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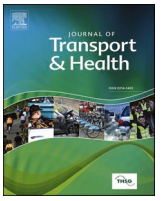

Association between local amenities, travel behaviours and urban planning: A spatial analysis of a nationwide UK household panel study.

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ABSTRACT

Introduction: Globally, there has been a recent resurgence in planning policies focused on local living (such as the 20-min neighbourhood) with proposed benefits of creating sustainable and healthy places. The policies aim to provide improved spatial access to local amenities within short walkable distances of home to encourage walking and cycling and discourage car use, however these pathways have not been examined. This study aimed to quantify the density and diversity of local amenities and their association with daily/weekly travel behaviours.

Methods: We used data from Understanding Society, a national panel survey of UK adults. Spatial data were used to quantify the number and diversity of amenities that have previously been associated with active travel and focused on in 20-min neighbourhood policies within small geographical areas across the UK. These were linked to individual-level data describing daily and weekly travel behaviour for: walking (at least 10-min), cycling, car and bus use. Logistic regression models measured the association between individual amenities, their diversity and daily/weekly travel, whilst controlling for individual factors such as age, sex and employment, residing in a retail centre, as well as area-level urbanicity and deprivation.

Results: Our analysis revealed variations in active travel and car usage patterns by sex, employment status, urbanicity, and area-level deprivation. Local amenities were associated with daily travel behaviours with more amenities generally associated with more frequent walking and less regular bus and car travel. Furthermore, increased amenity diversity was associated with reduced daily car use (OR: 0.77, $p < 0.001$). Similar patterns were apparent for weekly travel outcomes.

Conclusions: Both access to specific local amenities as well as their diversity are both important neighbourhood factors for achieving shifts from motorised to active transport modes. Policy makers and planners need to ensure the diversity of local amenities are included in local living policies.

1. Introduction

There is a growing emphasis on urban planning strategies that seek to ensure residents have access to a variety of essential amenities to meet their daily needs within walkable distances from their homes (Gower and Grodach, 2022; Thornton et al., 2022).

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This approach is well established and originates from the concept of compact and liveable cities (Büttner et al., 2022), which promote local areas designed for walkability and reduced reliance on private car transportation. Although the names and specific details of these policies may vary from country to country and city to city—such as liveable communities, 20-min neighbourhoods, 15-min cities, superblocks, and people-centred planning—they predominantly revolve around creating local living environments and fostering liveable neighbourhoods (Büttner et al., 2022). *Liveable neighbourhood* policies aim to tackle high car dependency by creating areas with a range of amenities within short distances that encourage people to travel actively (by walking or cycling) (Jones, 2001). These policies offer a range of anticipated advantages, including environmental, sustainability and health benefits achieved by curbing emissions from motorised transportation through a reduction in daily trips (O' Gorman and Dillon-Robinson, 2021), as well as reducing subsequent air pollution exposure. They may also improve residents' health outcomes by encouraging an increase in physical activity through more daily walking or cycling trips (Chau et al., 2022).

In a comprehensive analysis of various studies on the determinants of low-carbon transport mode adoption, Javaid et al. (2020) highlighted the significance of infrastructure-level factors in predicting the choice of sustainable travel modes. Specifically, factors such as amenity diversity, neighbourhood design, public transport proximity and availability played vital roles in influencing low-carbon travel mode preferences (Javaid et al., 2020). Cervero and Kockelman (1997) emphasised the essential elements of density, diversity, and design as crucial factors in attaining sustainable transportation objectives, including the reduction of motorised trips, promotion of active travel, and the decrease of overall travel distances (Cervero and Kockelman, 1997). Specific aspects of the environment were identified as important in achieving these goals, including urban density, destination accessibility, green areas and proximity to public transport (Haybatollahi et al., 2015; Wali et al., 2021). Evidence from North America highlighted that travel behaviours are largely explained by attitudes, however changes to the built environment can change travel behaviour (Handy et al., 2005). Aspects of urban form have been shown to be important for encouraging walking to a local destination, including the distance from home to the destination and quality of the local environment (Handy, 1996). Næss (2012) emphasised that travel behaviours are not solely influenced by the proximity to urban centres but also by the closeness of residents' homes to concentrations of facilities, often found within inner city areas. Variances in this proximity to facilities can result in longer travel distances, with a higher likelihood of being covered by car journeys (Næss, 2006). More recently, research conducted in Sweden has provided evidence indicating that a higher total number of local amenities correlates with an increase in walking and cycling trips, and a simultaneous decrease in both the distance travelled by car and the number of daily car trips (Elldér et al., 2022). Similarly, a review of built environmental characteristics and their association with active transportation found that shorter distances from home to grocery stores and post offices facilitated travel there by active modes (Salvo et al., 2018). A survey of three cities in the United Kingdom found that walking for transport was associated with availability of local amenities '*to walk or cycle to*', however this relationship did not hold for leisure trips or cycling (Adams et al., 2013).

Local living policies may be particularly useful for addressing health inequalities between the most deprived and least deprived neighbourhoods (O' Gorman and Dillon-Robinson, 2021). Research conducted in Scotland revealed that the presence of amenities within a 10-min walking distance from residential addresses was greater in the most deprived neighbourhoods compared to the least deprived ones (Olsen et al., 2022). Furthermore, certain factors are strong predictors of travel mode choice, for example, living in the most deprived areas, as well as younger age groups, exhibit a higher likelihood of actively traveling for both leisure and utilitarian purposes compared to their counterparts in the least deprived areas (Olsen et al., 2017). However, evidence from Colombia has demonstrated a more nuanced relationship between the presence of amenities within a 1 km (km) radius of residential areas and the inclination to engage in walking and reduce reliance on driving; increased number of local amenities were associated with increased levels of walking among higher socio-economic status but not among more deprived populations (Heroy et al., 2022). Urbanicity is an additional crucial factor that impacts both the accessibility to local amenities and the potential for local active travel. It has been observed that outside urban areas, the availability of local amenities within walking distances from homes is often limited (Larsson et al., 2022; Olsen et al., 2022).

