Alice Saunders_Dissertation

by Alice Saunders

Submission date: 01-Sep-2019 07:25PM (UTC+0100)
Submission ID: 110421013
File name: 64921_Alice_Saunders_Alice_Saunders_Dissertation_1064857_100127052.pdf (3.37M)
Word count: 17727
Character count: 103259

UCL Bartlett School of Planning:

BPLN0008 Dissertation in City Planning / BPLN0039 Dissertation in Planning / BPLN0052 Major Research Project

To be completed by the student submitting the dissertation:

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Programme name:	MSc Transport and City Planning
Time and date due in:	5pm 2nd Sept 19
Supervisor name:	Emilia Smeds

To be completed by the School office:

Time and date actually submitted:	
Lateness penalty applied (if applicable)**:**	
Supervisor name:	
Second marker name:	
Third marker name (if applicable):	

UNIVERSITY COLLEGE LONDON
FACULTY OF THE BUILT ENVIRONMENT
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Living at home and going nowhere?

How living with parents affects the travel behaviour of millennial Londoners

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MSc Transport and City Planning

Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc Transport and City Planning at University College London: I declare that this dissertation is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

Alice Saunders
2nd September 2019

Word count: 9,723
Appendices: 578

Acknowledgement

I would like to thank Transport for London who sponsored this MSc. Thank you to Collins Teye for his guidance on structural equation modelling.

I would especially like to thank Emilia Smeds for her supervision of this dissertation. She has been an invaluable source of encouragement and advice, probing questions and good ideas.

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List of abbreviations

BAME	Black and minority ethnic
GLA	Greater London Authority
ONS	Office for National Statistics
LTDS	London Travel Demand Survey
PTAL	Public Transport Accessibility Level
TfL	Transport for London

Abstract

A growing proportion of young adults live with their parents in London, driven in part by high housing costs and weak wage growth. Meanwhile, reductions in driver's license holding and car use among millennials have gained significant attention in transport research. A number of distinct lifestyle changes have been suggested to have contributed to these emerging trends. Millennials' delayed transition to adulthood is often acknowledged, but few studies have explored how living with parent's past adolescence affects travel behaviour.

This study uses survey data from Transport for London (TfL) to compare the travel behaviours of millennials who live with parents with those who live independently. The results show that those living with parents travel less frequently, and by less active and sustainable modes, with implications for health, social exclusion, and sustainability. Path analysis, a form of structural equation modelling, is used to uncover the mediating impacts of car access, socio-demographic and spatial characteristics. Millennials in multi-generational households largely live in outer London and in areas of lower public transport accessibility. Contrary to findings of previous studies, millennials who live with their parents are more likely to have access to a car than their counterparts who live independently, although they are less likely to have learnt to drive.

These results reveal wide variation in the travel behaviours of millennial Londoners, resulting from the interaction of cohort-specific and traditional determinants of travel demand. This challenges the implicitly assumed homogeneity of millennial travel behaviours in much of the literature. Further, this research demonstrates the need for transport planners to account for broader macro-economic uncertainty in their forecasts of travel demand. To ensure the continued growth of active and sustainable travel among young adults, policy interventions must span economic, housing and transport disciplines.

1. Introduction

'Generation Me' (Twenge, 2014), 'The Boomerang Generation' (Stone et al., 2014), the 'Go-Nowhere Generation' (Bulchoz and Bulchoz, 2012): millennials are portrayed as poor, lacking aspiration and outstaying their welcome in the parental home (LSE, 2018).

Intergenerational inequality has shot up policy and research agendas since the Global Financial Crisis (Milburn, 2019). Millennials have felt the effects of weak wage growth and London's housing affordability crisis most acutely (IMFO, 2013, Logan, 2014). As a result, young Londoners have delayed moving out of the family home. An estimated 14.5% of 25-34-year-olds now live with parents, up from 7.8% in 2002 (ONS, 2019).

Meanwhile, an emerging body of literature observes that millennials are both driving less and travelling less overall. Whether these trends will fade as millennials age remains a key question. Millennials make up 35% of London's population, so their emerging travel behaviours could accelerate or halt overall travel demand and mode shift, key factors for health and the transition towards sustainability (Banister, 2008).

Focus of the research

In response to gaps in current knowledge about the causes of emerging millennial travel trends, this study aims to explore the extent to which millennials who live with parents travel differently to those living independently in London. The remainder of this study is structured around three key research objectives:

1. Segment the sample of millennial Londoners based on their living context {*living with parents, living independently*}
2. Establish if millennial Londoners who live with parents have significantly different travel behaviours {*trip rate, mode share*} to millennial Londoners who live independently
3. Understand the direct and indirect impacts of living at home on travel behaviour {*trip rate, mode share*}, to derive mediating explanatory factors

This research is of interest to Transport for London (TfL) as they seek to forecast travel demand, and promote efficient, active and sustainable travel (TfL, 2018). TfL have provided access to the London Travel Demand Survey (LTDS). This provides access to rich travel data and demographic data about a sample of 6,400 18-37-year-old Londoners.

The remainder of this thesis is structured as follows. Chapter Two provides a critical review of the existing literature. Chapter Three outlines the research design and methodology. Empirical results are presented in Chapter Four, and discussed in relation to existing literature and the research question in Chapter Five. Chapter Six concludes, reflecting on implications for policy.

2. Literature Review

2.1. Introduction

Much has been written about the distinctive behaviours of 'millennials', generally defined as young adults born in the last two decades of the 20th century (McDonald et al., 2015). The literature on travel behaviour is no exception. Emerging evidence suggests that millennials also travel differently to previous generations (Garikapati et al., 2016, Chatterjee et al., 2018). Two trends have generated particular interest.

2.2. Key trends in millennial travel behaviour

Trend 1: Young adults are driving less

A considerable proportion of the existing research on millennial travel was conducted in relatively car-dependent U.S. cities (Dutzik and Inglis, 2014). Consequently, the literature is dominated by observations of reduced car travel and delayed license holding among young adults (cf. Berrington and Mikolai, 2014, McDonald et al., 2015, Clark et al., 2016, Delbosc and Ralph, 2017, Vij et al., 2017, Klein and Smart, 2017). But reductions in rates of driving and car ownership among young people are not inevitable (Delbosc and Ralph, 2017). A comparison of car ownership rates across 15 countries found a reduction in the number of young adult's holding a driving license in eight of the countries studied, alongside an increase in license holding in the other seven (Sivak and Schoettle, 2012). Most notably, they find a lower license holding rate is associated with a higher proportion of internet users. These findings highlight the role of cultural trends and the local context in shaping change in millennial travel behaviour (Delbosc et al, 2019).

In the UK, reductions in car use have been observed over a longer period (Lucas and Jones, 2009; Berrington and Mikolai, 2014, Chatterjee et al, 2018). This led to the development of the 'peak car' hypothesis which predicts that per-person motor vehicle travel has peaked (cf. Goodwin, 2011, Goodwin 2012, Metz 2010, Metz 2012, Metz 2013 and Millard-Ball and Schipper, 2010). Over two decades, London has seen a significant reduction in car travel, attributed to an expanding public transport network, reductions in road capacity, the introduction of London's congestion charge and high parking costs (Metz, 2012, Berrington and Milolai, 2014). Still, in

line with previous research, young adults have seen the most significant reduction in driving. Driving license rates have been falling among young adults since 1994 (Chatterjee et al., 2018). Between 1998-2008, the number of 18-34-year-old Londoners with access to a car fell by 14 percentage points (Le Vine et al., 2013).

It is unclear if this is the result of choice or constraint. Brown et al.'s 2016 study found that British millennials have more positive stated attitudes towards public transport than young adults of previous generations. Other studies suggest the rising cost of car use is the primary driver of declining car use among young adults (Berrington and Mikolai, 2014).

Trend 2: Young people are making fewer trips

It is also suggested that young people are travelling less overall than previous cohorts (Commission on Travel Demand, 2018). Evidence from developed economies reveals people are making fewer trips across all age groups, but young adults have seen the largest proportional decline (Polzin et al, 2014, Department for Transport, 2018). In London, trip making by those aged 17-24 has fallen by 22% since 2013/2014, compared to an average decline of 15% across the whole population (TfL, 2018). This coincides with evidence from time-use surveys that record young people today are spending more time at home than previous cohorts (Garikapati et al., 2016). This has fuelled speculation that travel has reached 'demand saturation' (Metz, 2013, Commission on Transport Demand, 2018). Beyond the 'peak car' hypothesis, we might also have reached 'peak travel' (Goodwin, 2012). Little of the literature on millennial travel behaviour has explored falling travel demand collectively across modes (Chatterjee et al., 2018).

