0, 0.4)	0.1 (0, 0.4)
Density of public transport stations or stops (nº stations/km^2)	0.4	21.2 (0, 189)	16 (0, 188)	30 (0, 103)	21 (0, 71)	11 (0, 53)	28 (0, 89)	24 (0, 189)	14 (0, 75)
Distance to 1st public transport station or stop (m)	0.4	145 (0, 999)	182 (0, 988)	115 (0, 999)	145 (0, 927)	188 (0, 993)	111 (0, 956)	137 (0, 888)	163 (0, 988)
$PM_{2.5}$ (µg/m^3)	0	17 (1, 29)	20 (11, 23)	19 (13, 22)	15 (11, 18)	9 (5, 14)	17 (10, 29)	21 (13, 25)	16 (1, 19)
NO_2 (µg/m^3)	0	36 (3, 61)	40 (12, 61)	46 (17, 58)	42 (18, 58)	17 (3, 32)	33 (11, 49)	36 (13, 52)	31 (3, 52)
Surrounding greenness (NDVI)	0.2	0.4 (0, 0.9)	0.5 (0.2, 0.9)	0.2 (0.1, 0.7)	0.4 (0.1, 0.8)	0.6 (0.2, 0.9)	0.3 (0.1, 0.8)	0.4 (0, 0.8)	0.6 (0.2, 0.8)
Green spaces (GS)									
Distance to the closest major GS (m)	0	1182 (0, 14054)	1179 (0, 3976)	968 (0, 3291)	1037 (0, 4434)	818 (0, 3758)	2280 (0, 14054)	985 (0, 4718)	642 (0, 2486)
Area of the closest GS (km^2)	0	16 (0, 8325)	1.3 (0.3, 53.5)	2.7 (0, 126.5)	1.5 (0.3, 62.2)	106.0 (0.3, 8325)	3.7 (0.3, 2254)	6.6 (0.3, 161.2)	5.6 (0.1, 134.4)
Access to major GS within 300m (%)	0	16.2	10.1	15.6	19.6	31.7	9.7	11.9	20.8
Blue spaces (BS)									
Distance to the closest major BS (m)	0	3394 (6, 31354)	2799 (17, 13945)	3096 (14, 31354)	3093 (20, 19332)	3418 (22, 13048)	3539 (21, 24846)	4531 (6, 19985)	3369 (36, 22555)

Mean (min, max) or %	% missing (N=9952)	Whole population (N=9952)	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)
Area of the closest BS (km^2)	0	17940 (0.3, 152581)	99 (0.3, 267)	38660 (0.3, 51087)	80336 (0.3, 124977)	450 (0.3, 55654)	5004 (0.3, 152581)	212 (0.3, 256)	87 (0.3, 834)
Access to major BS within 300m (%)	0	3.4	2.4	2.8	5.6	1.1	4.5	2.7	4.6

NDVI: normalized difference vegetation index.

Table D. Description of the imputation procedure.

Software used and key setting: STATA 14.0 software (Stata Corporation, College Station, Texas) –*ice* command (with 20 cycles)

Number of imputed datasets created: 20
• **Variables included in the imputation procedure:**
▪ All variables listed in Table A.
▪ All variables listed in Table C (and the same variables for the work/study address were included) at buffers 100m, 300m, and 500m.
▪ Additionally:
  ▪ Health related information (e.g. suffering back pain, nauseas, etc) and other information about personal circumstances (e.g. “I have to travel all the time to meet my obligations”).
  ▪ Method of transport used to do specific activities (e.g. visiting friends or the groceries).
  ▪ Residential built environment: whether the participant lives in the main city of study, elevation, bike lanes information (e.g. density of bike lanes). The same variables for the work/study address were included (at 100m, 300m and 500m).
• **Treatment of binary/categorical variables:** logistic, ordinal, and multinomial models.

We analysed the datasets following the standard combination rules for multiple imputations, which consist of three phases: 1) imputation - creating multiply imputed data, 2) completed data analysis of multiply imputed data, and 3) pooling of individual analyses from phase 2 using Rubin’s combination rules (Rubin 1987).

