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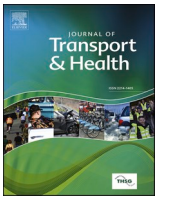

Constraints to travel outside the local area: Effect on social participation and self-rated health

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ABSTRACT

Background: Travel outside the local area allows people to meet others and access a wide selection of services and opportunities. However, travel can be constrained by the lack of good transport or by personal factors. This paper investigates whether these constraints are associated with poor self-rated health, and the extent to which the association is mediated by reduced social participation.

Method: Respondents in a survey in the North of England (n = 2747) stated levels of constraints to trip frequency, number of places visited, travel distance, and travel mode for trips more than 15 miles (24 km) away from home. Path analysis tested associations between these constraints, indicators of social participation (seeing family and friends frequently and being a member of clubs or societies), and self-rated health.

Results: Constraints to the number of places visited were associated with self-rated health via reduced social participation. Constraints to trip frequency had a negative association with self-rated health via pathways other than social participation. Constraints to travel distance were not significant and constraints to car use and public transport use were associated with self-rated health via other constraints. The results varied by age group and were robust to changes in variable specification and treatment of missing data.

Conclusions: The results confirm the importance of being able to travel outside the local area for social participation and health and emphasize the need for public policies that reduce constraints to travel, by providing better conditions for the use of both private and public transport and for the realization of more frequent trips to a wider set of places.

1. Introduction

Travel allows people to reach places where they can access opportunities (e.g. employment, education, leisure), go to shops, use services (e.g. healthcare), meet other people, or just see things. The ability to travel is especially important for older people, as it provides the freedom to do things independently, contribute to society, and feel connected to others (Musselwhite and Haddad 2010; Pantelaki et al. 2021). In theory, travel outside one's local area provides extra benefits, as it allows people to reach more places, access more opportunities, meet more people, and see more things. However, some people are constrained in their ability to travel outside their local area. This can be because of long travel times and costs, lack of good transport, or personal factors. Constraints to travel may

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lead to reduced social participation. This has possible negative consequences on health. In fact, constraints to travel, and associated unmet travel needs, may be more important than the actual number of trips in determining people's quality of life (Kolodinsky et al. 2013).

This paper looks at the pathways between perceived constraints to travel outside the local area and self-rated health, considering five aspects of travel: trip frequency, number of different places visited, travel distance, use of car, and use of public transport. We hypothesize that stronger constraints to travel are related to poorer self-rated health, via reduced social participation or other, unspecified, pathways (Fig. 1). In addition, transport constraints, social participation, and self-rated health are related to demographic factors (e.g. gender, age, household characteristics, income) and location (urban or rural).

The paper makes four contributions to the literature:

1. It analyses constraints to travel outside the local area (defined as more than 15 miles or 24 km from home), an issue with little research. Most previous studies on constraints to travel have either not specified distance or analysed shorter trips (Bergstad et al. 2011; Friman et al. 2017).
2. It looks at pathways between constraints to travel and self-rated health. Most previous studies focused on pathways to subjective wellbeing (Currie and Delbosc 2010; Stanley et al. 2011; Bergstad et al. 2011; Delbosc and Currie 2012; Friman et al. 2017).
3. It separates associations between constraints to travel, social participation, and self-rated health. Previously, social participation and health have been aggregated, together with economic participation, under an overarching concept of social exclusion (Delbosc and Currie 2011a, 2012; Stanley et al. 2011).
4. It uses a representative sample of the whole population. Most previous studies have focused on individuals that have constraints to travel or are at disadvantage in terms of income, employment, or mobility (Dobbs 2005; Casas 2007; Lucas et al. 2018).

The case study is the North of England. This region has had persistently worse health outcomes than the rest of England. For example, Buchan et al. (2017) found that the North had excess mortality among people aged <25 and 45+ in the period 1965–2015, and has seen an increase in excess mortality among those aged 25–44 since 1990. Constraints to travel have been identified as a factor contributing to economic disadvantage and lower subjective wellbeing in the North (Palacin et al. 2016; Lucas et al. 2018; Crisp et al. 2018), but there is little evidence on negative impacts on health. Large urban areas (e.g. Manchester) have good road and rail links with the rest of the North and beyond. However, many suburban and rural areas have poor accessibility, especially by public transport, due to the lack of frequent and regular services. Large investments are planned to reduce these constraints, including new and improved inter-city rail links, as a part of a larger economic development strategy (TfN 2019). These investments require evidence on the benefits of medium and long distance travel on population health. This paper provides this evidence, by using the results of a survey of residents in the North to assess the links shown in Fig. 1.

2. Existing evidence

2.1. Concept definition and measurement

Constraints to travel are limitations to the choices that individuals can make regarding travel, because of geographic isolation, lack of good transport, or personal factors (Nyaupane and Andereck 2008; Nasrin and Bunker 2021; Zhou et al. 2022). Related concepts in the literature include travel or transport (dis)satisfaction (Bergstad et al. 2011; Friman et al. 2017) or disadvantage (Currie and Delbosc 2010; Delbosc and Currie 2011a, 2012).

Social participation has been defined as "involvement in activities that provide interaction with others" (Levasseur et al. 2010). The concept has been measured in different ways, varying in the components of the definition above (e.g. levels of involvement, types of activity, types of interaction, and types of previous relationships with others). The frequency of meeting family and friends, and membership in clubs and societies, are commonly used indicators in academic studies and official national and international surveys on social participation (Guillen et al., 2011).

Self-rated health is a subjective indicator of health, usually collected in surveys by asking respondents about their overall health

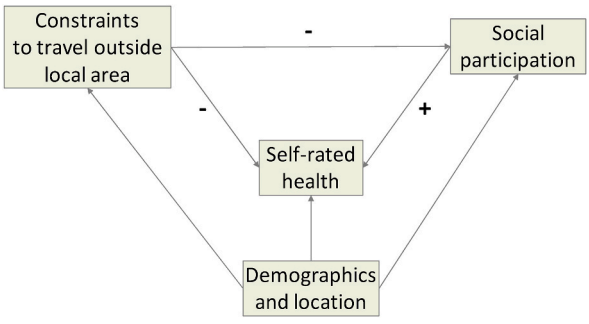

Fig. 1. Pathways between constraints to travel and self-rated health.

status, with some variations in the reference period, scales used, and wording of questions and possible answers. Self-rated health is influenced by contextual, demographic, and cultural factors (Baidin et al. 2021), but it tends to be a good predictor of mortality (Jylhä 2009; Benyamini 2011; Schnittker and Bacak 2014). As such, it has become a commonly used indicator in academic studies in various fields (not only medical but also social and economic) and in official health surveys (Jylhä 2009).