Research indicates that having access to, as well as a range of diverse amenities within short walking distances from one's residence may be linked to a decrease in car usage and an increase in active travel (Elldér et al., 2022; Heroy et al., 2022). However, there is an evidence gap establishing whether access to specific local amenities (including type, number, and amenity diversity) is associated with increased sustainable and active travel and reduced personal car travel. Furthermore, it remains unclear how these relationships may differ based on area-level socioeconomic indicators and individual-level factors such as age, sex, employment status, and deprivation, which are also predictors of travel mode choice (Ababio-Donkor et al., 2020; Buehler et al., 2017; Le and Teng, 2023). We use data from a large representative UK household survey linked to spatial data to achieve the following research objectives:

a) Within small geographical areas across the UK, define, geocode and quantify local amenities that may be associated with travel mode choice and/or local living policies.
b) Describe travel behaviours in terms of daily and weekly reported walking, cycling, using public transport, and car usage during the past year by sociodemographic factors.
c) Explore whether the number, type and diversity of local amenities are associated with individuals' daily and weekly travel behaviours.

2. Methods

2.1. Sample

Analyses are based on data from Understanding Society, the UK Household Longitudinal Study (UKHLS), details of which have been reported previously (Buck and McFall 2011). The UKHLS began in 2009 and is a longitudinal panel survey of, initially, ~40,000 households in England, Scotland, Wales and Northern Ireland with data currently available from twelve subsequent collection waves (Lynn, 2009). The current analyses are based on respondents (adults aged 16+) who gave a full interview at waves 9 and 10 of data collection (2017–2019) with their interview data linked to Lower Layer Super Output Area (LSOA) or data zone level data on local amenities (University of Essex, 2022). LSOA's are small geographical spatial areas comprising between 400 and 1200 households and have a usually resident population between 1000 and 3000 persons (Office for National Statistics, 2021) and data zones are the Scottish equivalent (Scottish Government, 2006). Waves 11 and 12 were excluded from the analysis due to these data being collected during the COVID-19 pandemic *'stay at home'* guidance that would have influenced transportation use and active travel.

2.2. Defining local amenity attributes

To measure availability of local amenities, we included 10 categories of amenities that have been identified as destinations for daily utilitarian or leisure travel using sustainable travel modes. These were: public transportation stops, supermarkets, financial establishments, pharmacies, primary care centres, schools, greenspaces, recreational facilities, eating establishments, and social and cultural locations. These were chosen based on recent studies highlighting their association with travel mode choice (Adams et al., 2013; Elldér et al., 2022; Salvo et al., 2018), inclusion in place-making tools focused on creating liveable neighbourhoods (Hasler, 2018), and in key place-based policies focused on providing access to key facilities and amenities locally for day-to-day needs, such as the 20-min neighbourhood (O' Gorman and Dillon-Robinson, 2021; Olsen et al., 2022; Thornton et al., 2022). Choice was also influenced by the availability of high quality national spatial data describing these amenities across all areas of the United Kingdom. The local amenities, definitions and sources are shown in Table 1.

2.3. Spatial data linkage

Spatial data were obtained for the local amenities (Table 1) for the period 2018 to correspond with the wave 9/10 survey data collection (2017–2019). All data were geocoded and mapped within GIS software ArcPro v2.9.5. Special licence data were approved by Understanding Society to provide data aggregated by Lower Layer Super Output Areas (LSOAs) in England and Wales and data zones in Scotland (University of Essex, 2022). For all point data (i.e., location of a public transport stop) the amenity count within each LSOA was calculated.

2.4. Outcomes: travel behaviours

The outcome variables were based on frequency of travel mode used within the local neighbourhoods: from wave 9, how many days in the past week did you walk more than 10 min (responses: 0 days–7 days); and from wave 10, frequency of travel by car, bus and bike

Table 1
Local area amenities, description, measure and source.

Amenity	Description	Measure	Source
Public Transport	Public transport stop location for bus, train, tram and underground.	Count of public transport stops points within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
Supermarket	Large or medium size supermarket	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
Finance	Financial (cash machine, bank & post office)	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
Pharmacy	Pharmacy	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a)
Primary Care	General Practitioner surgery or walk-in-centre	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
School	Primary aged (5–11) & secondary aged 11 to 18) schools.	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
Greenspace	Number of Greenspace Access points (Public Park or Garden access points, playing field access points, Play space access points.)	Count of greenspace access points within LSOA	Open Greenspace (October 2018) Ordnance Survey (2021b).
Recreational amenities	Sports and recreational facilities (including pitches, swimming pools, courts, etc)	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
Eating establishments.	Restaurants and cafes	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).
Social and cultural locations	Social and cultural locations (Gallery; Historic buildings; Museum; Theatre; Cinema; Social clubs).	Count within LSOA	Points of Interest (June 2018) (Ordnance Survey, 2021a).

(responses: At least once a day; Less than once a day but at least 3 times a week; Once or twice a week; Less than that but more than twice a month; Once or twice a month; Less than that but more than twice a year; Once or twice a year; Less than that or never). Responses were dichotomised into two outcomes (1) "Daily", (response "7 days" or "At least daily") and (2) "Weekly", (Reponses "1 day to 7 days"" or "At least once a day"; "Less than once a day but at least 3 times a week"; "Once or twice a week"). The outcome variables of the study were therefore *daily* and *weekly*: (i) *walking*, (ii) *car travel*, (iii) *travel by bus*, and (iv) *travel by bike*.

2.5. Independent variables: amenities, amenity diversity, individual and area-level

The main independent variables of interest were number of amenities and the diversity of the amenities within the LSOA of the respondent. Seven of the ten amenity counts were treated as continuous variables (public transport, finance, pharmacy, greenspaces, recreational amenities, eating establishments and social and cultural locations). Counts of the remaining three (large supermarkets, schools, primary care) were sparse (fewer than 10 per LSOA/data zone), over half contained zero values and were therefore modelled as binary (present or absent). Whilst these variables could have remined categorical, with each number being a level, this would use up degrees of freedom. Instead, we proceeded with dichotomisation, applying a Bonferroni corrected alpha of 0.00455 (0.05/11) to offset the potential of false positive outcomes (further detailed in Statistical Analysis).

The diversity variable was defined using a modified version of Shannon's Diversity Index (SDI) (Shannon, 1948), which is calculated by the following formula:

$$-\sum_{i=1}^{N} p_i \ln(p_i)$$

where N is the number of amenities (here 10), p is the proportion of amenity of type i, calculated by dividing the number of amenities of type i by the total number of amenities. There were cases where proportions were zero; for these, values were set to zero for summation. This SDI is interpreted as higher values indicating greater amenity diversity within the LSOA/data zone, with zero indicating an absence of amenities.