Table E. Results of the factor analysis for the residential built environment characteristics (300 m buffer)[a]

Original variables	Factor 1[b]	Factor 2[b]
Street length density (m/km^2)	0.85	-0.27
Connectivity (nºintersections/km^2)	0.79	-0.40
Building area density (m^2/km^2)	0.84	0.15
Population density (inhabitants/km^2)	0.71	0.16
Facilities density (nº facilities/km^2)	0.62	-0.18
Facilities richness (nº facilities types/nº facilities)	0.83	-0.13
Density of public transport stations or stops (nº stations/km^2)	0.64	-0.03
Distance to 1st public transport station or stop (m)	-0.37	0.02
$PM_{2.5}$ (µg/m^3)	0.52	0.53
NO_2 (µg/m^3)	0.81	0.32
Surrounding greenness (NDVI)	-0.84	-0.06
Distance to the closest major GS (m)	0.13	0.18
Area of the closest GS (km^2)	-0.12	-0.11
Distance to the closest major BS (m)	-0.24	0.19
Area of the closest BS (km^2)	0.28	-0.11
% of the total variance explained by each factor (Eigenvalue)	75% (5.97)	10% (0.81)

Cronbach's alpha: 0.87
NDVI: normalized difference vegetation index.
[a]To conduct the factor analyses variables were not scaled.
[b]Factor 1 labelled "high density residential area", and Factor 2 labelled "low density residential area"

Table F. Associations between residential built environment characteristics (300 m buffer) and frequency of public transport use excluding each city one by one[a].

Factors for built environment[b] and categories of frequency of public transport use (category of reference is "Never or less than once a month")	All cities	City excluded						
	N=9952	Antwerp (N=1357)	Barcelona (N=1632)	London (N=1313)	Örebro (N=1219)	Rome (N=1775)	Vienna (N=1375)	Zurich (N=1281)
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
1) *High density residential area*								
On 1-3 days/month	1.46 (1.32, 1.61)	1.36 (1.22, 1.51)	1.49 (1.27, 1.56)	1.45 (1.32, 1.61)	1.63 (1.45, 1.82)	1.46 (1.31, 1.62)	1.46 (1.31, 1.61)	1.46 (1.32, 1.61)
On 1-3 days/week	1.74 (1.55, 1.95)	1.75 (1.57, 1.95)	1.61 (1.42, 1.82)	1.79 (1.59, 2.01)	1.86 (1.64, 2.11)	1.73 (1.53, 1.96)	1.76 (1.55, 1.99)	1.77 (1.59, 1.97)
Daily or almost daily	1.22 (1.12, 1.34)	1.29 (1.17, 1.41)	1.15 (1.03, 1.28)	1.23 (1.12, 1.36)	1.25 (1.12, 1.40)	1.32 (1.19, 1.45)	1.17 (1.07, 1.29)	1.30 (1.19, 1.41)
2) *Low density residential area*								
On 1-3 days/month	1.20 (1.06, 1.36)	1.13 (0.99, 1.28)	1.23 (1.07, 1.42)	1.18 (1.04, 1.35)	1.27 (1.10, 1.46)	1.18 (1.02, 1.36)	1.17 (1.03, 1.34)	1.23 (1.08, 1.39)
On 1-3 days/week	1.18 (1.03, 1.35)	1.17 (1.02, 1.34)	1.24 (1.05, 1.46)	1.15 (1.00, 1.33)	1.21 (1.05, 1.40)	1.20 (1.03, 1.40)	1.14 (0.99, 1.32)	1.20 (1.05, 1.37)
Daily or almost daily	1.06 (0.94, 1.19)	1.20 (1.08, 1.34)	1.05 (0.91, 1.21)	1.04 (0.92, 1.17)	1.05 (0.92, 1.19)	1.06 (0.92, 1.22)	1.01 (0.89, 1.14)	1.15 (1.02, 1.29)

[a]All variables except access to green and blue spaces, and surrounding greenness were scaled based on the mean and standard deviation (all cities together).
[b]*Variables (none scaled) included in the factor analysis:* Residential street length density, connectivity, built area density, population density, density and richness of facilities, public transport station or stop distance and density, $PM_{2.5}$, NO_2, surrounding greenness and area of and distance to the closest green and blue spaces. See Table E for further information on the factor analysis for the residential built environment characteristics.