Implications

A key and disputed question emerges: will these trends persist over the longer term? Some scholars argue that the decline in driving is unlikely to persist as millennials age (Brown et al., 2016, Delbosc and Naznin et al., 2018). Garikapati et al., (2016) suggest that observed trends indicate a lag in adoption of historic travel trends, due to deferred lifecycle phases and slow economic recovery.

Other scholars argue that millennials will continue to exhibit different travel behaviours. Proponents argue that distinct millennial demographics (Delbosc and Naznine, 2018), the ubiquitous uptake of technology (Lyons, 2009), and fundamental changes in attitudes

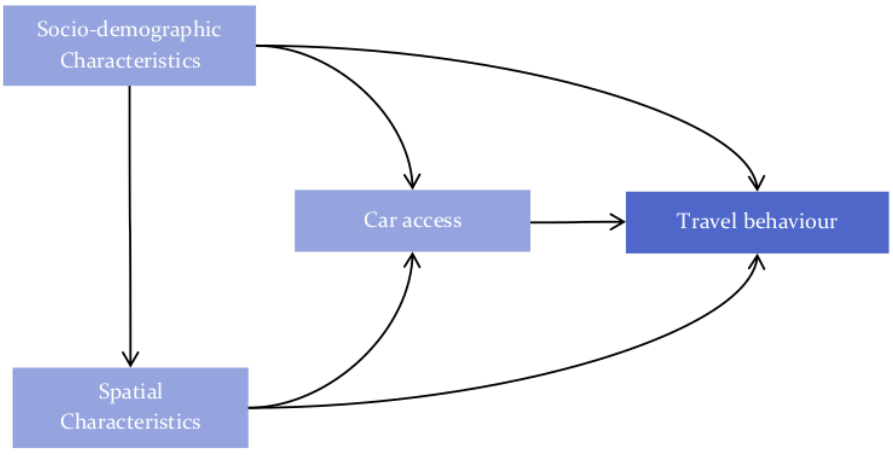
(Delbosc and Naznin, 2018) will cause lasting change to travel behaviours. Habits, socialisation and norms may also contribute to the longevity of these trends (Schwanen et al., 2012, Scheiner, 2018, Chatterjee et al., 2019). The socialisation of mobility in young adulthood is considered a 'pre-structuring' of later mobility (Scheiner, 2018). For example, there is evidence that being exposed to public transport at a young age positively influences perceptions towards public transport in later life (Smart and Klein, 2018).

Transport is a significant contributor to greenhouse gas emissions and air pollutants (Fuglestvet et al., 2007). Reducing the need to travel - particularly by motorised modes - is key to the transition to environmental sustainability (Banister, 2008). Should millennials mirror the travel behaviours of previous generations, planners will need to manage a sudden increase in automobility (McDonald et al., 2015). The likelihood of these trends persisting depends on what is driving these changes.

2.3. Traditional determinants of travel behaviour

Many determinants of travel behaviour have little to do with being a millennial. Empirical studies commonly consider the relative impact of (i) socio-demographic characteristics, (ii) spatial characteristics and (iii) car access on travel behaviour (Ewing and Cervero, 2001; Stead, 2001; Schwanen et al., 2004; Van Acker et al., 2006; Van Acker and Witlox, 2009, Stokes and Lucas, 2011) (Figure 1).

Figure 1. Traditional determinants of travel behaviour



Adapted from Ding and Lu (2016)

(i) Socio-demographic determinants

Studies have found substantial variation in travel demand according to socio-demographic characteristics (Boarnet and Sarmiento, 1998, Van Acker et al., 2006, Hanson and Hanson, 2016).

On average, women typically travel shorter distances than men (Ng and Acker, 2018), but make more complex trip-chains (Sarmiento, 2000, Rosenbloom, 2006, Tilley and Houston, 2016). This is related to the **gendered** division of labour within the household (Pratt and Hanson 1988, Gossen and Purvis, 2004). It is worth noting that more recently, there is evidence that male and female travel behaviours are converging (Kuhnimhof et al, 2012; Tilley and Houston, 2016). The impact of cultural trends on established determinants of travel demand are discussed in section 2.4.

A rich and established literature on 'mobility biographies' describes how travel changes with **age** (Jones et al., 2014, Scheiner, 2018). Biographical approaches find that travel patterns change in response to household roles, activities, resources and location decisions across life stages (Zimmerman, 1982, Su and Bell, 2009).

Education level, income and employment status are interwoven proxies for socio-economic group, with comparable findings for travel behaviour (Van Acker et al., 2007, Van Acker and Witlox, 2009). Higher socio-economic status is associated with long distance commuting, more frequent trip making and higher car use (Stead, 2001). Trip rates are significantly lower for economically inactive Londoners (TfL, 2015b).

Having a **disability** has also been shown to affect travel behaviour, even when controlling for age (Carey et al., 2017). Being another aspect of social disadvantage, different grades and types of disability present their own set of constraints on travel (Lucas et al., 2016, Carey et al., 2017, Schmöcker et al., 2018). People will disabilities tend to travel less overall (Corran et al., 2018), and are less likely to walk, cycle and use public transport (Carey et al., 2017).

Fewer studies have examined the association between **ethnic group** and travel behaviour (Syam et al., 2012). Black and minority ethnic (BAME) Londoners account for 41 per cent of the population (ONS, 2018), and ethnic diversity is higher among young people (TfL, 2015b).

BAME groups cite a greater number of barriers to travelling by public transport: including cost, safety and security (TfL, 2018).

(ii) Spatial determinants

It is also acknowledged that urban form influences travel behaviour (cf. Cervero, 1999; Giuliano, 2003; Handy et al., 2005). This can be categorised along four dimensions: **population density, land use diversity, design** of the built environment (Cervero and Kockelman, 1997), and **accessibility** (Geurs and van Wee, 2004).

High densities, land use diversity and pedestrian-oriented design have been found to encourage the use of non-motorised modes (Kockelman, 1997, Ewing and Cervero, 2001, Dargay & Hanly, 2004, Van Acker and Witlox, 2010). Proximity to services and lower travel costs in such neighbourhoods encourage shorter, more frequent trips (Kockelman, 1991, Crane, 1996). Accessibility refers to the ability to reach activities or locations by means of a combination of travel modes (Geurs and van Wee, 2004). Public Transport Accessibility Level (PTAL) is an established but basic method of measuring a location's connectivity by public transport (TfL, 2015a), combining walk access time and service frequency. PTAL is widely used in statutory documents such as the London Plan as a proxy for access to jobs and services (GLA, 2018). The simplicity of the calculation means that it is relatively easy to interpret, but it is unable to account for differences in service level across the week (Inayathusein and Cooper, 2018) or financial barriers to travel (Cass et al., 2005). Several studies have found accessibility to public transport to be positively associated with public transport use (Kitamura et al., 1997, Schmöcker et al. 2006). Accessibility, density, design and diversity go some way to explain the 'distinct patterns of travel in inner and outer London' (TfLb, 2014:4).

Residential self-selection is an increasingly important concept in research about the built environment and travel behaviour. This theory suggests that people chose to live in an area that is conducive to their attitudes and lifestyle preferences, including their transport preferences (Bagley and Mokhtarian, 2002, Mokhtarian and Cao, 2008, Cao et al., 2009, Ettema and Nieuwenhuis, 2017). For example, it has been observed that dense inner-city neighbourhoods tend to attract young adults, who seek good public transport links (cf. Florida, 2010, Klein and Smart, 2010, Brown et al., 2016, Ralph et al., 2016). These preferences shape both location choice and their resultant travel behaviour. Neglecting the impact of

residential self-selection leads to over-estimation of the direct influence of the built environment on travel behaviour.