Other independent and potential confounding variables included in the analysis were sex, age (modelled as a continuous variable and presented in descriptive tables using the following categories to aid interpretation: 18 to 24, 25 to 34; 35 to 44; 45 to 54; 55 to 65; and 65+ years), number of children in household under 16, employment type (working, not working, education/training, and retired/other), country, urban/rural status (UKHLS defined variable derived from the Office for National Statistics Rural and Urban Classification of Output Areas, 2001; UK Data Service, 2022)), and quintiles of UKHLS derived index of Multiple Deprivation ranking (UK Government, 2012) for each household's 2011 Lower Layer Super Output Area (LSOA) (or equivalent for Scotland). Additionally, a variable defining whether the person lived in an area considered a "retail centre" was included that spatially identifies the following 'retail centres': "Regional Centre"; "District Centre"; "Major Town Centre"; "Town Centre"; "Local Centre". (Singleton, 2022). Finally, two wave specific variables were used: quartiles of Bartlett's neighbourhood cohesion index (Buckner, 1988) (wave 9) and material deprivation (responses to: I/we have this, can't afford it, don't need it, does not apply) (wave 10).

Table 2
Percentage of respondents who live in LSOAs with each amenity present and total amenity count by area-level deprivation.

	Gender		Area-level deprivation				
	Male	Female	Most deprived	2	3	4	Least deprived
(a) Percentage of sample with amenity present by type of amenity within local area							
Public Transport	97.1	97.3	98.4	97.3	96.5	97.1	96.8
Finance	62.0	61.6	68.1	65.2	66.1	61.2	50.2
Pharmacy	57.2	58.0	57.1	61.1	64.5	59.1	46.9
Greenspace	87.2	87.0	85.7	87.2	88.5	89.7	84.3
Recreational amenities	60.4	60.9	49.2	58.5	65.1	68.3	60.0
Eating establishments	40.3	39.2	37.0	40.9	43.0	44.1	33.5
Social and cultural locations	63.7	64.5	65.5	67.2	70.1	66.0	52.7
Supermarket	21.9	22.4	21.6	24.1	23.5	21.3	20.5
Primary Care	21.9	23.1	25.0	25.3	22.4	23.9	16.9
School	49.1	49.9	48.6	48.5	51.9	54.0	44.4
(b) Percentage of sample with total number of amenities within local area							
0	0.5	0.5	0.3	0.6	0.5	0.3	0.6
1	3.1	3.1	2.0	2.0	2.5	3.0	5.4
2	6.8	6.6	6.4	5.4	4.9	5.3	11.2
3	8.6	9.1	8.6	9.1	6.4	8.7	11.4
4	12.3	12.5	13.7	12.5	12.1	11.4	12.4
5	15.2	14.0	16.2	15.2	14.1	12.6	15.0
6	15.8	15.3	17.8	15.5	15.1	15.4	14.3
7	15.4	16.1	16.1	14.7	19.1	16.3	12.6
8	12.9	12.7	11.2	13.8	14.0	14.7	10.0
9	7.5	7.8	6.0	8.5	8.6	10.0	5.1
10	2.1	2.4	1.6	2.6	2.8	2.2	2.1
Sample	9806	10,923	3587	3919	4263	4477	4484

Table 3
Daily and weekly travel behaviours by sociodemographic factors.

	Walking			Car			Bus			Cycling		
	Daily (%)	Weekly (5)	Sample (n)	Daily (%)	Weekly (5)	Sample (n)	Daily (%)	Weekly (5)	Sample (n)	Daily (%)	Weekly (5)	Sample (n)
Sex												
Male	44.5	88.0	13,907	55.5	82.3	9158	5.0	15.0	9186	3.7	12.5	9187
Female	44.7	88.0	15,065	52.7	81.5	9773	5.5	18.7	9822	1.0	4.7	9818
Age												
18–24	48.9	92.0	2934	36.6	67.5	2507	10.5	29.8	2540	2.7	7.6	2540
25–34	48.9	91.2	3705	52.1	77.0	3302	5.6	17.2	3320	2.2	6.2	3314
35–44	46.1	91.0	4284	59.6	85.0	3829	4.5	13.4	3840	1.9	9.0	3840
45–54	45.4	90.1	5255	60.1	86.5	4777	3.5	13.3	4787	3.1	10.7	4790
55–65	45.2	87.8	5251	54.7	86.1	4383	4.4	16.1	4389	1.7	7.9	4389
65+	38.9	81.8	7543	37.7	81.1	133	9.6	25.1	133	1.4	5.9	133
Area-level deprivation												
Most deprived	42.3	83.0	4993	45.2	73.0	3610	7.9	25.3	3629	2.5	6.3	3628
2	43.7	86.3	5391	47.8	75.2	3762	7.6	23.4	3783	2.3	7.3	3781
3	45.2	88.0	6014	55.0	83.5	3795	4.6	14.4	3821	1.7	8.8	3817
4	45.9	89.3	6288	59.4	86.3	3893	4.0	12.8	3901	2.7	9.3	3903
Least deprived	45.3	92.1	6287	62.3	90.6	3871	2.4	9.4	3874	2.5	10.6	3876
Resides in retail centre												
Yes	43.9	87.7	25,736	56.4	83.6	16,598	4.7	15.7	16,660	2.1	8.3	16,660
No	50.3	90.6	3236	37.9	69.7	2333	8.9	25.4	2348	3.6	9.8	2345
Urbanicity												
Urban	44.3	88.0	22,072	51.0	79.4	14,805	6.1	19.4	14,880	2.5	8.4	14,875
Rural	45.6	87.8	6901	65.1	90.8	4126	2.0	8.1	4128	1.8	8.6	4130
Employment status												
Working	47.7	91.9	16,427	62.3	85.8	14,061	5.1	13.7	14,101	2.5	9.0	14,100
Education/training	52.4	93.5	1152	28.7	64.5	1004	14.6	40.4	1018	2.2	8.0	1020
Not working	31.9	73.1	2126	19.2	59.9	1901	3.8	29.8	1921	2.4	7.6	1916
Retired/Other	40.9	83.8	9268	42.0	84.2	1965	2.8	15.6	1968	0.7	6.0	1969
Material deprivation												
I/We have this	n/a			56.1	83.8	17,132	4.9	15.7	17,193	2.3	8.7	17,189
Can't afford it				34.6	63.5	1362	9.0	30.0	1369	2.3	6.5	1367
Don't need it now				40.9	71.7	110	10.1	31.8	114	1.0	3.1	114
Does not apply				36.8	62.8	327	7.0	23.2	333	0.6	7.8	336

2.6. Statistical analysis

Firstly, daily and weekly travel behaviours are firstly described by sociodemographic factors. Secondly, binary logistic modelling that allows for a complex sample structure were used to explore the association between local amenity density and travel behaviours according to individual and area-level sociodemographic characteristics, with the predicted event set to "daily" or "weekly" travel as appropriate. The unit of analysis was at an individual level within areas (LSOA), the modelling used complex sample structure to address clustering. The main analyses considered associations of daily and weekly travel with local amenity density (count) and diversity (SDI) in models including all other explanatory variables. Results are reported as odds ratios (95% confidence intervals) for daily or weekly travel according to amenity density (modelled separately for each individual amenity) and diversity. Multicollinearity within the amenity types was not an issue as these were modelled separately, with SDI essentially a proxy for looking at all amenities together. Margins were extracted from the binary logistic models and plotted to show the predicted probability of daily and weekly travel by SDI. All models used inverse probability weights developed and provided by Understanding Society to ensure results are representative of the population from which respondents were drawn. Analyses were performed in StataMP 18.