Table G. Associations between importance of different aspects when travelling (*"How important are the following criteria for you when choosing a method of travel?"*) and frequency of public transport use (whole study population, N=9952). Category of reference is "Never or less than once a month" (N=1904, 19.1%).

Criteria[a]		1-3 days/month N=1874 (18.8%)		1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
	%	OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Short travel time							
Not important or less important	8.4	1		1		1	
Neutral	9.9	1.31 (0.96, 1.79)	0.09	1.40 (0.98, 2.00)	0.06	1.08 (0.75, 1.56)	0.68
Important	44.0	1.21 (0.95, 1.56)	0.13	1.25 (0.94, 1.66)	0.13	1.15 (0.86, 1.53)	0.34
Very important	37.7	0.99 (0.77, 1.28)	0.95	0.74 (0.55, 1.00)	0.04	0.81 (0.60, 1.08)	0.15
Lower travel cost							
Not important or less important	11.9	1		1		1	
Neutral	17.2	1.13 (0.89, 1.44)	0.33	1.44 (1.09, 1.91)	0.01	1.57 (1.19, 2.08)	0.001
Important	44.9	1.21 (0.98, 1.49)	0.07	1.43 (1.12, 1.82)	0.004	1.62 (1.27, 2.06)	<0.001
Very important	25.9	1.10 (0.87, 1.41)	0.42	1.31 (1.00, 1.73)	0.05	1.70 (1.30, 2.21)	<0.001
Higher travel comfort							
Not important or less important	24.1	1		1		1	
Neutral	32.5	1.24 (1.04, 1.49)	0.02	1.25 (1.02, 1.54)	0.03	1.41 (1.14, 1.73)	<0.001
Important	34.4	1.04 (0.86, 1.25)	0.70	1.03 (0.83, 1.26)	0.81	1.17 (0.95, 1.43)	0.14
Very important	9.0	0.50 (0.38, 0.65)	<0.001	0.41 (0.30, 0.55)	<0.001	0.50 (0.38, 0.66)	<0.001
Safer travel (with regard to traffic)							
Not important or less important	13.4	1		1		1	
Neutral	22.3	0.84 (0.66, 1.07)	0.17	1.04 (0.80, 1.36)	0.77	1.17 (0.89, 1.54)	0.27
Important	41.7	0.88 (0.71, 1.10)	0.27	1.04 (0.81, 1.33)	0.77	1.40 (1.09, 1.80)	0.009
Very important	22.6	0.72 (0.56, 0.92)	0.01	0.74 (0.56, 0.97)	0.03	1.25 (0.95, 1.64)	0.12
Safer travel (with regard to crime)							
Not important	11.4	1		1		1	
Less important	14.6	0.96 (0.73, 1.28)	0.79	1.03 (0.76, 1.40)	0.86	1.17 (0.85, 1.62)	0.34
Neutral	26.9	0.86 (0.67, 1.11)	0.24	0.86 (0.65, 1.13)	0.27	1.08 (0.81, 1.45)	0.58
Important	29.1	0.88 (0.69, 1.14)	0.34	0.74 (0.56, 0.98)	0.04	1.12 (0.84, 1.50)	0.43
Very important	18.1	0.57 (0.43, 0.76)	<0.001	0.50 (0.37, 0.68)	<0.001	0.74 (0.54, 1.00)	0.05
Lower exposure to air pollution							
Not important or less important	22.8	1		1		1	
Neutral	27.9	1.21 (1.00, 1.47)	0.05	1.20 (0.97, 1.49)	0.10	1.34 (1.08, 1.66)	0.01
Important	32.3	1.20 (0.99, 1.45)	0.07	1.25 (1.01, 1.55)	0.04	1.57 (1.27, 1.94)	<0.001
Very important	17.0	1.01 (0.80, 1.28)	0.93	1.03 (0.80, 1.34)	0.80	1.46 (1.14, 1.87)	0.003
Privacy							
Not important	23.1	1		1		1	
Less important	26.9	1.13 (0.93, 1.39)	0.22	1.04 (0.84, 1.31)	0.70	1.20 (0.96, 1.50)	0.10
Neutral	32.7	1.04 (0.86, 1.27)	0.67	0.92 (0.75, 1.15)	0.48	0.99 (0.80, 1.22)	0.90
Important	13.2	0.95 (0.75, 1.20)	0.66	0.70 (0.53, 0.91)	0.01	0.63 (0.48, 0.82)	0.001