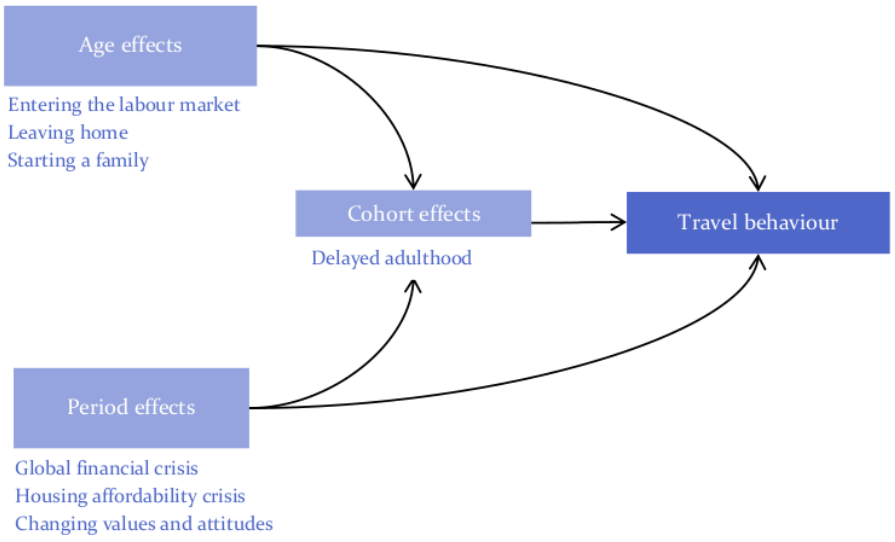
(iii) Car access

To put it simply, car owners make more car trips (Van Acker and Witlox, 2009). But car access is also a mediating variable between socio-demographic or spatial characteristics and travel behaviour. There is compelling evidence of the association between car ownership and income for example (Kockelman, 1991, Schwannen et al., 2004, Dargay & Hanly, 2004, Van Acker and Wilcox, 1997). Additionally, car ownership levels vary spatially. The need to own a car is shaped, in part, by residential density, land use, street design and public transport accessibility (Kitamura et al., 1997, Cervero, 1989).

2.4. Cohort-specific determinants of travel behaviour

Historic models based on socio-demographic, spatial and car use variables do not account for new social phenomena (Kaufmann et al., 2004). In addition to the established determinants, it is suggested that various economic, demographic and cultural developments are fundamentally changing millennial travel patterns. Some studies seek to differentiate between age effects, period effects and cohort effects (Yang and Land, 2013, McDonald et al., 2015), a helpful framework to consider new and changing drivers of millennial travel behaviours (Figure 2).

Figure 2. Cohort determinants of millennial travel behaviour



(i) Age effects

Age effects describe apply to people of a certain age, across periods. For example, young adults traditionally migrate to urban areas when entering the labour market (Dennet and Stilweel, 2010). The birth of a child often triggers the purchase of a car and relocation to the suburbs (Oakil et al., 2011, Oakil et al., 2014, Scheiner, 2018). Such life events, previously standard trajectories for young adults, act as 'turning points' in travel behaviour, disrupting habits (Clark et al., 2016).

(i) Period effects

Changes are 'rarely so localised in age… that their burden falls exclusively on the shoulders of one cohort' (Ryder, 1965:847). Some social changes and structures affect travel behaviour across all age groups at a particular period in time (Chatterjee and Scheiner, 2015). For example, Vij et al's 2017 study of the San Francisco Bay area attributes the observed reduction in car dependency among millennials to broader attitudinal changes towards motorised modes that transcend generational differences. Meanwhile, an increase in education and employment of women has increased female mobility across all age groups (Tilley and Houston, 2016).

(ii) Cohort effects

Cohorts are an important category of analysis in the travel behaviour literature (cf. TfL, 2014a, Polzin et al., 2014, McDonald et al., 2015, Resolution Foundation, 2018). Ryder contends that birth cohort membership is a key determinant of travel behaviour, shaped by a unique combination of structural forces, life stage and peer-to-peer socialisation (Ryder, 1965: 861). The literature on "millennial travel" proposes several causes of declining mobility, many of which are presented as being 'unique' to millennials. These include the ubiquitous uptake of technology and virtual communications (Lyons, 2009, McDonald et al., 2015, Kroesen and Handy, 2015), changing attitudes in relation to the environment (Garikapati et al., 2016) preferences for urban living (Florida, 2010, Klein and Smart, 2010, Brown et al., 2016, Ralph et al., 2016), poor economic opportunities (Logan, 2014, Le Vine et al., 2013) and delay to traditional markers of adulthood (Lamberti, 2015, Delbosc and Nakanishi, 2017, Delbosc and Naznin, 2018).

2.5. Living with parents: a cohort effect

Delayed markers of adulthood

Insights from psychology describe the development of a new 'emerging adulthood' life stage (Arnett, 2000, Arundel and Ronald, 2016). This involves deferral of the traditional trajectories to adulthood: leaving education, entering the labour market, leaving home and starting a family (Rosenfeld, 2010). The delay and de-standardisation of traditional markers of adulthood (Billari and Liefbroer, 2010, Mui, 2015, Arundal and Ronald, 2016) is a key rhetoric in the literature on millennial travel behaviour (Berrington et al., 2009, Krueger et al., 2018).

Multi-generational living

There is strong evidence to suggest that leaving the family home, a traditional marker of adulthood, is being delayed in London. Attitudinal studies show a growing acceptance of the need to live with parents, where previously it was met with notions of 'shame' or 'failure' (Stone et al., 2014). According to research by Shelter (2012), 22 is considered the ideal age to move out of the family home in the UK. Yet, in London, an estimated 14.5% of 25-34 year-olds live with parents, up from 7.8% in 2002 (ONS, 2017). In addition, young people who do move out are increasingly likely to return home on multiple occasions (Furlong and Cartmel, 2007), fuelling the label 'boomerang generation' (Stone et al., 2014, LSE, 2018). Despite their struggles, the majority of young adults retain aspirations to owner-occupation in the long term (Taylor, 2011).

Arundal and Ronald (2016) ascribe this strong desire but inability to leave home to a culture of weak family ties but low social assistance (Rosenfeld, 2010, Dykstra et al., 2013), drawing on Esping Anderson's 1990 classification of the UK as a liberal, individual-oriented society. Historically, the UK has encouraged independent living at any earlier age than many southern European cultures, where multi-generational households are more normalised (Holdsworth, 2000, Iacovou, 2001, Dykstra et al., 2016, Roberts et al., 2016). In their theorisation of the 'housing pathways' of British young adults, Clapham et al. identify six structural factors driving changes in the housing circumstances of young people: the employment situation; reforms to welfare benefits; declining provision of housing related support systems; reduced access to owner-occupation; shrinking availability of social housing and the high cost but lack of security in the private rental sector. As a result, 'stay at home to own' was the most popular

housing pathway identified from interviews with young adults in the UK (Clapham et al., 2019).

The global financial crisis and housing affordability

While some changes associated with delayed adulthood are cultural, the increasing prevalence of multi-generational households is generally considered a consequence of the 2008 financial crisis (Lamberti, 2015).

Indeed, the financial crisis has been credited with building 'generational consciousness' (White, 2013). Millennials are often defined in relation to their 'coming of age' during the height of the Global Financial Crisis (Brown et al., 2017, Dimock, 2019, Milburn, 2019). The Resolution Foundation define the boundaries as the birth years of 1981-2000, highlighting the unique economic outlook faced by those born in the United Kingdom at this time, particularly in relation to stagnant wage growth and housing costs.

Millennials entered employment with record student debt (Fry, 2012), and low wage and uncontracted employment has led to a significant age-based pay gap (Resolution Foundation, 2018). This gap has been particularly pronounced in London amid sharp rises in house prices (IMFO, 2013). Between 2002 and 2015, real housing costs grew by 29%, while average real wages reduced by 4% over the same period (Resolution Foundation, 2016). Impacts are particularly acute for younger Londoners, many of whom are delaying independent living as a result.

Metz (2010) and Goodwin (2012) both find that declining mobility among young adults was observed prior to the Global Financial Crisis. Similarly, Delbosc et al., 2019, argue that common macro-economic trends across the developed world exist alongside divergent travel patterns. Although not the only explanatory factor, the unique economic constraints placed on millennials at a formative age are considered an important determinant of changing millennial travel behaviours (IMFO, 2013, Klein and Smart, 2017, Chatterjee et al., 2018). The precise causal mechanisms are less well understood.

Travel behaviour as 'choices within constraints'

Kaufmann et al., (2004) argue that the spatial distribution of goods, information and people follow transformations of society. In particular, they present the construct of 'motility', where

the capacity of individuals to be both socially and spatially mobile, tiis dependent on their circumstances. They adopt an expanded definition of accessibility which is influenced not just by the network options available, but also constrained by cultural, economic and political structures. In this way, travel behaviour is the outcome of choices made within constraints (Hanson and Hanson, 2016). Living alongside parents out of economic necessity is one such constraint.