3. Results

3.1. Amenity accessibility within local area by participant sex, age and area-level deprivation

Table 2a shows the presence of amenities within local areas according to respondent area deprivation. Overall, over 9 in 10 respondents had a public transport stop within their local area, and almost 9 in 10 had a greenspace. The amenities with the worst access were supermarkets and primary care, with around a fifth of respondents having these amenities within their local area. Results by area deprivation indicate that a higher proportion of individuals living in the most deprived areas had a finance, pharmacy and primary care amenity within their local area compared to those residing within the least deprived area. In contrast, Individuals residing within the least deprived area had a higher proportion of recreational amenities.

Table 2b examines the total number of amenities (out of 10) within local areas, only 2% of individuals had access to all 10 amenities. However, a third had access to 7 or more within their local area and two thirds 5 or more. Individuals residing in the most deprived areas had access to a wider range of amenities: for examine, 5 or more amenities (most deprived: 69%, least deprived 59%) and 7 or more amenities (most deprived: 35%, least deprived 30%).

3.2. Travel behaviours by sociodemographic factors

Daily and weekly travel behaviours according to respondent and area characteristics are presented in Table 3.

3.2.1. Daily travel behaviours

Less than half (44%) of respondents reported walking daily for more than 10 min and there was little difference by sex, area deprivation, or urban/rural status, although individuals who were working (48%), in education (52%), or retired and did not reside in a 'retail centre' (50%) were more likely to walk every day compared with those who were not working (32%), retired (41%), or resided in a retail centre (44%). There were differences in daily car use by area deprivation with greater use among respondents who lived in less deprived areas (most deprived: 45%, least deprived: 62%), resided in a retail centre (yes: 56%, no: 38%), rural areas (urban: 51%, rural: 65%), who were employed (employed: 62%, not working 19%), and who had lower levels of material deprivation (we have this: 56%, can't afford it: 37%). Reported daily bus use and daily cycling were less frequent with only 5% of respondents using the bus daily and 2% cycling every day. Daily bus use was reported more frequently for those living in the most deprived areas (most deprived: 8%, least deprived 2%), residing in a retail centre (yes: 5%, no: 9%), urban areas (urban: 6%, rural: 2%) and those in education or training (Working: 5%, Education/training 15%). Cycling daily was more common among men (4%) compared to women (1%) and not living in a retail centre (4%) compared to not (2%).

3.2.2. Weekly travel behaviours

Almost 9 in 10 individuals reported walking for at least 10 min on one or more day during the past week. There was little variation by sex for any travel behaviours except for cycling, where a higher proportion of males reported cycling during the previous week compared to females (males: 12%, females: 5%). A part from bus travel, a greater proportion of respondents from the least deprived areas reported using each form of transport more frequently than those residing in the most deprived (weekly walking: most deprived 83%, least deprived 92%; weekly car use: most deprived 73%, least deprived 91%; weekly cycling: most deprived 6%, least deprived 11%). Conversely, weekly bus use was reported more frequently for those living in the most deprived areas compared to least deprived (most deprived 25%, least deprived 9%), and for those not residing in retail centres (yes: 25%, no 16%). Again, car use was lower and bus use higher among respondents living in urban areas (car use: urban 79%, rural 91%; bus use: urban 19%, rural 8%). Respondents who were employed (92%) or in education (93%) were again more likely walk regularly; while, retired individuals (84%), along with those who were working (86%) were also more likely to drive at least weekly. Respondents in education were most likely to use the bus (40%). As was the case for daily travel, car use was lower and bus use higher in respondents with greater material deprivation.

Table 4
Association between daily travel behaviours and amenity presence.

	Daily walking				Daily car use				Daily bus use				Daily cycling			
	Odds Ratio	95% CI		p value	Odds Ratio	95% CI		p value	Odds Ratio	95% CI		p value	Odds Ratio	95% CI		p value
		LL	UL			LL	UL			LL	UL			LL	UL	
Amenity Diversity (SDI)	1.03	0.95	1.11	0.506	0.78	0.70	0.87	<0.001	0.93	0.73	1.18	0.539	1.06	0.75	1.52	0.728
Public Transport~	1.00	0.99	1.00	0.244	1.02	1.01	1.02	<0.001	0.95	0.93	0.97	<0.001	1.00	0.98	1.02	0.689
Supermarket[a]	1.07	0.98	1.16	0.115	0.88	0.79	0.99	0.031	0.82	0.63	1.05	0.118	1.03	0.73	1.44	0.886
Finance~	1.01	1.00	1.02	0.043	0.99	0.98	1.00	0.046	0.99	0.97	1.01	0.224	0.98	0.95	1.01	0.181
Pharmacy~	1.00	0.98	1.01	0.637	1.00	0.97	1.02	0.756	0.90	0.83	0.98	0.015	1.06	0.99	1.14	0.094
Primary Care[a]	0.97	0.89	1.05	0.388	0.92	0.82	1.04	0.167	1.05	0.84	1.32	0.666	1.03	0.69	1.53	0.901
School[a]	0.93	0.87	0.99	0.025	1.00	0.91	1.11	0.938	0.77	0.63	0.95	0.012	0.95	0.72	1.27	0.754
Greenspace~	1.00	1.00	1.00	0.994	1.01	1.00	1.02	0.003	0.97	0.95	0.99	<0.001	1.00	0.98	1.02	0.783
Recreational amenities~	1.00	0.98	1.01	0.531	1.01	0.98	1.03	0.623	0.95	0.90	1.00	0.034	1.03	0.98	1.09	0.251
Eating establishments~	1.01	1.00	1.02	0.005	0.97	0.95	0.98	<0.001	0.98	0.97	1.00	0.059	1.00	0.98	1.02	0.961
Social and cultural locations~	1.00	0.99	1.01	0.905	1.00	0.98	1.01	0.609	0.91	0.86	0.97	0.002	1.03	0.99	1.06	0.113
Rural area^	1.04	0.97	1.13	0.285	1.66	1.46	1.88	<0.001	0.42	0.29	0.60	<0.001	0.80	0.53	1.19	0.266

Model adjusted for age, sex, number of children, employment, material deprivation, area-level deprivation and urbanicity.
[a] Reference category = absence of amenity. ^Reference category = urban area. ~ continuous measure.