2.2. Travel constraints vs. social participation

Studies in several countries have found that some individuals make fewer trips to visit family and/or friends due to lack of access to a car (Van den Berg et al. 2011; Shergold 2019; Shirgaokar et al. 2020) or not holding a driving licence (Luiu et al. 2018; Pristavec 2018). The provision of public transport has also been linked to increased visits to family and friends in a Japanese region (Utsunomiya 2016). In a study in Switzerland, social networks were significantly smaller for individuals who lacked a public transport pass and narrower (in space) for those who lacked a car (Frei et al. 2009).

There is also consistent evidence that not having access to a car, driving licence, or public transport, reduce participation in out-of-home social activities such as taking a course or attending sport or cultural events (Richard et al., 2009; Adeel et al. 2016; Spinney et al. 2020). The ability to travel also affects community engagement, including volunteering work (Curl et al., 2014; Utsunomiya 2016; Shergold 2019), and membership and participation in organizations (Utsunomiya 2016).

Finally, not being able to travel limits opportunities for social interaction while travelling. This applies mostly to public transport trips (Green et al. 2014), but improvement on interpersonal relationships has also been reported by individuals sharing cars/vans to go to work (Robbins et al. 2015).

2.3. Social participation vs. health

The hypothesis that social participation contributes to better health is supported by many studies, as listed in the reviews of Silva et al. (2005) for mental health, Holt-Lunstad et al. (2010) for mortality, and Choi et al. (2014) for cancer, cardiovascular disease, and mortality. These effects can often been explained by the mediating role of increased social support, which influences health-promotion behaviours related to the prevention, diagnosis, and treatment of diseases.

Social participation tends to have a particularly noticeable effect on the health outcomes of older people, being associated with better self-rated health (Lee et al. 2008; Sirven and Debrand 2008; Gilmour 2012), cognitive functioning (Kelly et al. 2017), psychological well-being (Thanakwang et al. 2012) and reduced probability of depression (Chiao et al., 2011). These associations are usually estimated with cross-sectional datasets but also apply across time (Kim et al. 2016).

2.4. Travel constraints vs. health

A direct link between composite measures of travel constraints and poor self-rated health has been reported by Delbosc and Currie (2011b) and Ma et al. (2018). Haustein and Siren (2014) also found an association between lack of a driving licence and poorer self-rated health. However, in these studies, causes and effects were not ascertained. The link is probably bidirectional. Poorer self-rated health constrains individuals because it affects physical accessibility to vehicles and the ability to walk and cycle (Luiu and Tight 2021). In the current study, we isolate the analysis from this effect, as explained in the next section. Travel constraints can also lead to poorer health - as hypothesized in the current study. Several explanations are plausible, as detailed below.

Travel constraints affect health when they limit access to health-supportive destinations. 77% of 108 studies reviewed by Kelly et al. (2016) found that patients living at longer travel distances or times from healthcare facilities had worse health outcomes (e.g. survival rates, length of stay in hospital, missing appointments, late diagnoses). The same rationale could apply to travel distances or times to green areas or to food shops, but in this case, there is little evidence on negative health outcomes (see for example Hawkesworth et al. 2017).

Travel constraints also affect health by limiting the use of some travel modes and forcing individuals to use other, less healthy, modes. Evidence exists mostly for commuting trips. In a study in Sweden, Mattisson et al. (2018) found that commuting by public transport was linked to fewer walking difficulties and lower probability of being obese, compared to commuting by car. Car travel has also been identified as the most stressful commuting mode (Rissel et al. 2014; Legrain et al. 2015), while public transport users have the health benefits of walking and cycling to access stations/stops and for interchange (Lachapelle and Noland 2012). While this evidence points to better health outcomes for public transport users, Jacob et al. (2021) found no significant effect of shifts from car to public transport or vice-versa and Tajalli and Hajbabaie (2017) found differences among the various types of public transport (with better outcomes for underground users and worse for bus users, compared with car users). Different travel modes also have different degrees of exposure to air pollution. A review of ten studies found that car users to be the most exposed road users (De Nazelle et al. 2017), although other studies have shown that users in cars with windows closed or good ventilation are the least exposed (Qiu et al., 2017; Onat et al. 2019).

Finally, constraints to travel can affect health through its intermediate negative effects on employment, income, and social exclusion (Mackett and Thoreau 2015).

2.5. Main gaps

As detailed above, there is strong evidence on each of the separate links shown in Fig. 1. Most of the evidence, however, is for short

trips, especially commuting trips. Furthermore, no study has integrated the three types of links.

3. Data

We conducted an online survey of 3014 residents in the North of England. Respondents were recruited via e-mail from a nationally representative panel. No quotas were imposed. The survey was conducted under the terms of the Code of Conduct of the Market Research Society. Names and addresses were not collected. No problems were encountered on a pilot with 53 interviews. The main stage was conducted in January 2019.

Respondents were asked about the level to which they feel constrained in relation to travel outside their local area, defined as more than 15 miles (24 km) from home. This was asked as the level of agreement with five statements, from 1 (disagree strongly) to 5 (agree strongly):

- "*I travel beyond my local area less often than I would ideally like to*" – henceforth treated as constraints to trip frequency.
- "*I travel to fewer places (e.g. cities or towns outside my local area) than I would ideally like to*" – constraints to number of places
- "*I travel to places that are nearer than the ones I would ideally like to go*" – constraints to travel distance.
- "*I travel by public transport to places I would ideally like to go by car*" – constraints to the use of car.
- "*I travel by car to places I would ideally like to go by public transport*" – constraints to the use of public transport.