It has been argued that multi-generational living benefits parents and millennials through the sharing of resources (Muenning et al., 2017), reduction in loneliness (Rosenfeld, 2010) and accrual of savings for the future (Roberts et al., 2016). On the other hand, the literature on transport-related social exclusion (cf. Church et al., 2000, Social Exclusion Unit, 2003, Tunstall et al., 2013) describes the propensity for the urban environment to 'physically and metaphorically' exclude people from accessing the 'jobs, services and facilities that they need to participate fully in society' (Church et al., 2000: 197). As a result, socially disadvantaged groups exhibit different travel behaviours (Dargay, 2008, Lucas et al., 2011). Where economic circumstances restrict young adults to the residential location choices of parents, they may find it harder to access peers, jobs and daily activities (Fieldhouse and Gould, 1998; Syam et al., 2012, Lucas et al., 2011). This has the potential to accelerate the intergenerational transfer of advantage and disadvantage (Green, 2017).

The impact of living at home on travel behaviour

Despite its prevalence, there is a lack of consensus about the impact of living with parents on travel behaviour. Chatterjee et al. (2018) is one of few papers to address this subject. They find that millennials living with parents are no less likely to be car drivers than those living independently, despite strong links between other traditional markers of adulthood and obtaining a driver's license. They conclude that the increase in millennials living at home is unlikely to be a major cause of lower levels of driving. In contrast, Berrington and Mikolai, (2014) find young adults who live with parents are less likely to hold a driving license. An IMFO (2013) report links changing travel patterns to the tendency to live at home for longer, because of implied but un-evidenced implications for license holding and car ownership.

2.6. Cohorts: a meaningful analytical category?

With growing interest in so-called 'generational differences', it is pertinent to consider the extent to which cohorts are a meaningful category of analysis. Some scholars find generations to be a useful analytical construct (Dimock, 2019), in that they describe a group born in contiguous birth years who have shared experiences (Mannheim, 1952) at a seminal life stage (Gentile, Campbell and Twenge, 2013).

Others argue that cohorts are an arbitrary segmentation of society. As with all categorisation, the division of society along generational lines is often non-neutral (Bourdieu, 1991, White, 2013). The representation of generations as clear delineations within discrete boundaries can often overlook more gradual differences across a continuum of birth years (Campbell et al., 2017, Milburn, 2019). Many studies split generations into smaller subgroups for analysis (cf. McDonald et al., 2015, Garikapati et al., 2016, Delbosc and Naznin, 2018). Chatterjee et al., (2018) observe a mix of education levels and employment status among millennials living with parents until the age of 30. But beyond the age of 30, they are more likely to be unemployed with fewer qualifications.

Additionally, claims about millennial travel are often over-simplified, masking 'multiple intersecting differences' within generations (Fraser, 1997: 180). Few empirical studies go beyond the use of basic statistics. They fail to account for differences in millennial travel behaviour across and within analytical categories (McCall, 20015, Dodson et al., 2010) or acknowledge that power relations, preferences and constraints controlled by intersecting axis of identity (Haraway, 1988, Lykke, 2010, Hopkins, 2017). This can cause a disconnect between theory and social reality (White, 2013).

2.7. Summary

This chapter has examined the traditional determinants of travel behaviour, the phenomenon of delayed adulthood and the unique set of labour and housing market constraints faced by millennials in London. The following chapters focus on the growing proportion of millennials who live with parents, and the impact of their living arrangement on their travel behaviour.

In doing so, this thesis seeks to fill a number of gaps identified in the literature:

1. A focus on living with parents, a previously unexplored cohort-specific determinant of millennial travel behaviour;
2. A multi-modal approach to millennial travel behaviour moves beyond the existing emphasis on car use, and contributes to the emerging debate on wider travel demand saturation;
3. Use of London as a case study allows examination of travel behaviour within a specific spatial context, and in relation to London's unique economic and cultural change;
4. Path analysis, a form of structural equation modelling allows the consideration of inter-cohort differences, and their intersecting impact on travel behaviour.

3. Data and Methods

3.1. Data

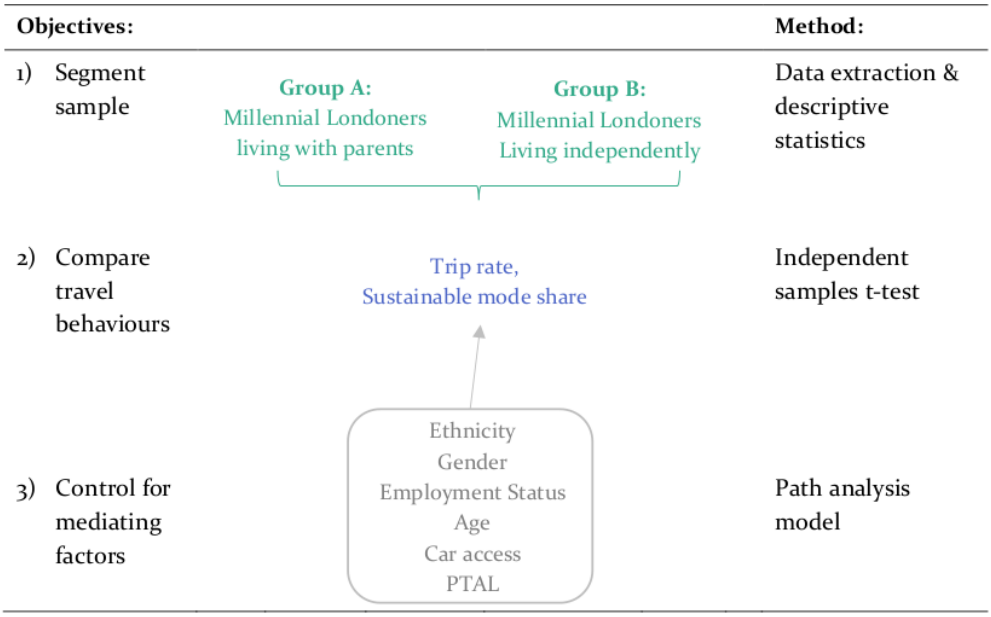
Informed by the literature review and London's economic context, this study defines millennials as those born between 1981 and 2000 (aged 18-37 in 2017/18). This group reached adulthood at a time of unparalleled growth in London's housing costs, but are the first generation whose average real wages are no higher than equivalent wages of recent generations (Resolution Foundation, 2018). Data pertaining to this age group was extracted from the London Travel Demand Survey 2017/18 (LTDS).

LTDS is a continuous household travel survey, capturing information about 8,000 London households each year. LTDS is based on a random sample of households across London. Data is reported in a series of household, person, trip and trip-stage databases. For each household member, LTDS records household location, car ownership, income, demographic characteristics and every trip made on the previous day.

3.2. Methods

Research methods were selected based on the research objectives. Figure 3 summarises the three research objectives and the corresponding statistical methods used.

Figure 3. Research objectives and methods



(i) Sample segmentation

The first research objective was to classify the sample population into two segments:

1) Millennials who live with a parent
2) Millennials who live independently

Because LTDS doesn't record relationships between household members, I took an innovative approach to infer households where millennials lived with parents/guardians from the relative ages of household members. Similar techniques have been used in the literature. The IPUMS tool constructs family interrelationships from historic census data, using age, surname and marital status (Ruggles and Sobek, 1997, Gorsuch and Williams, 2017). This study is interested in households with multi-generations, rather than the precise nature of the relationship.

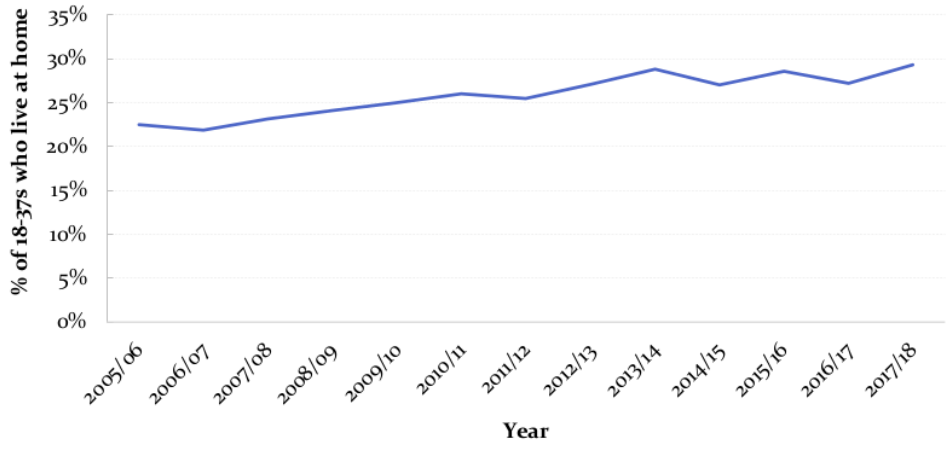
A 20-year age gap was considered appropriate to infer 'parental' relationships between household members. Where a millennial was living with at least one household member more than 20 years their senior, they were inferred to be 'living with parents', rather than independently (Figure 4). Sample extraction and segmentation were undertaken using the open-source software package 'R'. The relevant R scripts can be found in Appendix 4.