Criteria[a]	%	1-3 days/month N=1874 (18.8%)		1-3 days/week N=2147 (21.6%)		Daily or almost daily N=4027 (40.5%)	
		OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Very important	4.2	0.41 (0.29, 0.58)	<0.001	0.18 (0.12, 0.27)	<0.001	0.25 (0.18, 0.36)	<0.001
Personal health benefits							
Not important or less important	10.8	1		1		1	
Neutral	22.1	1.19 (0.89, 1.60)	0.24	1.36 (0.98, 1.87)	0.06	1.14 (0.85, 1.52)	0.39
Important	44.0	1.39 (1.06, 1.82)	0.02	1.70 (1.27, 2.28)	0.001	1.03 (0.79, 1.35)	0.83
Very important	23.0	1.21 (0.91, 1.61)	0.18	1.12 (0.82, 1.53)	0.49	0.70 (0.53, 0.94)	0.02
Low environmental impact							
Not important or less important	9.5	1		1		1	
Neutral	20.0	1.42 (1.08, 1.88)	0.01	1.36 (1.01, 1.84)	0.04	1.35 (1.02, 1.79)	0.04
Important	42.1	1.98 (1.53, 2.56)	<0.001	2.22 (1.68, 2.92)	<0.001	2.12 (1.63, 2.75)	<0.001
Very important	28.4	2.17 (1.66, 2.84)	<0.001	2.11 (1.57, 2.82)	<0.001	1.89 (1.44, 2.49)	<0.001
Flexible departure time							
Not important, less important or neutral	17.2	1		1		1	
Important	45.0	1.16 (0.92, 1.46)	0.22	1.01 (0.79, 1.29)	0.96	0.71 (0.56, 0.90)	0.005
Very important	37.8	0.85 (0.67, 1.07)	0.16	0.46 (0.36, 0.59)	<0.001	0.24 (0.19, 0.31)	<0.001
More predictable time and journey reliability							
Not important, less important or neutral	12.5	1		1		1	
Important	48.5	1.44 (1.15, 1.79)	0.001	1.55 (1.21, 1.98)	0.001	1.58 (1.24, 2.02)	<0.001
Very important	39.1	1.09 (0.87, 1.37)	0.45	0.70 (0.69, 1.17)	0.46	0.92 (0.72, 1.18)	0.52

[a]Each type of determinant was included separately in the base model.

Table H. Results of the principal component analysis (PCA) for the "importance of (criteria)" (*"How important are the following criteria for you when choosing a method of travel?"*)

Original variables	PC 1[a]	PC 2[a]	PC 3[a]	PC 4[a]
Short travel time	0.05	0.52	0.13	0.38
Lower travel cost	0.19	0.17	0.23	0.71
Higher travel comfort	0.21	0.31	-0.39	-0.09
Safer travel with regard to traffic	0.41	-0.05	-0.27	0.11
Safer travel with regard to crime	0.40	0.00	-0.35	0.11
Lower exposure to air pollution	0.44	-0.24	0.05	0.07
Privacy	0.31	0.09	-0.34	-0.22
Personal health benefits	0.35	-0.22	0.34	-0.17
Low environmental impact	0.34	-0.29	0.44	-0.02
Flexible departure time	0.16	0.42	0.32	-0.44
More predictable time and journey reliability	0.18	0.48	0.24	-0.22
% of the total variance explained by each PC (Eigenvalue)	26% (2.91)	15% (1.70)	12% (1.32)	9% (1.03)

Cronbach's alpha: 0.69

PC: principal component

[a]PC1 labelled "Safe, healthy, sustainable and private travel", PC2 labelled "Short, flexible and predictable travel, do not care about health or environment", PC3 labelled "Flexible and predictable travel. Health and environment are relevant, but not comfort or safety", and PC4 labelled "Cheap and short travel.

Table I. Associations between built environment characteristics at work or study address (300 m buffer) and frequency of public transport use (N=8624). Category of reference is "Never or less than once a month" (N=1634, 19.0%).