3.3. Association between travel behaviours, amenity presence and diversity

Associations of daily active and car travel according to amenity density and diversity are presented in Table 4.

3.3.1. Daily walking

Under the adjusted alpha, (0.00454), no associations between daily walking and amenities were found.

3.3.2. Daily car use

Daily car use was higher among respondents living in areas with greenspace access (OR for each additional amenity: 1.01 95% CI: 1.00 to 1.02, p: 0.003) and more public transport amenities (OR: 1.01, 95% CI: 1.01 to 1.02, p: <0.001), but lower in areas with more eating establishments (OR: 0.96, 95% CI: 0.95 to 0.97, p: <0.001) and greater amenity diversity (OR: 0.78, 95% CI: 0.80 to 0.87, p: <0.001). Residing within a rural area was associated with an increased likelihood of daily car use compared to those in urban areas (OR: 1.66, 95% CI: 1.46 to 1.88, p: <0.001).

3.3.3. Daily bus use

There were mixed associations between local amenities and daily bus use. Perhaps surprisingly, each additional public transport stop was associated with a small decreased likelihood of daily bus use (OR: 0.95, 95% CI: 0.93 to 0.97, p: <0.001). Similarly, access to greenspaces (OR: 0.97, 95% CI: 0.95 to 0.99, p: <0.001) and social and cultural amenities (OR: 0.91, 95% CI: 0.86 to 0.97, p: 0.002) were associated with less daily bus use. Bus use was also lower among respondents living in areas with more amenity diversity (OR: 0.89, 95% CI: 0.78 to 1.00, p: 0.05).

3.3.4. Daily cycling

There were no associations between amenities and daily cycling. However, these analyses were based on the very small numbers of respondents who were daily cyclists.

3.3.5. Weekly travel behaviours

Supplementary Table 1 presents the model outputs describing the association between weekly travel behaviours and amenity presence. Overall, the model outputs for weekly travel behaviours highlight similar relationships between the amenities and daily travel behaviours, with small or non-significant in effect sizes. No associations between amenities and the daily or weekly bicycle use were found.

3.4. Predicted probability of travel behaviour by amenity diversity

Fig. 1 presents the predicted probability of daily travel by local area amenity diversity (SDI) (Weekly outcome presented in Supplementary Fig. 1). The plots highlight that as the amenity diversity (SDI) increases, the predicted probability of daily walking increases and daily car use decreases. There were no differences in the predicted probabilities of daily bus use or cycling and with amenity diversity (SDI). Similar patterns were apparent between weekly travel behaviours and SDI. Full models including the control variables are presented in Supplementary Table 2.

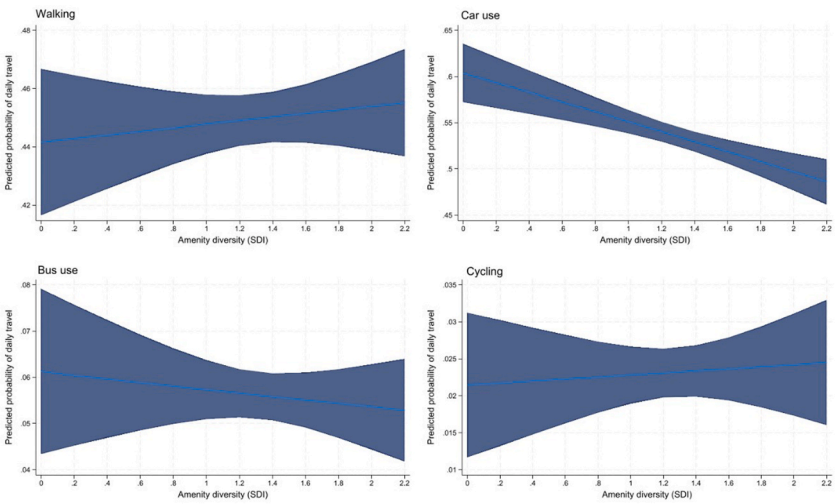

Fig. 1. Predicted probability of daily walking, car use, bus use and cycling by local area amenity diversity (SDI).

4. Discussion

This study defines and quantifies a range of local amenities previously identified as being destinations for local travel and local living planning policies, within small geographical areas within the UK. These data were linked to national population survey data to examine whether the presence or number and diversity of local amenities were associated with daily and weekly travel behaviours relating to walking, car and bus use, and cycling.

There was variation in amenity presence or number within local areas by amenity type. A large proportion of participants had access to a public transport stop or greenspace within their local area but considerably fewer had access to a supermarket or eating establishment. There was variation in access to amenities according to area deprivation; individuals from the most deprived areas had greater access to some amenities (finance, pharmacy, primary care and social and cultural amenities) whereas those in the least deprived area had greater access to others (greenspaces and recreational amenities). There was variation in active travel and car use according to respondents' sex, employment status, residing in a retail centre, as well as area urbanicity and deprivation.

The presence or density of some local amenities was associated with daily travel behaviours. Associations with specific amenities varied between travel modes but, in general, more local amenities were associated with less car and bus use. Increased amenity diversity was also associated with reduced daily car use. However, there was no strong evidence that any specific type of amenity was particularly consistently associated with multiple travel types, which highlights the complexity of creating liveable neighbourhoods. We found a similar association between amenity presence and diversity when examining weekly walking, cycling, car and bus use (as compared to daily).