Figure 4. Segmentation criteria and sample size, millennial Londoners, LTDS 2017/18

Segment	Criteria	Sample size (n)
Millennial Londoners	Aged 18-37	6438
Lives with a parent	Household member who is 20+ years older than the millennial	1950
Lives independently	No household member who is 20+ years older than the millennial	4488

According to the ONS, just 3% of mothers, and 1.1% of fathers in the UK are under 20 (ONS, 2019). Additionally, just 0.5% of marriage partners have age difference of more than 20+ years (Wilson and Smallwood, 2008). Therefore, this segmentation criteria should identify the majority of multi-generational households within the sample. In total, 30% of millennial Londoners were inferred to be living at home in 2017/18. Analysing change over time (Figure 5), this segmentation approach produces results that are broadly in line with ONS estimates of young adults who live with parents (ONS, 2018).

Figure 5. Proportion of millennials inferred to be living at home over time



(ii) Independent T-tests

An independent t-test was conducted to meet research objective (ii). T-tests compared the sample means of the two millennial segments in relation to travel behaviour to determine the extent to which they differ (Snedecor and Cochran, 1989).

The literature sets out many dimensions of travel behaviour, including trip frequency, travel distance, timings, purpose and mode share (McFaden, 1974, Lyons et al., 2002, Rosenbloom, 2004, Páez et al., 2007, Metz, 2010). While unable to fully capture the complexity of daily travel activity patterns (Hanson and Hanson, 2016), these are useful metrics to uncover key differences between population segments. Transport for London primarily considers trip rate and sustainable mode share when examining travel demand trends (TfL, 2018: 23), taken as the dependent variables in the following analysis.

- **Trip rate** indicates frequency of travel. It measures the average number of trips made per person per day.
- **Sustainable mode share** is the percentage of all trips made by walking, cycling and public transport. Values range from 0 to 1 for each person; 1 indicates that all trips were made by walking, cycling and public transport.

The central limit theorem states that sample means approach a normal distribution as the sample size grows (Hogg and Craig, 1978). Given the sample size, t-tests were considered an appropriate method to compare the dependent variables, despite their non-normal distribution. Independent t-tests were calculated for both measures of travel behaviour using the following formula, null hypothesis and alternative hypothesis:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

N_i	Sample size (Live independently)
$\bar{X}_i$	Sample mean (Live independently)
s_1^2	Sample variance (Live independently)
N_2	Sample size (Live with parent)
$\bar{X}_2$	Sample mean (Live with parent)
s_2^2	Sample variance (Live with parent)

Trip rate

H_0: The mean trip rate of millennial Londoners who live with parents is equal to the mean trip rate of millennial Londoners who live independently ($\bar{X}_1=\bar{X}_2$)

H_a: The mean trip rate of millennials who live with parents is not equal to the mean trip rate of millennials who live independently ($\bar{X}_1\neq\bar{X}_2$)

Sustainable mode share

H_0: The mean sustainable mode share of millennial Londoners who live with parents is equal to the mean sustainable mode share of millennial Londoners who live independently ($\bar{X}_1=\bar{X}_2$)

H_a: The mean sustainable mode share of millennials who live with parents is not equal to the mean sustainable mode share of millennials who live independently ($\bar{X}_1\neq\bar{X}_2$)

(iii) Path analysis

The literature acknowledges complex inter-dependencies between socio-demographic characteristics, land use and travel patterns. But few studies reflect such complexity in their research methodology (Van Acker and Witlox, 2009). Multiple regression models, commonly used to understand the determinants of travel behaviour (cf. Cervero, 1989; Ewing, 1995; Kitamura et al, 1997, Stead, 2001), are unable to account for correlation between independent variables, causing multicollinearity (Van Acker et al., 2007).

Research objective (iii) was to understand the direct and indirect impacts of living at home on travel behaviour {*trip rate, mode share*}, and derive mediating explanatory factors. To meet this objective, I employed a path analysis technique. Path analysis is a form of structural equation modelling (Rigdon, 1998, Hoyle, 1995), an extension of multiple regression. It examines situations where there are hypothesised 'chains' of influence between multiple variables e.g. independent variable A affects mediating variable B, which affects dependent variable C.

Path analysis an established tool in the analysis of travel demand (cf. Golob, 1997, Golob, 2003, Liu, 2017). It has been used to model relationships between demographic factors and trip generation when controlling for spatial factors (Golob, 2003, Van Acker and Witlox, 2009). Cheng et al., (2019) model trip rate and mode share separately as a function of exogenous socio-demographic and accessibility factors. Following this approach, I created two path models using the 'Lavaan' package within 'R' (Rosseel, 2012).

- Model A: Factors affecting trip rate
- Model B: Factors affecting mode share

Model design

Path models are constructed based on hypothesised relationships between variables. (Papaioannou and Martinez, 2015). Model specification must be guided by existing theory and 'good sense' (Golob, 2003). Figures 6 and 7 present input path diagrams for model A and model B. They visualise the relationships between key independent determinants of travel behaviour as theorised in the literature (Figure 8). Arrows represent hypothesised relationships between variables.

Several model structures were tested to capture the relationships set out in the literature. Where variables were highly correlated (see correlation matrix, Appendix 3), the less significant explanatory factors were removed from the model. For example, being a student was found to be highly correlated with age. PTAL, population density and living in inner London were also highly associated.

Model fit

The two models were refined using a backwards stepwise approach (Jeon, 2015). The z-value indicates the ratio of each parameter estimate to its standard deviation. Where $z < 2$, variables were insignificant and removed from the models (Hoyle, 1995). The most significant models were retained for analysis.