	Exposure contrast[a]	1-3 days/month N=1623 (18.8%)		1-3 days/week N=1808 (21.0%)		Daily or almost daily N=3559 (41.3%)	
		OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Built environment correlates (300 m buffer)[b]							
Street length density (m/km²)[c]	7912	1.10 (1.01, 1.20)	0.04	1.15 (1.04, 1.26)	0.01	1.35 (1.24, 1.48)	<0.001
Street connectivity (intersections/km²)[c]	134	1.03 (0.93, 1.13)	0.58	1.07 (0.97, 1.18)	0.19	1.33 (1.21, 1.46)	<0.001
Building area density (m²/km²)[c]	150681	1.05 (0.97, 1.14)	0.20	1.16 (1.06, 1.27)	0.001	1.25 (1.15, 1.35)	<0.001
Population density (inhabitants/km²)[c]	8796	1.07 (0.98, 1.18)	0.19	1.11 (1.01, 1.23)	0.04	1.09 (0.99, 1.21)	0.08
Facilities[d] density (nº facilities/km²)[c]	353	0.95 (0.87, 1.03)	0.21	1.06 (0.97, 1.16)	0.17	1.16 (1.07, 1.26)	<0.001
Facilities[d] richness (nº facilities types/nº facilities/km²)[c]	0.11	1.09 (1.00, 1.19)	0.06	1.20 (1.09, 1.31)	<0.001	1.34 (1.22, 1.46)	<0.001
Density of public transport stations or stops (nºstations/km²)[c]	19.0	1.08 (0.99, 1.18)	0.08	1.24 (1.13, 1.35)	<0.001	1.29 (1.18, 1.41)	<0.001
Distance to the 1st public transport station or stop (m)	104	0.97 (0.91, 1.04)	0.40	0.87 (0.80, 0.95)	0.001	0.93 (0.86, 1.00)	0.07
$PM_{2.5}$ (µg/m³)	3.5	1.41 (1.18, 1.70)	<0.001	1.76 (1.33, 2.31)	<0.001	2.36 (1.79, 3.11)	<0.001
NO_2 (µg/m³)	10.4	1.27 (1.13, 1.43)	<0.001	1.31 (1.16, 1.47)	<0.001	1.45 (1.28, 1.66)	<0.001
Surrounding greenness (NDVI)	0.19	1.00 (0.89, 1.12)	0.94	0.85 (0.75, 0.97)	0.02	0.67 (0.59, 0.76)	<0.001
Distance to the closest major GS (m)	1061	1.00 (0.92, 1.08)	0.95	1.02 (0.93, 1.11)	0.71	0.99 (0.91, 1.07)	0.83
Area of the closest GS (km²)	131	1.01 (0.95, 1.07)	0.69	0.93 (0.72, 1.21)	0.58	1.08 (1.03, 1.13)	0.001
Access to major GS (within 300m)	Yes	Model does not converge					
Distance to the closest major BS (m)	2175	0.99 (0.91, 1.07)	0.73	1.02 (0.94, 1.11)	0.61	0.96 (0.89, 1.05)	0.39
Area of the closest BS (km²)	41207	1.00 (0.86, 1.17)	0.95	1.09 (0.97, 1.22)	0.13	1.03 (0.90, 1.17)	0.70
Access to major BS (within 300m)	Yes	Model does not converge					
Factors for built environment correlates obtained through factor analysis at work or study address [e]							
1) *High density WOS area*: high street length density and connectivity, population density, density and richness of facilities, density of public transport stations/stops and high air pollution but low surrounding greenness		1.14 (1.04, 1.25)	0.006	1.29 (1.16, 1.44)	<0.001	1.46 (1.32, 1.62)	<0.001
2) *Low density WOS area*: low street length density and connectivity and low density of public transport stations/stops, moderate air pollution		1.35 (1.19, 1.54)	<0.001	1.36 (1.14, 1.63)	0.001	1.11 (0.93, 1.32)	0.32