4.1. Comparison with other literature

Previous research has found that the total number of amenities within a 1 km buffer from individuals' home was associated with decreased annual vehicle kilometres travelled, car trips and increases in trips actively travelled for non-work or education purposes (Elldér et al., 2022). Our results for walking and car use support these findings to some extent, although we also found a decrease in bus use associated with more public transport and greenspaces. This may be attributed to dense urban centres experiencing high motorised traffic, creating situations where walking is quicker than using public transport (Mayers and Bamford, 2018). Additionally, we were unable to assess whether participants had access to a public transport stop at their workplace, a factor associated with increased bus travel (Gascon et al., 2020). Moreover, dense urban centres with transportation hubs may serve as destinations for individuals residing outside these areas. Furthermore, we found that participants living in retail centres exhibited higher car usage and less walking compared to those not residing in such centres, underscoring that public transport usage may be greater for non-residents traveling to these destinations than for those residing in these areas. Further research is required to understand whether public transport serves the population residing within retail and town centres with access to work and social destinations. However, our travel behaviour outcomes were unable to identify the trip purpose, although this is an important predictor of mode choice. There are a number of other important factors that are determinants of transport choice decisions, such as trip purpose (work/education/leisure), cost, time (both availability and journey length), traffic reduction measures (congestion charging and traffic bans), as well as individual-level measures such as age, education and income (Ababio-Donkor et al., 2020; Buehler et al., 2017; Le and Teng, 2023). Although our results suggest that more local amenities may encourage more active and less car travel, the reasons underlying these associations remain unclear and are worthy of further investigation.

We found mixed evidence for the effect of public transportation stops within a local area and travel behaviours; for bus and car use, the presence was associated with increased and decrease travel by mode respectively. However, increases in the public transportation count was associated with decreased daily travel by bus, this may represent areas which have more bus stops for outward travel that does not relate to the travel of local residents. However, our measure did not assess the frequency of transit visits to the stop, and this is an important measure of quality. Transport for London define a high quality public transport stop as having 4 transit visits or more per hour between 6am and 9pm (Transport for London, 2020). Research in Scotland found that 91% of residential addresses had a public transport stop within a 10-min walk of their home but when the Transport for London quality measure was applied, this decreased to 60% (Olsen et al., 2022). Research in Melbourne, Australia, found that short distances to public transport stops were important for encouraging walking, cycling and public transport use, but the effect of the home-to-amenity distances varied between bus and train travel (Boulange et al., 2017).

For daily car use, an increased diversity of amenities within the local area was associated with favourable outcomes in terms of lower odds of daily car use. Highlighting that access to a diverse range of amenities are important for encouraging sustainable transport choices and increased opportunities for local living. Previous research in North America, China, Belgium, France, Hungary, the Netherlands and the UK, have highlighted the association between living in mixed-use neighbourhoods and reduced car use (Den Braver et al., 2020; Ding et al., 2017; Hong et al., 2014; Li and Zhao, 2017). A study examining transport mode choice in both Germany and the USA found a reduction in car drips when individuals lived in close proximity to public transport and areas with a greater diversity of housing and amenities (Buehler, 2011). Similarly, evidence from Australia highlighted that greater residential density and access to 9 or more amenities were associated with increased walking trips and reductions in car travel (Boulange et al., 2017).

We observed that a higher availability of eating establishments was linked to a decrease in car usage, underscoring the significance of these amenities for local living and a reduction in car dependency. Various suggested local living destinations aim to diminish reliance on car travel, and our findings suggest that having access to eating establishments within a walkable distance from home serves as a crucial local destination that diminishes car travel. Additionally, the proximity of these destinations to homes may discourage individuals from choosing to drive, as driving is more likely to be preferred for longer-distance trips (Ding et al., 2017). A

greater proportion of greenspaces were associated with increased daily car use and decreased bus use. Previous research has indicated that the availability of greenspace is not correlated with increased walking or physical activity (Ali et al., 2017). Simply having access to greenspace may not directly impact travel modes. Other factors play a crucial role in influencing both transport mode and greenspace utilisation, including the walkability of the local area (Roscoe et al., 2022) Greenspaces can only offer walkable routes to local destinations if participants perceive them as safe, especially during daylight hours (Rahm et al., 2021), and if they feature well-maintained paths and good connectivity.

4.2. Policy impact

Our results hold policy significance. Overall, our results suggest that amenity-rich local environments do host populations that use cars less. They support the principles of liveable neighbourhood policies for sustainable living and emphasise the importance of a having diverse range of local amenities to encourage increased daily walking and reducing car travel. This transportation shift is a key benefit proposed for these planning policy which aim to create sustainable and healthy urban places (Logan et al., 2022). However, creating diverse local areas for urban residents requires robust local planning. A review of 20-min neighbourhood concept in planning policies globally found that the majority of cities that adopted the concept do not have robust implementation plans specifying how the plan will be adopted or how change monitored and evaluated (Gower and Grodach, 2022). Additionally, modifications to the built environment alone may not be effective in eliciting behavioural changes from car to active or public transport travel modes, Xiao et al. (2022) highlighted in their review of population-level interventions to healthier transportation choices found that a combination of both behavioural and built environment interventions were most effect to reduce car use.

4.3. Strengths and limitations

Our study has a number of strengths. We were able to draw on a large and representative national household panel survey to examine travel behaviours by mode and link to nationally robust and accurate spatial data collected during the same time period. The survey data also collected a number of sociodemographic variables at an individual level that are important determinants of travel mode choice and were controlled for in the analysis. We were able to create an amenity diversity measure for each local area and link this to individuals. We conducted a sensitivity analysis for our outcome variable by daily and weekly use of travel mode.

However, our study also had limitations. We were unable to consider the trip purpose, and our correlations may have been stronger if we were able to focus on trips where the amenities served as destinations. Additionally, we considered using a households car access variable, but the data was poor quality with around a 1/7 data missing overall and would bias the sample against females and most deprived respondents, with 20% missing for females (14% for males) and almost a third of those in most deprived area (8% in the least deprived area). The definition of local areas was based on the scale at which the data were available, namely LSOA/data zone, and we recognise that the scale at which neighbourhood effects are most important may vary, although a recent review of neighbourhood effects across outcomes found little theoretical or empirical guidance on which scale different effects might operate (Knies et al., 2021). We did not know the precise residential location of the individual to draw individual-level catchments around their home to define, at an individual-level, their 20-min neighbourhood. We defined the individuals home location as the LSOA they resided within, which is typically made up of between 400 and 1200 households (Office for National Statistics, 2021). This may result in urban LSOA's being geographically smaller than those in rural areas; however, we accounted for the size of the LSOA and national survey using weighting within the analysis. In addition, although we were able to derive a measure of the quantity and diversity of amenities in an area, we were unable to assess the quality. Importantly, amenity data was only available at the area level and there is no way of knowing if respondents actually used them. There may also be residential selection bias whereby people who want to actively travel or not use cars may move to areas that permit it and there would be no guarantee that adding amenities/increasing diversity would result in behaviour change among existing residents. Our study is based on cross-sectional data, meaning we are unable to determine causality between local amenities and travel behaviours. Future research should integrate qualitative and qualitative research methods to understand causal influences between travel behaviours and urban design (Næss, 2015).