The questions referred to general travel behaviour, not trips made for specific trip purposes. Respondents who stated that they agree or agree strongly with a statement (i.e. levels 4 or 5 on the scale) were asked about the reason. They could choose one or more from a list of possible reasons (compiled from the literature) or add their own reason.

Table 1
Sample composition, compared with population.

		Sample	Population	Sample (weighted)
Gender (sample)* or Sex (population)	Male	38%	49%	49%
	Female	62%	51%	51%
Age group	18–24	8%	12%	12%
	25–34	18%	16%	16%
	35–44	19%	17%	17%
	45–54	20%	18%	18%
	55–64	18%	15%	15%
	65–74	15%	11%	11%
	75+	2%	10%	10%
Self-rated health	Very good	18%	46%	47%
	Good	43%	33%	33%
	Fair	28%	14%	14%
	Bad	8%	5%	5%
	Very bad	2%	1%	1%
Employment status	Self-employed	7%	8%	7%
	Employed full-time	38%	37%	40%
	Employed part-time	14%	14%	13%
	Student	3%	9%	3%
	Unemployed	4%	5%	4%
	Carer or looking after the home/children	8%	4%	6%
	Retired or unable to work	26%	22%	26%
Type of area	Urban	87%	85%	87%
	Rural	13%	15%	13%
County	Cheshire	6%	7%	5%
	Cumbria	3%	3%	3%
	Derbyshire	1%	2%	1%
	Durham	6%	6%	6%
	East Riding of Yorkshire	4%	4%	4%
	Greater Manchester	19%	17%	20%
	Lancashire	11%	10%	11%
	Lincolnshire	3%	2%	3%
	Merseyside	9%	9%	8%
	North Yorkshire	8%	7%	8%
	Northumberland	2%	2%	2%
	South Yorkshire	7%	9%	7%
	Tyne and Wear	8%	7%	8%
	West Yorkshire	13%	15%	13%

Notes: Population proportions calculated from 2011 census, except type of area, from ONS rural-urban classification dataset. *: Other = 0.1% of sample.

Self-rated health status was assessed on a 5-point scale: very good, good, fair, bad, and very bad, as possible answers to the question "How would you describe your health in general?"

Social participation was collected through three variables. The first two variables were how often respondents met family and friends (never, less than once a year, about once a year, 2–3 times a year, about once a month, about once a week, 2–3 days a week, 5 days a week or more, and 'I live with them'). The third variable was membership in clubs or societies (choosing one or more from: education; arts or music groups or evening classes; sports clubs, gyms, or exercise classes; and other). Memberships in other types of organizations (e.g. resident groups) were also probed, but the answers were not used in the analyses that follow, as it is likely that these memberships do not involve travelling outside the local area.

The following demographic variables were collected: gender; age group (nine categories); how long the respondent has lived in the local area and in the United Kingdom; ethnic group (White, Mixed, Asian, Black, Other); number of adults and children in the household; number of hours of unpaid care provided for an adult relative/partner, disabled child or friend/neighbour (0, 0–20,20-50, or 50+); household income (nine categories); employment status; educational qualifications; housing tenure; number of bedrooms; and whether the respondent or any other member of the household receives state benefits (choosing one or more from a list of 13 possible types of benefits).

We also linked the respondents' postcode area to two other datasets, using a geographic information system (GIS). Postcode areas were first geo-coded, using Ordnance Survey Open Data. We then identified: 1) respondents living in urban areas with a population over 10,000, using data from the 2013 Office for National Statistics rural-urban classification of census areas; and 2) the decile of the respondent's census area in the country's income distribution, using data from the 2015 Index of Multiple Deprivation dataset, published by the Ministry of Housing, Communities and Local Government (MHCLG).

Respondents could skip questions, choosing a "*don't know*" or "*would rather not say*" option. This led to incomplete data for 240 respondents, who were excluded from further analysis. We also excluded 27 respondents who stated that the reason for the constraints to travel was poor health. This was to mitigate reverse causality problems in the models, as the hypothesized links in this study are from travel constraints to self-rated health. The final dataset, used in all analyses, has 2747 respondents, i.e. 91.1% of the original dataset.

Income was missing for 195 of the remaining respondents. These respondents were retained in the analysis for two reasons: 1) to prevent data loss on a key variable explaining self-rated health, and 2) to avoid bias, since nonresponse in income questions tends to be related to income levels themselves, which leads to bias when excluding missing data (Valet et al. 2019). Household income was first converted into per-person income, based on the number of adults and children in the household. We then defined a low-income dummy variable representing per-person income below £7500 per year. Missing values were inputted from the forecasts of a logit model relating low income with the following variables: being unemployed, working part time, being a student, looking after the home/-children full-time, having no qualifications, living in social housing, bedrooms per person, not receiving any benefits, number of benefits received, and the decile of the respondent's census output area in the country's income distribution (entered as a continuous variable). This model gave 80% correct predictions. In Section 7, we test the sensitivity of the results to the definition of a cut-off value for low income and the inputation of missing income data.

Table 2
Incidence of bad and very bad self-rated health, by group.

Group		% of sample	Self-rated health (% of group)			
			Very bad		Bad	
All			1.5		4.9	
Social participation						
See family at least once a month	Yes	88	1.3		4.6	
	No	12	3.0	***	7.0	***
See friends at least once a month	Yes	84	1.0		4.2	
	No	16	3.9	***	8.6	***
Memberships in clubs/societies	Yes	35	0.5		2.6	
	No	65	2.0	***	6.2	***
Constraints to travel $\geq$ ***4***						
Trip frequency	Yes	43	2.0	***	7.0	***
	No	57	1.1		3.5	
Number of places	Yes	49	2.0	***	6.4	***
	No	51	1.0		3.6	
Travel distance	Yes	42	1.7	*	6.5	***
	No	58	1.3		3.8	
Use of car	Yes	24	1.6		4.7	
	No	76	1.4		5.0	
Use of public transport	Yes	25	1.2		5.0	
	No	75	1.6	*	4.9	

Note: Chi-square test. Significance levels: ***0.1, **1%, *5%.