Figure 6. Model A input path diagram

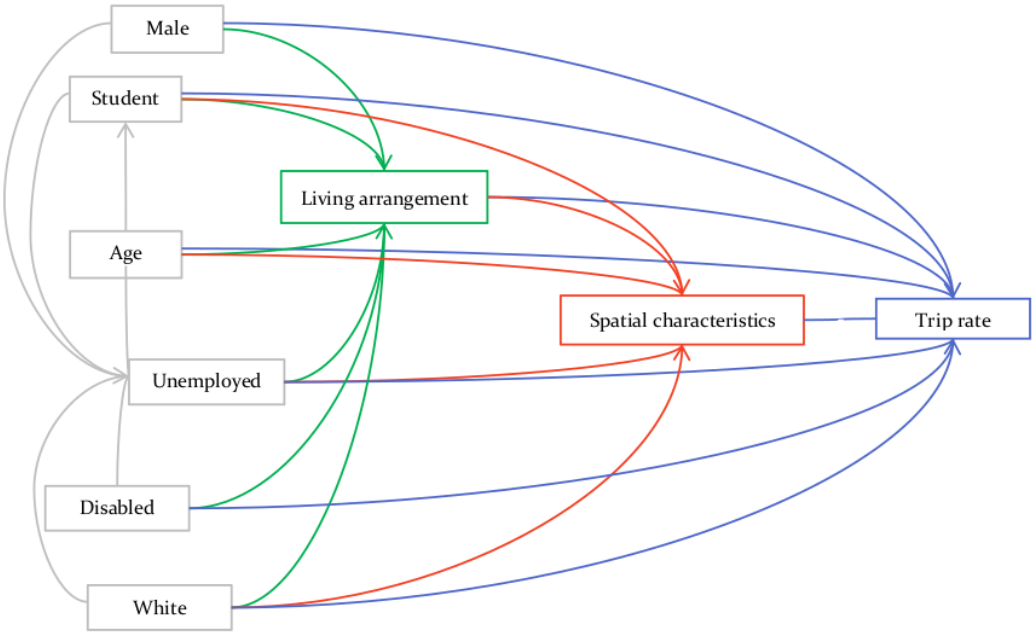


Figure 7. Model B Input path diagram

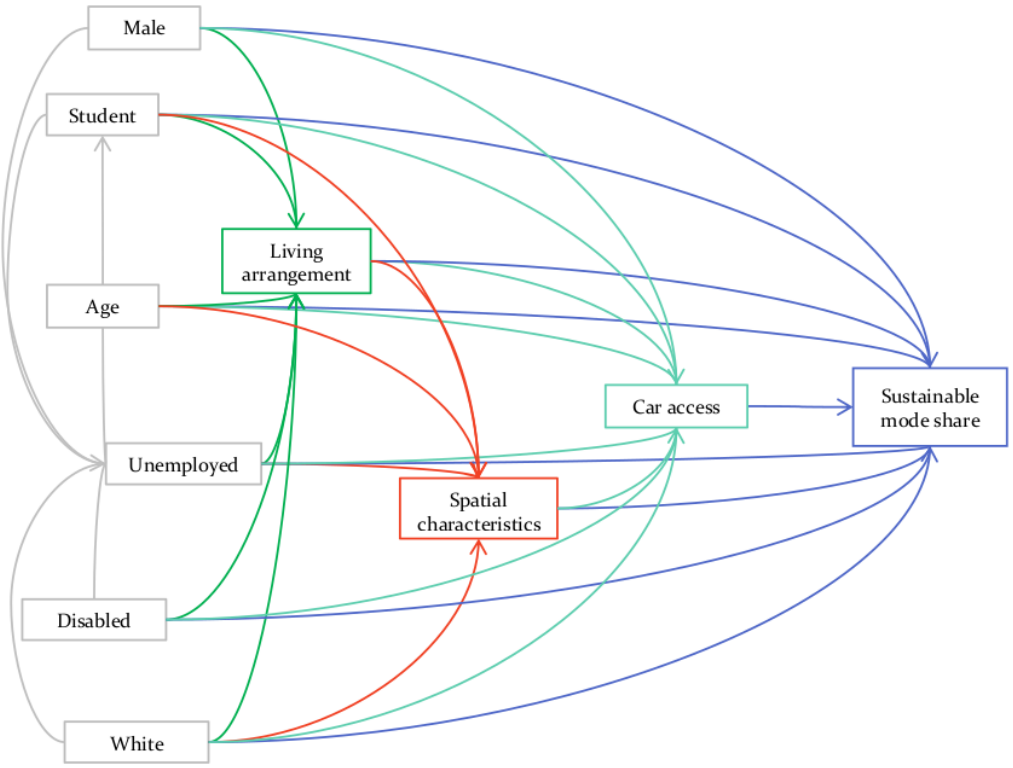


Figure 8. Independent variables

Variable	References
Socio-demographic characteristics	
Age	Schmöcker et al., 2008, Stead, 2001, Van Acker et al., 2007, Stokes and Lucas, 2011, Su and Bell, 2009; Chatterjee and Sheiner, 2015
Gender*	Boarnet and Sarmiento, 1996; Sarmiento, 2000; Stokes and Lucas, 2011; Rosenbloom, 2006; Kuhnimhof et al, 2012, Lucas et al., 2011; Tilley and Houston, 2016; Ng and Acker, 2018.
Ethnic group*	Lykke, 20010; Reyes and Mulinari, 2005; TfL, 2015b; Lucas et al., 2011; Corran et al., 2018.
Employment status*	Stead, 2001; Van Acker et al., 2007; Lucas et al., 2011; Corran et al., 2018.
Household income	Stead, 2001; Van Acker et al, 2007, Van Acker and Witlox, 2009
Disability*	Van Acker et al., 2007; Schmöcker et al. 2008; Lucas et al., 2011; Clery et al., 2017; Corran et al., 2018.
Student status*	Delbosc et al., 2019
Car access	
Household car ownership*	Boarnet and Sarmiento, 1996; Stead, 2001; Camagni et al., 2002; Dargay & Hanly, 2004; Paulley and al., 2006; Van Acker and Witlox 2010.
Driver's license*	Sivak and Schoettle, 2012; Berrington and Mikolai, 2014, Chatterjee et al., 2018
Spatial characteristics	
Public Transport Accessibility Level (PTAL)**	Kitamura et al., 1997; Schmöcker et al., 2006; Lucas et al., 2011, Inayathusein and Cooper, 2018
Population density**	Kockelman, 1997, Ewing and Cervero, 2001, Dargay & Hanly, 2004, Van Acker and Witlox, 2010
London region*	TfL 2014a, Coran, 2018

* categorical variables analysed through creation of dummy variables (Golob 1989)
** secondary data source spatially joined using GIS (TfL, 2018)

3.3. Research Ethics

This research analyses secondary data, thereby avoiding the risks associated with the collection of primary data. LTDS data is not in the public domain and access to this data requires that I am trained in data security protocol. Records have been anonymised so that individual respondents cannot be identified.

4. Empirical Results

4.1. Exploratory analysis

Descriptive statistics provide insight into the composition of the two millennial segments (millennials who live with parents, millennials who live independently), compared to all millennials and the adult population (Figure 9).

Figure 9. Descriptive statics of millennial segments

		Live with parent	Live independently	All millennials (18-37)	All adults (18+)
n	sample size	1950	4488	6438	19428
Socio-demographic					
Age	mean age	24.8	30.4	28.7	37.4
Gender	% male	53%	46%	48%	48%
Ethnic group	% white	50%	66%	61%	65%
Disability	% disabled	0%	0%	0%	10%
Work status	% unemployed	14%	14%	14%	31%
Student	% student	24%	7%	12%	5%
Household income	% of sample with household income under £50,000	50%	54%	53%	59%
Spatial					
PTAL	mean PTAL	2.54	3.26	3.05	3.05
Population density	mean persons per ha	95.2	110.0	105.0	98.3
Area of London	% of sample living in	73%	55%	60%	65%
Commute distance	mean distance from residence to employment/ education	10.3km	8.98km	9.39km	7.37km
Car access					
Household car ownership	% sample with household car access	79%	50%	59%	65%
Driver's license holding	% of sample with full driver's license	50%	65%	61%	65%
Travel behaviour					
Trip rate	mean trips per person	1.63	2.27	2.07	2.14

Sustainable mode share	% of trips made by public transport, walking and cycling	66%	74%	71%	63%
Travel distance	mean daily km	18.4km	16.4km	16.9km	15.9km
Travel time	mean daily minutes	87.1 mins	86.5 mins	86.7 mins	82.7mins

4.2. T-tests

Millennial Londoners who live with parents (μ=1.63, s=1.47) have a lower average trip rate than millennial Londoners who live independently (μ= 2.27, s=1.8) (Figure 10).

Millennial Londoners who live with parents also have a lower sustainable mode share (μ=0.66, s=0.45) than millennial Londoners who live independently (μ=0.75, s= 0.41) (Figure 11).

The results of both t-tests show that these differences are significant at the 95% confidence level ($p<0.05$) (Figure 12), so null hypothesis are rejected. These differences are discussed in section 5.

Figure 10. Trip rate by millennial segment

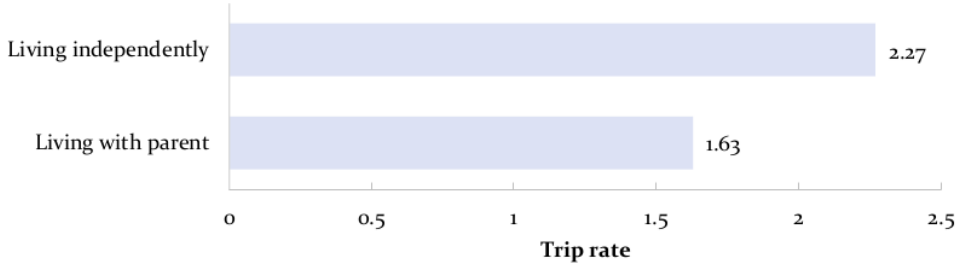


Figure 11. Sustainable mode share by millennial segment

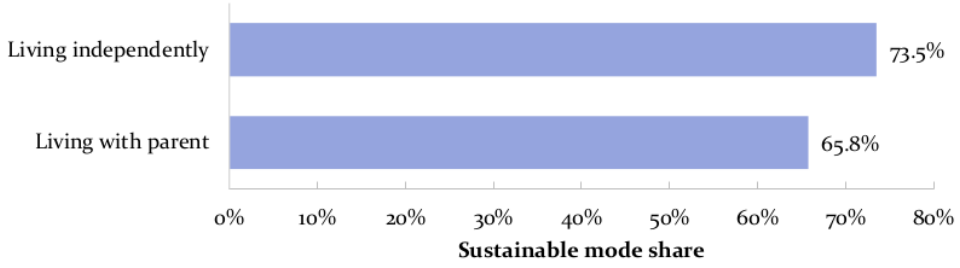


Figure 12. T-test results

	Trip rate	Sustainable mode share
$\mu_{\text{live with parent}}$	1.63	0.658
$s_{\text{live with parent}}$	1.47	0.45
$\mu_{\text{live independently}}$	2.27	0.735
$s_{\text{live independently}}$	1.80	0.41
t	14.8	5.33
df	4508	2135
p-value	2.2E-16	1.07E-07

4.3. Path analysis models

Output path diagrams are presented in Figures 13 and 14.