IQR=interquartile range; WOS=work or study

GS: green spaces, BS: blue spaces; NDVI: normalized difference vegetation index.
[a]All variables were scaled based on the mean and standard deviation (SD) (all cities together) and therefore the unit of contrast is the SD, with the exception of access to green and blue spaces (binary variables) and surrounding greenness (we used the interquartile range - IQR).
[b]Variables were included one by one in the base model. All variables except access to green and blue spaces, and surrounding greenness were scaled based on the mean and standard deviation (all cities together).
[c]Streets length, connectivity, building area, population, facilities, and public transport stations/stops are expressed per km^2 (density). However, in terms of interpretation, the reader might desire to use the indicators per area of the buffer (area of a 300m buffer=0.2809 km^2). In this case the SD of each of these variables has to be multiplied by 0.2809 [e.g. if SD of street length density is 7912 m/km^2, then the new value for area of the buffer is 2222 m].
[d]Definition of "facilities": private and public points of interest including shops, schools, theatres and leisure activities, supermarkets, administration offices, banks, hospitals...motorized vehicle related points were excluded (e.g. parking lots, petrol stations…).
[e]*Variables (none scaled) included in the factor analysis:* Residential street length density, connectivity, built area density, population density, density and richness of facilities, public transport station/stop distance and density, $PM_{2.5}$, NO_2, surrounding greenness and area of and distance to the closest green and blue spaces. See Table E for further information on the factor analysis for the residential built environment characteristics.

Table J. Results of the factor analysis for the work/study built environment characteristics (Factors A1 and A2) (N=8624)[a].

	Factors for the work/study address characteristics	
	Factor A1[b]	**Factor A2[b]**
Street length density (m/km^2)	0.84	-0.15
Connectivity (nºintersections/km^2)	0.80	-0.27
Building area density (m^2/km^2)	0.78	0.10
Population density (inhabitants/km^2)	0.49	0.26
Facilities density (nº facilities/km^2)	0.66	-0.14
Facilities richness (nº facilities types/nº facilities)	0.84	-0.11
Density of public transport stations or stops (nº stations/km^2)	0.54	-0.01
Distance to 1st public transport station or stop (m)	-0.29	0.00
PM2.5 (µg/m^3)	0.41	0.72
NO2 (µg/m^3)	0.77	0.36
Surrounding greenness (NDVI)	-0.77	0.09
Distance to the closest major GS (m)	0.22	-0.13
Area of the closest GS (km^2)	-0.08	-0.07
Distance to the closest major BS (m)	-0.28	0.15
Area of the closest BS (km^2)	0.41	-0.24
% of the total variance explained by each factor (Eigenvalue)	**68% (5.38)**	**12% (0.97)**

[a]Variables were not scaled to conduct the factor analyses
NDVI: normalized difference vegetation index.
[b]Factor A1 labelled "High density work/study area" and Factor A2 labelled "Low density work/study area".

Table K. Results of the factor analysis for the residential and work/study built environment characteristics together (Factors B1 and B2) (N=8624)[a].

	Factors for the residential and the work/study address characteristics	
	Factor B1[b]	Factor B2[b]
Residential built environment characteristics (300 m buffer)		
Street length density (m/km^2)	0.71	-0.44
Connectivity (nºintersections/km^2)	0.66	-0.38
Building area density (m^2/km^2)	0.72	-0.45
Population density (inhabitants/km^2)	0.63	-0.35
Facilities density (nº facilities/km^2)	0.55	-0.29
Facilities richness (nº facilities types/nº facilities)	0.71	-0.39
Density of public transport stations or stops (nº stations/km^2)	0.53	-0.34
Distance to 1st public transport station or stop (m)	-0.30	0.20
PM2.5 (µg/m^3)	0.56	-0.22
NO2 (µg/m^3)	0.81	-0.26
Surrounding greenness (NDVI)	-0.73	0.39
Distance to the closest major GS (m)	0.10	-0.07
Area of the closest GS (km^2)	-0.12	0.03
Distance to the closest major BS (m)	-0.17	0.13
Area of the closest BS (km^2)	0.35	0.07
Work/study built environment characteristics (300 m buffer		
Street length density (m/km^2)	0.66	0.50
Connectivity (nºintersections/km^2)	0.61	0.52
Building area density (m^2/km^2)	0.60	0.50
Population density (inhabitants/km^2)	0.50	0.13
Facilities density (nº facilities/km^2)	0.48	0.48
Facilities richness (nº facilities types/nº facilities)	0.60	0.62
Density of public transport stations or stops (nº stations/km^2)	0.44	0.30
Distance to 1st public transport station or stop (m)	-0.22	-0.18
PM2.5 (µg/m^3)	0.54	-0.07
NO2 (µg/m^3)	0.76	0.28
Surrounding greenness (NDVI)	-0.64	-0.44
Distance to the closest major GS (m)	0.12	0.23
Area of the closest GS (km^2)	-0.08	-0.02
Distance to the closest major BS (m)	-0.17	-0.24
Area of the closest BS (km^2)	0.38	0.25
% of the total variance explained by each factor (Eigenvalue)	**48% (8.44)**	**19% (3.32)**