4. Descriptive analysis

As shown in Table 1, the distribution of the sample according to employment status, type of area, and region (county) are aligned with those of the population of the North of England. The majority of respondents are employed (59%) and live in urban areas (87%). The sample has a lower proportion of men, individuals aged above 75, and those rating their health as 'very good', compared with the population. We thus estimated a set of weights, using a raking (i.e. iterative proportional fitting) procedure (Särndal 2007, Kott, 2006). This ensured that the sample-weighted proportions of genders, age groups, and health status categories (last column of Table 1) matched those in the population. The weights were applied in all subsequent analyses.

Table 2 shows the proportions of respondents reporting bad and very bad health, for key groups in the sample, compared with the rest of the sample. The statistical significance of differences in proportions was tested with chi-square tests of proportions. The key groups are respondents who see family less than once a month (12% of the sample), see friends less than once a month (16%), have no memberships in clubs and societies (65%), and reported the two highest levels of constraints to travel (from 24% to 49%, for constraints to car use and number of places, respectively). The hypothesis is that these groups have higher proportions of respondents reporting bad or very bad health.

The proportions of respondents reporting bad or very bad health were significantly higher among respondents who see family or friends less than once a month, have no memberships, and reported the two highest levels of constraints to trip frequency, number of places, and travel distance. There were no significant differences between the proportions among respondents who reported the two highest levels of constraints to use of car or public transport and other respondents. The proportion reporting bad health was significantly higher among respondents who did not report the two highest levels of constraints to the use of public transport.

5. Model specification

We used path analysis to analyse our dataset as this method allows the simultaneous modelling of direct and indirect relationships among exogenous and (several) endogenous variables. We tested whether travel constraints are related to poorer self-rated health, either directly (i.e., via unspecified pathways other than social participation) or indirectly (via lower social participation) (Fig. 2), Self-rated health was treated as a continuous variable, with values from 1 (very bad) to 5 (very good). Approximating ordinal variables with continuous variables tends to perform well, if the number of categories is above four, which is the case (Rhemtulla et al. 2012). This is common in studies of self-rated health, with studies finding comparable results using continuous variables and ordinal or binary variables (Garbarski et al. 2015; Assari et al. 2016; Bozick 2021).

Three binary indicators of social participation were defined: seeing family frequently (at least once a month); seeing friends frequently (at least once a month); and being a member of at least one club or society. In Section 8, we test the sensitivity of the results to other variable specifications (seeing friends/family at least once a week or 2/3 times a year, memberships in two or more clubs and societies, and number of memberships). It should be noted that the indicators were not approximated as continuous variables using the mid-point of the intervals defined in each category because one of the intervals was open (e.g. "less than once a year"). Using the original ordinal variable would lead to convergence issues in the model estimation.

We hypothesized that self-rated health is positively associated with social participation and negatively associated with constraints to trip frequency, number of places, and travel distance. In addition, social participation is negatively associated with these three types of constraints.

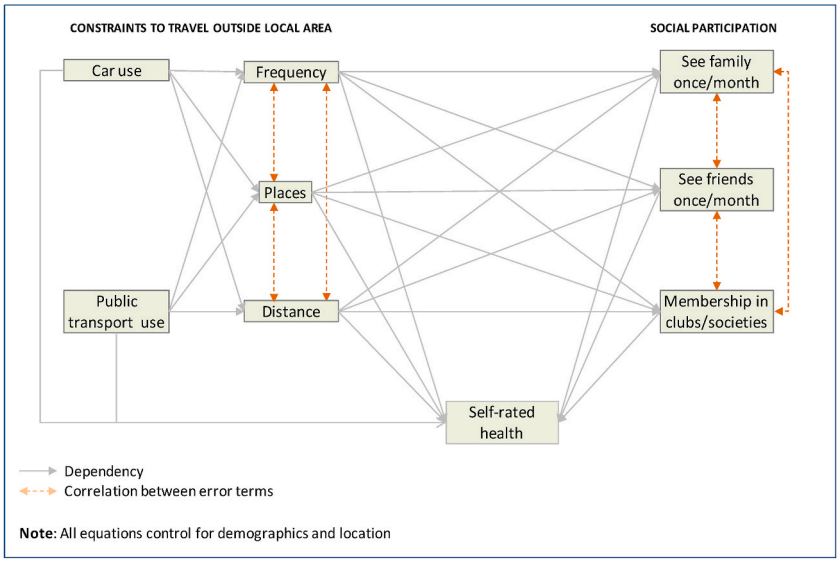

Fig. 2. Model specification.

Constraints to the use of travel modes (car or public transport) are not assumed to be directly associated with social participation. The constraints were formulated in the respective survey questions in relation to an alternative mode that the respondent uses, so the constraints do not directly affect the ability to travel. However, these constraints may have a negative effect on social participation via their effect on constraints to trip frequency, number of places, or travel distance. This is because being forced to use a given mode may mean that an individual is not able to travel as often as desired, or to travel to as many places as desired, at the desired distance. That may be the case of constraints to car use that force individuals to use public transport, which may have long travel times and unsuitable routes and schedules. We also allow a possible direct association between constraints to the use of car or public transport and self-rated health. This association may be positive or negative. As mentioned in Section 2 of the paper, the choice of a particular travel mode may lead to a variety of different health outcomes, positive or negative.

Social participation and self-rated health also depend on location (urban or rural) and on the following binary demographic variables: 1) gender (female); 2) age (<25, 25–34 45-54, 55–64, 65–74, or 75+, with 35–44 as omitted category); 3) living in the local area for less than a year; 4) living in the United Kingdom for less than a year; 5) ethnicity (ethnic minority, i.e., not identifying as "white"); 6) household type (single household, single parent, couple with children); 7) providing 20+ hours of unpaid care; and 8) low income. Variables that were used to input missing values in the low-income variable were not entered in the model.

Path analysis is a special case of structural equation modelling that contains no latent variables. We tested treating the five types of constraints to travel and the three social participation variables as components of two latent variables. However, these latent variables were weakly related to the components. This suggests the existence of separate dimensions of travel constraints (which is probably due to the characteristics of the available transport in relation to the places where individuals would like to go) and social participation (which is probably due to personality characteristics and the location of friends, family, and clubs/societies). We therefore treated the five types of constraints and three social participation variables separately. However, we assume correlation among the error terms of the equations of constraints to trip frequency, number of places, and travel distance, and among the error terms of the equations of the three social participation variables.