The area-level deprivation measure used combines three country-specific deprivation measures into quintiles (most to least deprived) for England, Wales and Scotland; meaning we were unable exclude domains that included geographic accessibility (1 of 7 domains). However, a comprehensive assessment of risk of endogeneity bias using individual domains or overall composite measures found the difference between deprivation quintiles were negligible and research on health inequalities are unlikely to be affected (Bradford et al., 2023).

4.4. Conclusions

Specific local amenities and their diversity within local areas were associated with an increased likelihood of daily/weekly walking and reduced car use. The evidence supports the premise of local place-based planning concepts, such as the 20-min neighbourhood, which encourage areas to be designed to support local living, increase sustainable transport choices, and reduce dependency on car travel. Our results provide additional evidence to support policy makers by highlighting they must consider a diverse range of amenities to support local living, as well as additional behavioural interventions, to narrow both socioeconomic and sex differences in daily walking, cycling and car use.

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CRediT authorship contribution statement

Jonathan R. Olsen: Conceptualization, Formal analysis, Methodology, Project administration, Writing – original draft. **Natalie Nicholls:** Formal analysis, Methodology, Writing – review & editing. **Elise Whitley:** Data curation, Writing – review & editing. **Richard Mitchell:** Methodology, Writing – review & editing.

Declaration of competing interest

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

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

We confirm that each author has disclosed on the form below any conflict of interest, in accordance with Elsevier's standard guidelines. These are summarized below, and given in full at: www.elsevier.com/authors/author-rights-and-responsibilities#responsibilities.

We understand that the Corresponding Author is the sole contact for the Editorial process. He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Appendix A. Supplementary data

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References

Ababio-Donkor, A., Saleh, W., Fonzone, A., 2020. Understanding transport mode choice for commuting: the role of affect. Transport. Plann. Technol. 43, 385–403.
Adams, E.J., Goodman, A., Sahlqvist, S., Bull, F.C., Ogilvie, D., 2013. Correlates of walking and cycling for transport and recreation: factor structure, reliability and behavioural associations of the perceptions of the environment in the neighbourhood scale (PENS). Int. J. Behav. Nutr. Phys. Activ. 10, 1–15.
Ali, O., Di Nardo, F., Harrison, A., Verma, A., 2017. The link between perceived characteristics of neighbourhood green spaces and adults' physical activity in UK cities: analysis of the EURO-URHIS 2 Study. Eur. J. Publ. Health 27, 761–765.
Boulange, C., Gunn, L., Giles-Corti, B., Mavoa, S., Pettit, C., Badland, H., 2017. Examining associations between urban design attributes and transport mode choice for walking, cycling, public transport and private motor vehicle trips. J. Transport Health 6, 155–166.
Bradford, D.R., Allik, M., McMahon, A., Brown, D., 2023. Assessing the risk of endogeneity bias in health and mortality inequalities research using composite measures of multiple deprivation which include health-related indicators: a case study using the Scottish Index of Multiple Deprivation and population health and mortality data. Health Place 80, 102998.
Buck, N., McFall, S., 2011. Understanding Society: design overview. Longitud Life Course Stud 3, 5–17.
Buckner, J.C., 1988. The development of an instrument to measure neighborhood cohesion. Am. J. Community Psychol. 16, 771–791.
Buehler, R., 2011. Determinants of transport mode choice: a comparison of Germany and the USA. J. Transport Geogr. 19, 644–657.
Buehler, R., Pucher, J., Gerike, R., Götschi, T., 2017. Reducing car dependence in the heart of Europe: lessons from Germany, Austria, and Switzerland. Transport Rev. 37, 4–28.
Büttner, B., Seisenberger, S., Baquesro Larriva, M.T., Rivas De Gante, A.G., Haxhija, S., Ramirez, A., B, M., 2022. Urban Mobility Next 9 ±15-Minute City: Human-Centred Planning in Action Mobility for More Liveable Urban Spaces. EIT Urban Mobility, Munich.
Cervero, R., Kockelman, K., 1997. Travel demand and the 3Ds: density, diversity, and design. Transp Res D Transp Environ 2, 199–219.
Chau, H.-W., Gilzean, I., Jamei, E., Lesley, P., Preece, T., Quirke, M., 2022. Comparative analysis of 20-minute neighbourhood policies and practices in Melbourne and Scotland. Urban Plan 7, 13–24.
Den Braver, N.R., Kok, J.G., Mackenbach, J.D., Rutter, H., Oppert, J.-M., Compernolle, S., Twisk, J.W., Brug, J., Beulens, J.W., Lakerveld, J., 2020. Neighbourhood drivability: environmental and individual characteristics associated with car use across Europe. Int. J. Behav. Nutr. Phys. Activ. 17, 1–11.
Ding, C., Wang, D., Liu, C., Zhang, Y., Yang, J., 2017. Exploring the influence of built environment on travel mode choice considering the mediating effects of car ownership and travel distance. Transp Res Part A Policy Pract 100, 65–80.
Elldér, E., Haugen, K., Vilhelmson, B., 2022. When local access matters: a detailed analysis of place, neighbourhood amenities and travel choice. Urban Stud. 59, 120–139.
Gascon, M., Marquet, O., Gràcia-Lavedan, E., Ambròs, A., Götschi, T., de Nazelle, A., Panis, L.I., Gerike, R., Brand, C., Dons, E., 2020. What explains public transport use? Evidence from seven European cities. Transport Pol. 99, 362–374.