- Model A: Factors affecting trip rate
- Model B: Factors affecting mode share

Arrows represent significant associations between variables, labelled with their relative path coefficients. Model fit statistics for both path models can be found in Appendix 1. Both models have a relative chi-square value (controlled for degrees of freedom) of <5, indicating good fit. Other measures indicate that the model perform well (CFI >0.95, RMSEA <0.05) (Kline, 2005).

Figure 13. Model A output path diagram

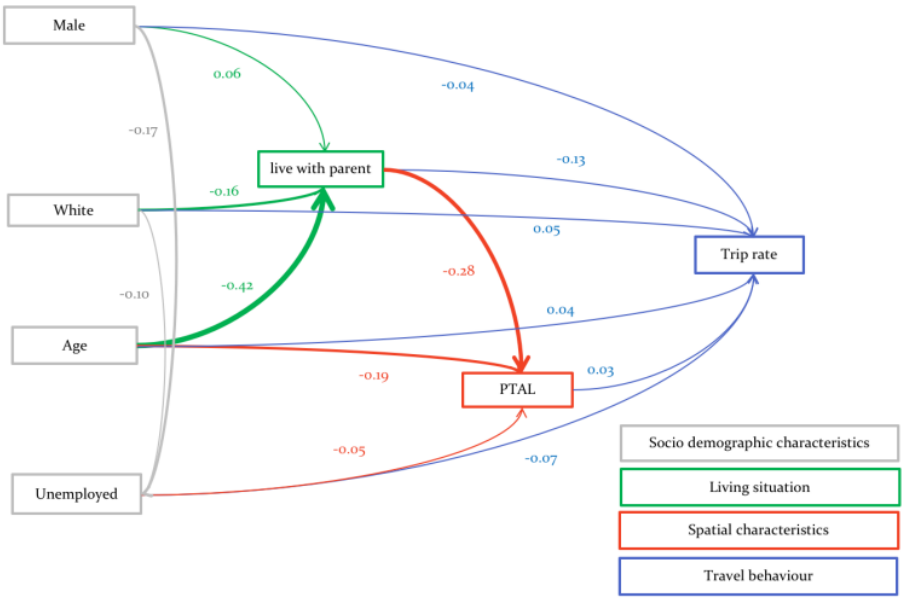
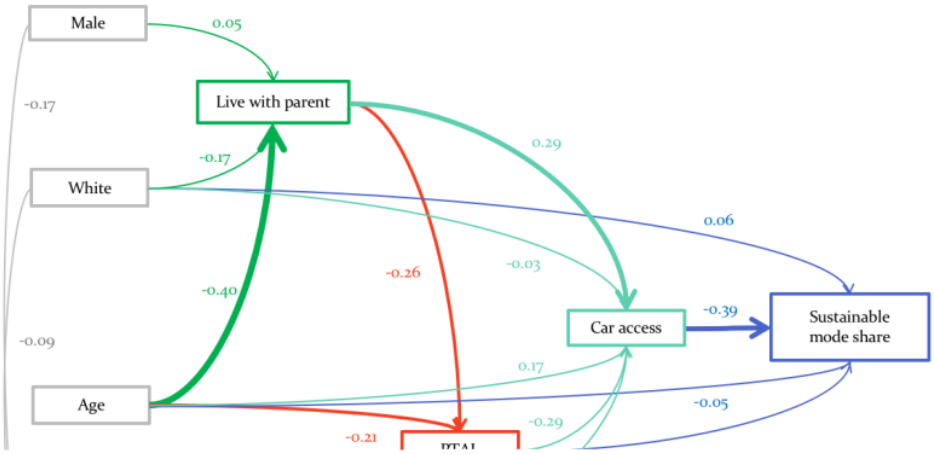


Figure 14. Model B output path diagram



Path coefficients

Standardised path coefficients estimate the strength of association between all connected variables (Roseeel, 2019). Figures 15 and 16 compare the relative direct, indirect and total effects of explanatory variables on trip rate and sustainable mode share (Papaioannou and Matrinez, 2015).

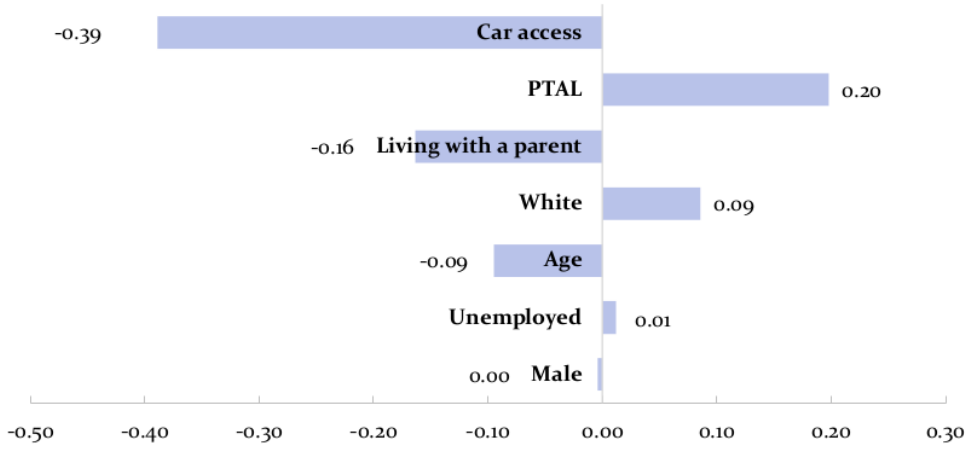
Figure 13 shows that living at home has a small but negative direct effect on trip rate (-0.14), very little of which is explained by the mediating factors included in model A. Living at home is a more significant determinant of millennial trip rate than any of the socio-demographic or spatial variables that were accounted for.

Figure 15. Model A determinants of trip rate

	Effect on trip rate		
	Direct	**Indirect**	**Total**
White	0.05	0.03	0.08
Age	0.04	0.05	0.09
Male	-0.04	0.00	-0.04
Live with parents	-0.13	-0.01	-0.14
Unemployed	-0.07	0.00	-0.07
PTAL	0.03		0.03

In model B, living arrangement had no direct impact on sustainable mode share (Figure 14). Instead, living at home affects mode share indirectly (-0.16), through mediating variables PTAL and car access. On average, millennials who live with parents live in less accessible locations which are more conducive to driving, and subsequently have a lower sustainable mode share. Similarly, millennials living at home are more likely to have access to a car, the most significant determinant of sustainable mode share (-0.39).

Figure 16. Model B determinants of sustainable mode share



	Effect on sustainable mode share		
	Direct	**Indirect**	**Total**
White	0.06	0.03	0.09
Age	-0.05	-0.04	-0.09
Male		0.00	0.00
Unemployed		0.01	0.01
Live with parents		-0.16	-0.16
PTAL	0.09	0.11	0.20
Car access	-0.39		-0.39