The models were estimated in STATA SE15, using maximum likelihood. The model was run on the whole dataset and then separately on data for respondents aged below and above 55 years of age, using the same specification. Models using different age cut-off values (below and above 65) are reported as part of sensitivity analysis in Section 7.

Goodness of fit was assessed by five statistics commonly used in structural equation models: relative $\chi 2$, root mean square error of approximation, standardised root mean square residual, goodness of fit index, and comparative fit index.

6. Model results

6.1. Goodness of fit

As shown in Table 3, the models met almost all the criteria that are usually accepted in the literature as defining a good model fit, with only slightly lower than desirable goodness of fit indices.

6.2. Main model

Fig. 3 shows the results of the main model. The figure shows only the associations significant at the 5% level. The values are standardised on a 0–1 scale. Grey lines represent direct relationships. Orange dotted lines represent co-variances between error terms. As hypothesized, self-rated health was significantly and positively associated with all three social participation variables. The strongest association was with seeing friends frequently (0.106), followed by memberships (0.080) and seeing family frequently (0.040). Only one type of travel constraint (trip frequency) was directly associated with self-rated health, with a negative effect, as expected (−0.083).

Constraints to trip frequency and travel distance were not significant associated with any of the social participation variables. Constraints to the number of places visited were negatively associated with seeing family and friends frequently (effect of −0.081 and −0.104, respectively). Constraints to the use of car and public transport contribute positively to each of the other three types of constraints.

Table 3
Goodness of fit measures.

Statistic	Model			Scale [worst-best]	Criteria
	Main (n = 2747)	Age<55 (n = 1783)	Age 55+ (n = 964)		
Relative $\chi 2$	4.17	3.39	1.78	–	<5 (Wheaton et al., 1977)
Root mean square error of approximation (90% confidence interval)	0.034 (0.030–0.038)	0.037 (0.032–0.041)	0.029 (0.021–0.036)	[1–0]	<0.06 (Hu and Bentler 1999), <0.07 (Steiger 2007), <0.08 (MacCallum et al., 1996)
Standardised root mean square residual	0.02	0.02	0.02	[1–0]	<0.08 (Hu and Bentler 1999)
Goodness of fit index	0.94	0.93	0.94	[0–1]	>0.95 (Shevlin and Miles 1998)
Comparative fit index	0.95	0.95	0.97	[0–1]	>0.95 (Hu and Bentler 1999)

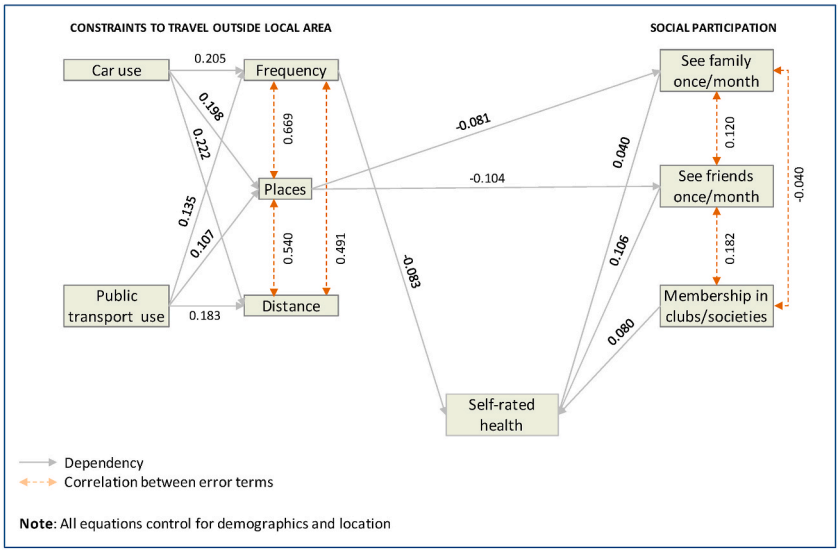

Fig. 3. Path analysis: significant associations.

The co-variances between the error terms of the equations of seeing friends and the other two social participation variables were both significant and positive. The co-variances between the error terms of seeing family frequently and memberships in clubs/societies were negative. The co-variances among the error terms of constraints to frequency, places, and distance, were all significant and positive.

The full results of the model are in appendix. The results obtained for the control (demographic and locational) variables were in line with previous expectations. As an example, self-rated health was highest for the youngest age groups (<25) and lowest for the oldest age group (>75 m), with an almost linear progression between these groups. Respondents with low income and those living alone also had worse health.

6.3. *Models by age group*

Fig. 4 shows the significant associations (on a 0–1 scale) in the models segmented by age. In the model for respondents aged below 55, seeing family frequently was not significantly associated with self-rated health. The other two social participation variables were significant and positive. Only constraints to public transport were associated with self-rated health, with a positive effect (0.060). Constraints to number of places were negatively associated to seeing family frequently (−0.085).

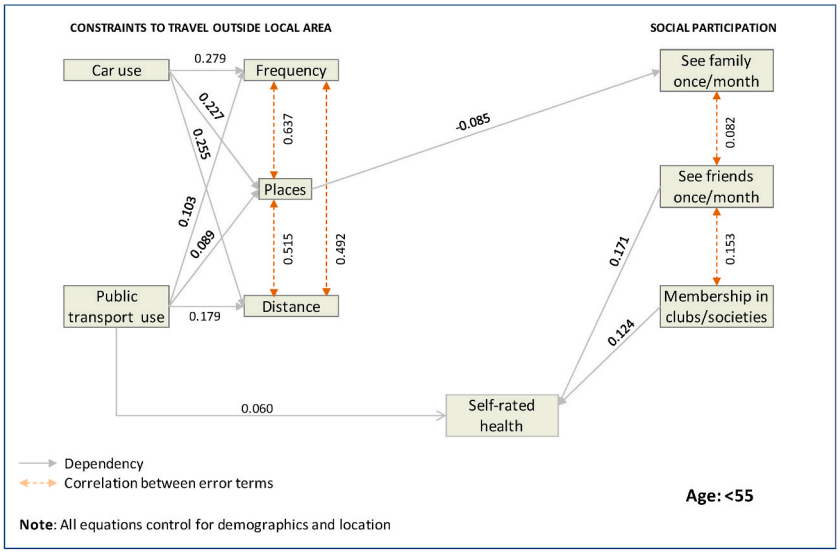

Fig. 4. Path analysis (age<55): significant associations.