[a]Variables were not scaled to conduct the factor analyses
NDVI: normalized difference vegetation index.
[b]Factor B1 labelled "High density residential and work/study areas", and Factor B2 labelled "Low density residential, but high work/study areas".

Table L. Associations between the different correlates, including the WOS built environment characteristics, and frequency of public transport use (working/studying population, N=8624) for the full model (all variables included). Category of reference is "Never or less than once a month" (N=1634, 19.0%).

Population characteristics, and factor or principal component[a]	1-3 days/month N=1623 (18.8%)		1-3 days/week N=1808 (21.0%)		Daily or almost daily N=3559 (41.3%)	
	OR (95%CI)	p-val	OR (95%CI)	p-val	OR (95%CI)	p-val
Age	0.99 (0.98, 1.00)	0.06	0.98 (0.97, 0.99)	<0.001	0.98 (0.98, 0.99)	<0.001
Gender (female)	1.02 (0.87, 1.20)	0.79	1.09 (0.91, 1.31)	0.35	1.35 (1.14, 1.61)	0.001
High level of education (yes)[a]	1.25 (1.03, 1.51)	0.03	1.45 (1.15, 1.84)	0.002	1.36 (1.10, 1.68)	0.004
Employment status (full-time worker is reference)						
Part-time worker	1.04 (0.84, 1.29)	0.69	1.21 (0.96, 1.53)	0.11	0.85 (0.68, 1.07)	0.18
Student	1.74 (1.26, 2.42)	0.001	2.22 (1.55, 3.17)	<0.001	1.91 (1.38, 2.66)	<0.001
Access to a car and/or bike						
Only bike	1.57 (0.60, 4.11)	0.36	0.65 (0.26, 1.60)	0.35	0.19 (0.08, 0.43)	<0.001
Only car	0.69 (0.26, 1.80)	0.45	0.25 (0.10, 0.63)	0.003	0.12 (0.05, 0.26)	<0.001
Both car and bike	0.76 (0.30, 1.94)	0.56	0.28 (0.12, 0.66)	0.004	0.06 (0.03, 0.14)	<0.001
Factors of the WOS built environment characteristics (300 m buffer)						
High density WOS area[b]	1.12 (1.02, 1.23)	0.02	1.28 (1.15, 1.43)	<0.001	1.49 (1.35, 1.66)	<0.001
Low density WOS area[c]	1.34 (1.18, 1.53)	<0.001	1.34 (1.12, 1.61)	0.001	1.08 (0.91, 1.29)	0.36
PCs of importance of criteria						
Safe, healthy, sustainable and private travel	0.96 (0.95, 1.04)	0.86	0.94 (0.89, 0.99)	0.02	0.97 (0.93, 1.03)	0.33
Short, flexible and predictable travel, do not care about health or environment	0.89 (0.84, 0.95)	<0.001	0.80 (0.74. 0.86)	<0.001	0.79 (0.74, 0.85)	<0.001
Flexible and predictable travel. Health and environment are relevant, but not comfort or safety	1.20 (1.12, 1.28)	<0.001	1.17 (1.08, 1.27)	<0.001	1.02 (0.94, 1.10)	0.66
Cheap and short travel	1.02 (0.95, 1.10)	0.59	1.17 (1.07, 1.28)	0.001	1.54 (1.41, 1.67)	<0.001

WOS=work or study

[a]No: no degree, primary school or secondary school, Yes: education above secondary school

[b]High street length density and connectivity, population density, density and richness of facilities, high air pollutants but low surrounding greenness (see Table I).

[c]Low street length density and connectivity, moderate population density, and low density and richness of facilities and high air pollutants (see Table I).

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