Gower, A., Grodach, C., 2022. Planning innovation or city branding? Exploring how cities operationalise the 20-minute neighbourhood concept. Urban Pol. Res. 40, 36–52.
Handy, S., Cao, X., Mokhtarian, P., 2005. Correlation or causality between the built environment and travel behavior? Evidence from Northern California. Transport. Res. Transport Environ. 10, 427–444.
Handy, S.L., 1996. Urban form and pedestrian choices: study of Austin neighborhoods. Transport. Res. Rec. 1552, 135–144.
Hasler, K., 2018. Place Standard: a practical tool to support the creation of healthier places. Eur. J. Publ. Health 28 cky213. 022.
Haybatollahi, M., Czepkiewicz, M., Laatikainen, T., Kyttä, M., 2015. Neighbourhood preferences, active travel behaviour, and built environment: an exploratory study. Transport. Res. F Traffic Psychol. Behav. 29, 57–69.
Heroy, S., Loaiza, I., Pentland, A., O'Clery, N., 2022. Are neighbourhood amenities associated with more walking and less driving? Yes, but predominantly for the wealthy. Environ. Plan. B Urban Anal. City Sci. 50, 958–982.
Hong, J., Shen, Q., Zhang, L., 2014. How do built-environment factors affect travel behavior? A spatial analysis at different geographic scales. Transport 41, 419–440.
Javaid, A., Creutzig, F., Bamberg, S., 2020. Determinants of low-carbon transport mode adoption: systematic review of reviews. Environ. Res. Lett. 15, 103002.
Jones, E.J., 2001. Liveable neighbourhoods. World Transport Pol. Pract. 7, 38–43.
Knies, G., Melo, P.C., Zhang, M., 2021. Neighbourhood deprivation, life satisfaction and earnings: comparative analyses of neighbourhood effects at bespoke scales. Urban Stud. 58, 2640–2659.
Larsson, A., Elldér, E., Vafeiadis, E., Curtis, C., Steiner, A., 2022. Exploring the potential for sustainable accessibility across settlement types. A Swedish case. Transp Res D Transp Environ 107, 103297.
Le, J., Teng, J., 2023. Understanding Influencing Factors of Travel Mode Choice in Urban-Suburban Travel: a Case Study in Shanghai. Urban Rail Transit, pp. 1–20.
Li, S., Zhao, P., 2017. Exploring car ownership and car use in neighborhoods near metro stations in Beijing: Does the neighborhood built environment matter? Transp Res D Transp Environ 56, 1–17.
Logan, T., Hobbs, M., Conrow, L., Reid, N., Young, R., Anderson, M., 2022. The x-minute city: measuring the 10, 15, 20-minute city and an evaluation of its use for sustainable urban design. Cities 131, 103924.
Lynn, P., 2009. Sample Design for Understanding Society. Underst Soc Work Pap Ser, p. 2009.
Mayers, M., Bamford, D.. When is it quicker to walk, than catch a bus? The Conversation. Retrieved 25/01/2024, 2024, from. https://theconversation.com/when-is-it-quicker-to-walk-than-catch-a-bus-99347.
Næss, P., 2006. Accessibility, activity participation and location of activities: exploring the links between residential location and travel behaviour. Urban Stud. 43, 627–652.
Næss, P., 2012. Urban form and travel behavior: experience from a Nordic context. Journal of Transport and Land use 5, 21–45.
Næss, P., 2015. Built environment, causality and travel. Transport Rev. 35, 275–291.
O' Gorman, S., Dillon-Robinson, R., 2021. 20 Minute Neighbourhoods in a Scottish Context. ClimateXChange, Edinburgh, UK, pp. 1–75.
Office for National Statistics, 2021. Census 2021 Geographies.
Olsen, J.R., Mitchell, R., Mutrie, N., Foley, L., Ogilvie, D., 2017. Population levels of, and inequalities in, active travel: a national, cross-sectional study of adults in Scotland. Prev Med Rep 8, 129–134.
Olsen, J.R., Thornton, L., Tregonning, G., Mitchell, R., 2022. Nationwide equity assessment of the 20-min neighbourhood in the scottish context: a socio-spatial proximity analysis of residential locations. Soc. Sci. Med. 315.
Ordnance Survey, 2021. Points of Interest Classification Scheme, 4.3. Retrieved 02/02/2022, 2022, from. https://www.ordnancesurvey.co.uk/documents/product-support/tech-spec/points-of-interest-technical-specification-v4.3.pdf.
Ordnance Survey, 2021b. OS Open Greenspace - Technical Specification, 1.2. Retrieved 02/02/2022, 2022, from. https://www.ordnancesurvey.co.uk/documents/os-open-greenspace-technical-specification.pdf.
Rahm, J., Sternudd, C., Johansson, M., 2021. "In the evening, I don't walk in the park": the interplay between street lighting and greenery in perceived safety. Urban Des. Int. 26, 42–52.
Roscoe, C., Sheridan, C., Geneshka, M., Hodgson, S., Vineis, P., Gulliver, J., Fecht, D., 2022. Green walkability and physical activity in UK Biobank: a cross-sectional analysis of adults in Greater London. Int. J. Environ. Res. Publ. Health 19, 4247.
Salvo, G., Lashewicz, B.M., Doyle-Baker, P.K., McCormack, G.R., 2018. Neighbourhood built environment influences on physical activity among adults: a systematized review of qualitative evidence. Int. J. Environ. Res. Publ. Health 15, 897.
Scottish Government, 2006. Scottish Neighbourhood Statistics Guide. Scotland's Statistical Geography.
Shannon, C.E., 1948. A mathematical theory of communication. Bell Syst Tech J 27, 379–423.
Singleton, A., et al., 2022. Retail Centre Boundaries and Open Indicators. Consumer Data Research Centre. University of Liverpool.
Thornton, L.E., Schroers, R.-D., Lamb, K.E., Daniel, M., Ball, K., Chaix, B., Kestens, Y., Best, K., Oostenbach, L., Coffee, N.T., 2022. Operationalising the 20-minute neighbourhood. Int. J. Behav. Nutr. Phys. Activ. 19, 1–18.
Transport for London, 2020. Bus Routes & Borough Reports; Common Questions.
UK Data Service, 2022. Understanding Society: Waves 1-12, 2009-2021 and Harmonised BHPS: Waves 1-18, 1991-2009: Special Licence Access, Census 2001 Rural-Urban Indicators.
UK Government, 2012. English Indices of Deprivation.
University of Essex, Institute for Social and Economic Research, 2022. Understanding society: waves 1-12, 2009-2021 and harmonised BHPS: waves 1-18, 1991-2009: special licence access. In: fourteenth ed.Service, U.D. (Ed.), Census 2001 Lower Layer Super Output Areas
Wali, B., Frank, L.D., Chapman, J.E., Fox, E.H., 2021. Developing policy thresholds for objectively measured environmental features to support active travel. Transp Res D Transp Environ 90, 102678.
Xiao, C., van Sluijs, E., Ogilvie, D., Patterson, R., Panter, J., 2022. Shifting towards healthier transport: carrots or sticks? Systematic review and meta-analysis of population-level interventions. Lancet Planet. Health 6, e858–e869.