In the model for respondents aged 55+ (Fig. 5), self-rated health was positively associated with seeing family frequently (0.054). Constraints to trip frequency were directly associated to self-rated health, with a negative effect (−0.175). Constraints to the number of places visited were negatively associated with seeing friends frequently and memberships (−0.222 and −0.119, respectively). Contrary to expectations, constraints to trip frequency had a positive association with seeing friends frequently.

In both models, constraints to the use of car and public transport contributed positively to each of the other three types of constraints.

The co-variances between the error terms of the equations of seeing friends frequently and the other two social participation variables were both significant and positive in both models. The co-variance between the error terms of seeing family frequently and memberships was negative for the 55+ group and insignificant for the <55 group. The co-variances between the error terms of constraints to frequency, places, and distance, were all significant and positive.

6.4. Direct and indirect effects

Table 4 shows the estimated direct and indirect effects on self-rated health of a 1-level increase in travel constraints (in a 1-5 scale), for the whole sample and the two age groups. The direct effects are equal to the coefficient of the constraints in the self-rated health equation. For constraints to trip frequency, places, and distance, the indirect effect is the sum of the products of the coefficients in the equations of the three social interaction variables and the coefficients of these variables in the self-rated health equation. For constraints to car and public transport use, the indirect effects also factor in the associations between those constraints and constraints to trip frequency, number of places, and travel distance.

For the whole sample, four impacts were significant, all negative. The strongest was the direct impact of constraints to trip frequency (−0.083), followed by the indirect impact of constraints to car use (−0.027), number of places (−0.017), and public transport use (−0.017).

For the <55 group, the direct effect of constraints to trip frequency and the indirect effect of constraints to number of places became insignificant and the direct effect of constraints to public transport became significant, with a positive sign. The indirect effects of constraints to car use and public transport use were significant, as in the main model.

For the 55+ group, the indirect effects of constraints to number of places and car use became insignificant. Only two effects were significant: the direct effect of constraints to trip frequency and the indirect effect of constraints to public transport use, both as in the main model.

7. Sensitivity analysis

The impact of the various choices made in variable specification and treatment of missing data was tested by comparing direct and indirect effects of travel constraints on self-rated health for the main model and for models using alternative methods.

Eleven alternatives were tested. Alternatives 1–4 used different cut-off values for frequency of seeing family and friends (once a week or more or 2–3 times a year or more, rather than once a month), membership in two or more clubs or societies (rather than one or more), and number of memberships (rather than a dummy for a cut-off value of memberships). Alternatives 5–7 used different transformations of the self-rated health variable, aggregating respondents reporting bad and very bad health and defining dummy variables for health statuses of good or better and fair or better. Alternatives 8–9 used different cut-off values to define the low-income

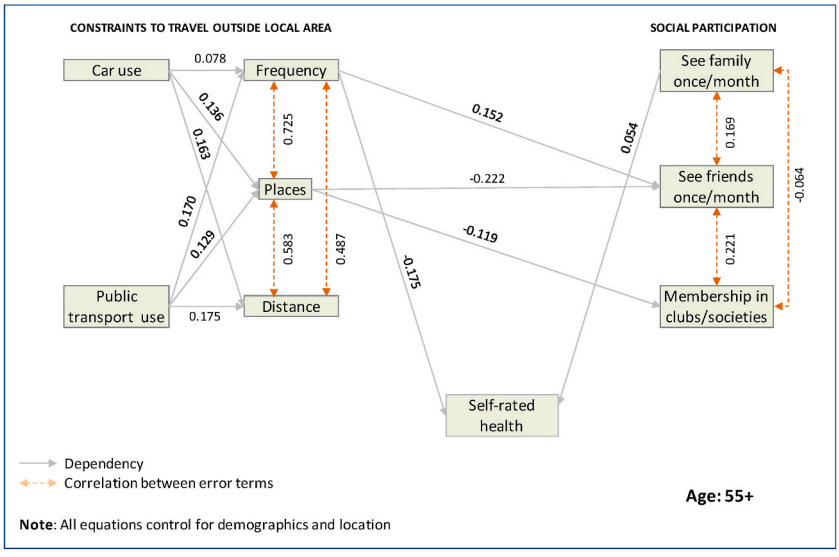

Fig. 5. Path analysis (age 55+): significant associations.

Table 4
Direct and indirect effects on self-rated health, overall and by age.

	All		Age<55		Age 55+	
	n = 2747		n = 1783		n = 964	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Travel constraints						
Trip frequency	−0.083***	0.004	−0.032	−0.005	−0.175***	0.001
Number of places	−0.019	−0.017***	−0.045	−0.014	0.039	−0.009
Travel distance	−0.020	0.005	−0.021	0.001	−0.036	0.003
Car use	0.025	−0.027***	0.022	−0.029***	−0.019	−0.015
Public transport use	0.017	−0.017***	0.060*	−0.013**	−0.052	−0.032***

Significance levels: ***0.1%, **1%, *5%.

variable and Alternative 10 did not input missing values for the low-income variable (thus excluding respondents with missing income data). Alternatives 11–12 used a different cut-off point for age-segmented models (above/below 65 years of age, rather than 55).

Table 5 shows the results. The impacts of alternatives 1–10 on the set of significant effects were minimal. The only difference is that the indirect effect of constraints to travel distance became significant in Alternatives 3 and 10, with a positive sign. In Alternative 11 (respondents below 65 years of age), the significant direct and indirect effects were the same as the ones for respondents aged below 55 (reported in Table 5), with the same sign. In Alternative 12 (respondents above 65), the direct effect of constraints to public transport became significant (and negative), comparing to the ones for respondents above 55.

8. Discussion and directions for further work

This paper found evidence that constraints to travel outside the local area (>15 miles from home, or 24 km) are related to poorer self-rated health, both via reduced social participation and other, unspecified paths. The results were robust to altering assumptions about variable specification and treatment of missing data.

Different aspects of travel had different associations with social participation and self-rated health. Constraints to travel distance did not have any significant association. Constraints to the number of places visited outside the local area were linked to reduced social participation, overall and among the two age groups considered. Among respondents aged less than 55, those constraints were linked to seeing family infrequently. Among those older than 55+, the constraints were linked to seeing friends infrequently and not being a member of clubs and societies. Constraints to trip frequency also had a negative association with self-rated health through pathways other than social participation, overall and among the 55+ age group.

Constraints to car use (i.e., having to make trips by public transport) were only linked with self-rated health via other constraints. This was also the case of constraints to the use of public transport (i.e., having to make trips by car), in the overall sample and among the <55 age group. However, among the <55 age group there was a positive link between constraints to public transport and self-rated health. This does not contradict the literature. As mentioned in Section 2, while some studies suggest that the use of public transport is linked to better health outcomes than the use of car, the associations between mode choice and health are complex.

The use of a larger sample size could uncover further associations and determine how the associations vary by age group and interact with other demographic factors. In particular, our sample had a relatively small number of respondents in the 75+ age group. While this aspect was mitigated by weighting data, the small sample may not cover all relevant combinations of demographic factors related to social participation and self-rated health within this age group.

The key concepts analysed in this study could also be extended. For example, we investigated constraints to general travel outside the local area. Future work could distinguish between constraints to trips made for different purposes. However, this would require strategies to account for multi-purpose trips.

In addition, we looked at social participation, not at social capital (which implies trust and reciprocity in social relationships). Social capital may show stronger links with both travel constraints and health. We also did not consider contacts with family and friends via phone or internet and local contacts with neighbours and acquaintances, which are means of social participation and can contribute to better health outcomes. In addition, membership in clubs and societies can generate non-local, local, and online activities. We excluded from analysis the clubs and societies that are likely to be local, but future work could ask about the location of activities, for a more accurate classification. Other possibilities include asking about combinations of social activities (e.g., meeting family and friends at the same time), and other unobserved aspects that are now accounted in the correlations between the error terms of the social participation equations.

The use of self-rated health also has some caveats. As mentioned in Section 2.1, self-rated health is a subjective indicator of health condition. Individuals may not be aware of some health issues. They may also perceive the scale presented in the survey in different ways (e.g. “very good” may mean different things for different people, depending on age, culture, past experience, and comparison with others). The concept also aggregates physical and mental health, losing potentially relevant information (e.g., lack of social participation may be related to mental health but not to physical health, or vice-versa). As an alternative, health status could be specified as a latent variable composed of several indicators.

We mitigated reverse causality from self-rated health to travel constraints by excluding respondents who reported being constrained because of poor health. However, reverse causality cannot be completely ruled out, as it is possible that poor health reduces

Table 5
Direct and indirect effects on self-rated health: sensitivity analysis.

Modification to model	Main model		Alternative 1		Alternative 2		Alternative 3		Alternative 4	
			See family/friends ≥ once/week		See family/friends ≥ 2–3 times/year		Membership in more than 1 club/society		Number of memberships	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
Travel constraints										
Trip frequency	−0.083***	0.004	−0.085***	0.007	−0.081**	0.001	−0.086***	0.007	−0.087***	0.007
Number of places	−0.019	−0.017***	−0.019	−0.016***	−0.025	−0.011*	−0.019	−0.018***	−0.018	−0.019***
Travel distance	−0.020	0.005	−0.018	0.005	−0.017	0.003	−0.023	0.007*	−0.021	0.006
Car use	0.025	−0.027***	0.020	−0.026***	0.022	−0.027***	0.022	−0.027***	0.022	−0.027***
Public transport use	0.017	−0.017***	0.016	−0.017***	0.020	−0.017***	0.022	−0.018***	0.018	−0.017***

Modification to model	Alternative 5		Alternative 6		Alternative 7		Alternative 8		Alternative 9	
	Aggregate 'bad' and 'very bad' health		Health at least good vs. not		Health at least fair vs. not		Low income: <£5000		Low income: <£10,000	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
Travel constraints										
Trip frequency	−0.084***	0.003	−0.086***	0.003	−0.060*	0.003	−0.080**	0.004	−0.085***	0.003
Number of places	−0.017	−0.017***	−0.005	−0.014***	−0.027	−0.013***	−0.022	−0.017***	−0.025	−0.019***
Travel distance	−0.020	0.004	−0.011	0.004	−0.038	0.003	−0.022	0.004	−0.021	0.004
Car use	0.024	−0.026***	0.003	−0.022***	−0.001	−0.027***	0.022	−0.028***	0.013	−0.029***
Public transport use	0.015	−0.017***	0.022	−0.014***	0.017	−0.018***	0.013	−0.018***	0.016	−0.019***

Modification to model	Alternative 10		Alternative 11		Alternative 12	
	No low-income imputation (n = 2507)		<65 age group (n = 2283)		65+ age group (n = 464)	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Travel constraints						
Trip frequency	−0.090***	0.003	−0.034	−0.003	−0.258***	0.001
Number of places	−0.016	−0.016***	−0.049	−0.012	0.112	−0.006
Travel distance	−0.033	0.008*	−0.038	0.002	0.037	−0.005
Car use	0.030	−0.031***	−0.001	−0.032***	0.042	0.008
Public transport use	0.033	−0.020***	0.068***	−0.016***	−0.181***	−0.022*

social participation for reasons other than the impact on travelling (e.g., fatigue). Reduced social participation may also become a constraint to travel (e.g., limiting the possibility of ridesharing). However, there are no obvious instrumental variables that could be used to minimize the problem of reverse causality.

The set of pathways modelled could also be extended. This study did not specify pathways between constraints to travel and self-rated health other than through social participation. These were treated as direct links and were found to be significant in the case of constraints to trip frequency, in the overall sample and in the 55+ age group. Economic participation is a possible pathway. While data on income and employment was available, we did not model these variables in relation to travel constraints and self-rated health as it was not possible to ascertain causality (individuals with poor health are possibly more likely to have low income and then more likely to be constrained to travel because of economic reasons). A direction for further research is therefore to disentangle the links that in this study we specified as direct links between constraints to travel and self-rated health. This could be either through further surveys collecting more variables on constraints to travel, economic participation, and health conditions, or qualitative studies probing the causes and effects of not making trips outside the local area.

It should be noted that the collection of the information we suggest in this section would clarify the results found in this study and address some of its limitations. However, it would also increase survey duration and could increase non-responses, as respondents could be reluctant to provide detailed information about their travel behaviour, economic and social activities, and health condition.

Overall, this study provides evidence on the importance of being able to travel outside the local area for social participation and self-rated health. This adds to a literature that so far had focused on local trips and subjective wellbeing (rather than self-rated health) or analysed the problem in terms of an overarching concept of social exclusion aggregating both social participation and health. The results suggest that this aggregation masks important detail, as travel constraints are related to self-rated health both directly and indirectly, via social participation.

The results also emphasize the need for policies that reduce constraints to travel, by providing better conditions for the use of both private and public transport and for the realization of more frequent trips to a wider set of places. The existence of a possible reverse path from health to travel constraints, to ascertain in future research, reinforces those implications: policies should reduce travel constraints as these can lead to poorer health outcomes, which in some cases may lead to even more constraints.

Acknowledgements

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Appendix. Path analysis full results

Travel constraints

	Car use		Public transport use		Trip frequency		Number of places		Travel distance	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Travel constraints										
Trip frequency										
Number of places										
Travel distance										
Car use					0.205	0.019***	0.198	0.019***	0.222	0.019***
Public transport use					0.135	0.019***	0.107	0.019***	0.183	0.019***
Demographics										
Female	−0.039	0.018*	–	–	–	–	0.056	0.014***	0.054	0.016***
Age<25	0.142	0.022***	–	–	0.088	0.018***	0.060	0.019**	0.054	0.018**
Age 25–34	0.077	0.023***	0.055	0.019**	–	–	–	–	–	–
Age 45–54	−0.053	0.024*	–	–	–	–	–	–	–	–
Age 55–64	−0.151	0.024***	–	–	–	–	–	–	–	–
Age 65–74	−0.102	0.023***	−0.058	0.019**	–	–	–	–	–	–
Age 75+	−0.066	0.023**	–	–	–	–	–	–	–	–
<1 year in area	−0.042	0.019*	−0.052	0.019**	–	–	–	–	–	–
<1 year in UK	0.044	0.019*	0.043	0.019*	–	–	–	–	–	–
Ethnic minority	0.043	0.019*	0.101	0.019***	–	–	0.031	0.014*	0.035	0.016*
Single household	–	–	–	–	0.029	0.013*	–	–	–	–
Single parent	–	–	–	–	0.069	0.013***	–	–	–	–
Couple with children	−0.045	0.020*	–	–	–	–	−0.035	0.013**	–	–
20+ hours care	0.067	0.018***	0.102	0.018***	0.060	0.013***	–	–	0.052	0.015***
Low income	0.098	0.019***	–	–	–	–	0.035	0.013**	–	–
Urban	0.046	0.018**	–	–	0.099	0.018***	0.113	0.018***	0.061	0.018***
Constant	1.649	0.077***	1.720	0.034***	1.550	0.071***	1.737	0.074***	1.776	0.074***

Notes: Significance levels: ***0.1%, **1%, *5%. "-": insignificant at 5% level in preliminary runs, not included in final model. Co-variances of error terms: constraints to frequency vs. places: 0.669***, frequency vs. distance: 0.491***; distance vs. places: 0.540***.

Social participation and self-rated health

	See family once a month or more		See friends once a month or more		Membership in clubs		Self-rated health	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Social participation								
See family 1/month							0.040	0.018*
See friends 1/month							0.106	0.018***
Membership in clubs							0.080	0.018***
Travel constraints								
Trip frequency	0.010	0.026	0.031	0.027	−0.002	0.027	−0.083	0.025***
Number of places	−0.081	0.027**	−0.104	0.028***	−0.039	0.028	−0.019	0.026
Travel distance	0.029	0.023	0.037	0.023	−0.006	0.024	−0.020	0.023
Car use							0.025	0.020
Public transport use							0.017	0.019
Demographics								
Female	0.054	0.019**	0.053	0.019**	–	–	–	–
Age<25	0.043	0.019*	–	–	0.083	0.019***	0.088	0.020**
Age 25–34	–	–	–	–	–	–	0.075	0.020***
Age 45–54	–	–	−0.058	0.019**	–	–	−0.088	0.020**
Age 55–64	–	–	−0.099	0.019***	–	–	–	–
Age 65–74	–	–	–	–	–	–	−0.081	0.020***
Age 75+	–	–	−0.096	0.019***	0.062	0.019***	−0.133	0.019***
<1 year in area	−0.055	0.018**	−0.055	0.018**	–	–		
<1 year in UK	–	–	–	–	–	–	−0.055	0.018**
Ethnic minority	−0.049	0.019**	–	–	–	–	0.066	0.018***
Single household	−0.184	0.019***	–	–	0.043	0.019*	−0.064	0.019***
Single parent	–	–	–	–	–	–	–	–
Couple with children	0.067	0.019***	–	–	0.050	0.020*	0.071	0.020***
20+ hours care	–	–	–	–	−0.050	0.019**	–	–
Low income	–	–	−0.084	0.019***	−0.078	0.019***	−0.141	0.018***
Urban	–	–	–	–	–	–	–	–
Constant	2.776	0.071***	2.459	0.072***	0.815	0.063***	4.342	0.108***

Notes: Significance levels: ***0.1%, **1%, *5%. "-": insignificant at 5% level in preliminary runs, not included in final model. Co-variances of error terms: See family vs. see friends: 0.120***; see family vs. memberships: −0.040*: see friends vs. memberships: 0.182***.

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