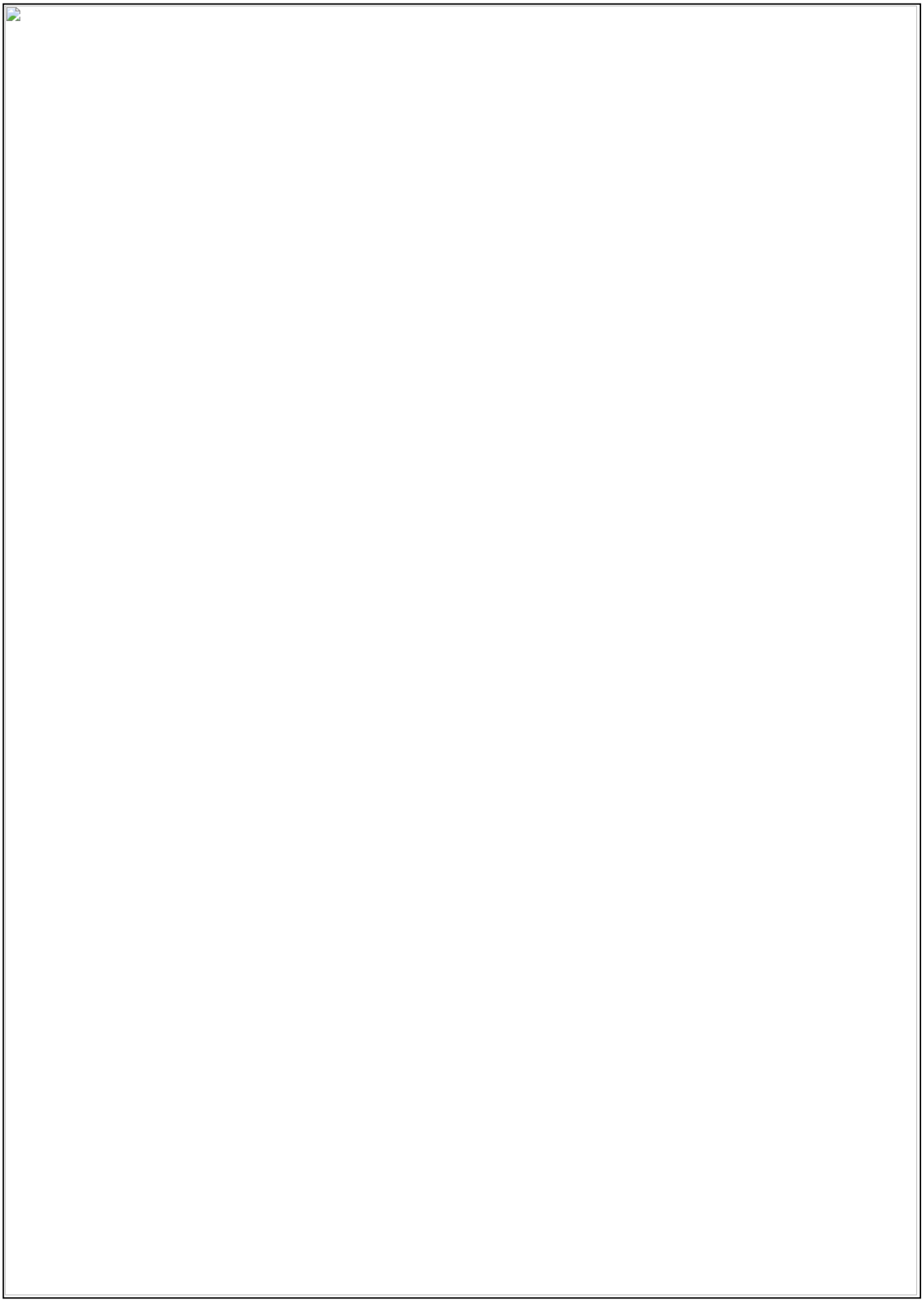
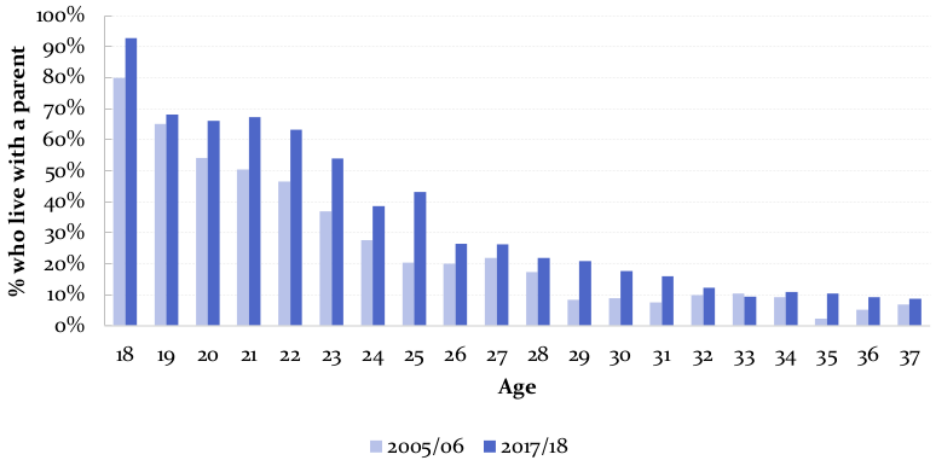


Figure 17. % of millennials inferred to live with parents by age over time



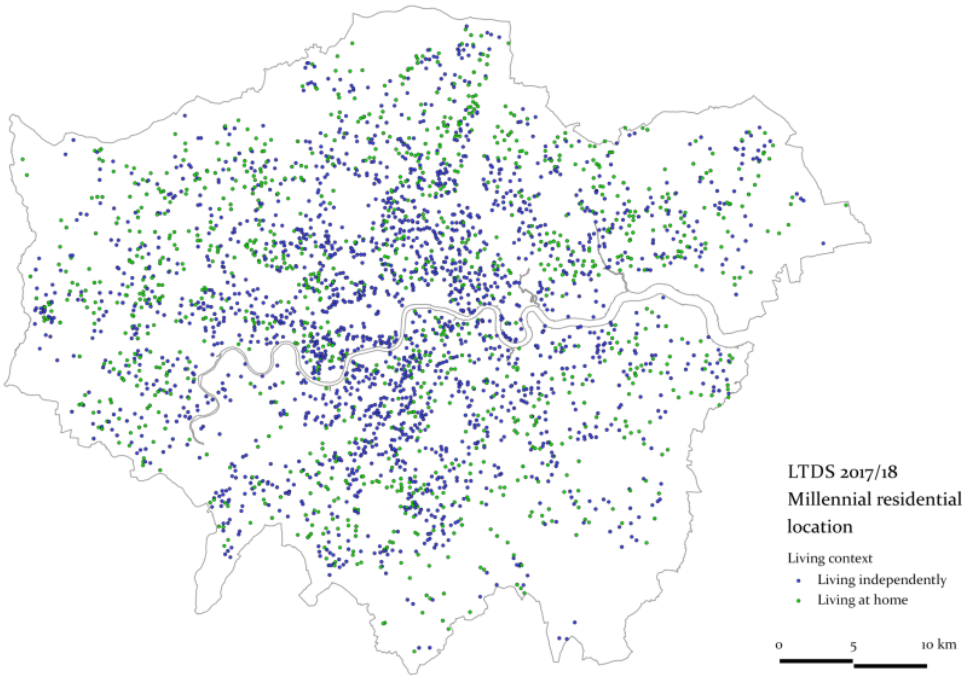
Contrary to the hypothesised relationship, models found no significant association between unemployment and living with parents. 14% of the millennial sample, both dependent and independent, were unemployed (Figure 9).

Employment status was modelled as a proxy for socio-economic group, but is unable to control for the increase in low wage, insecure and part-time employment among millennials (Resolution Foundation, 2018). While income is a more graduated differentiator of economic status, LTDS collects data on household rather than personal income and this was not considered representative of a millennials' economic situation. Household incomes were actually marginally higher in multi-generational households, probably due to the additional wage of adult dependents. Where lodging is provided at a subsidised rate or free of charge, millennials living with parents might record higher disposable incomes. Still, it is clear from the literature that material constraints shape the housing pathway of millennials (Clapham et al., 2019) and have necessitated a growing proportion to live with parents (IMFO, 2013, Roberts et al, 2013, Arundel and Ronald, 2016), an aspect that was not fully captured in these models and requires further research. This missing socio-economic facet may account for some of the unexplained differences in travel behaviour.

5.2. Location decisions

Overall, millennials are more likely to live in central and inner London than other cohorts, supporting previous evidence of millennial preferences for urban locations (Myers, 2016, Klein and Smart, 2017). But plotting where millennials live reveals differences in their distribution across London according to living arrangement (Figure 18 and Appendix 3). 55% of millennials who live independently live in outer London, compared to 72% of those living with parents. Subsequently, those living with parents are more likely to reside in areas of lower population density and low public transport accessibility (Figure 9). Such neighbourhoods tend to be more conducive to car use, leading to less frequent but longer trips. Of the variables tested, PTAL had the second strongest total effect on sustainable mode share (0.20) after car access. It had a weaker but still positive influence on trip making (0.03).

Figure 18. Spatial distribution of the millennial sample by living arrangement



If as studies suggest, young adults largely prefer to live in dense, transit-rich urban environments, this analysis suggests that millennials who live with parents are often constrained to residential locations that don't meet their preferences. There is, of course, some element of residential self-selection intrinsic to the decision of whether to move out of the family home. The literature on residential self-selection implicitly assumes that choice of residential location is unconstrained (Ettema and Nieuwenhuis, 2017). This disregards those who trade-off their travel preferences because of market restrictions (Wolday et al., 2018) or those with no choice at all. The extent to which young adults are living and making travel choices in a built environment that is different to one that they would self-select has implications for geographic and transport-related social exclusion (Church et al., 2000).

5.3. Travel distances

It follows that millennials who live with parents have longer commutes, living an average 10.3km from their place of work or education. This compares to an average commute distance of 8.98km for millennials who live independently and 7.37km for all adults. There are several potential explanations for this: millennials may have a higher propensity to commute long distances. Alternatively, they may be less able to locate close to employment because of housing costs, or the fixed location of their parents. Even where millennials can choose their place of work, many are not afforded the choice of residential location. Additionally, if living at home is considered temporary, dependent millennials might have a higher willingness to put up with long commute distances in the short term.

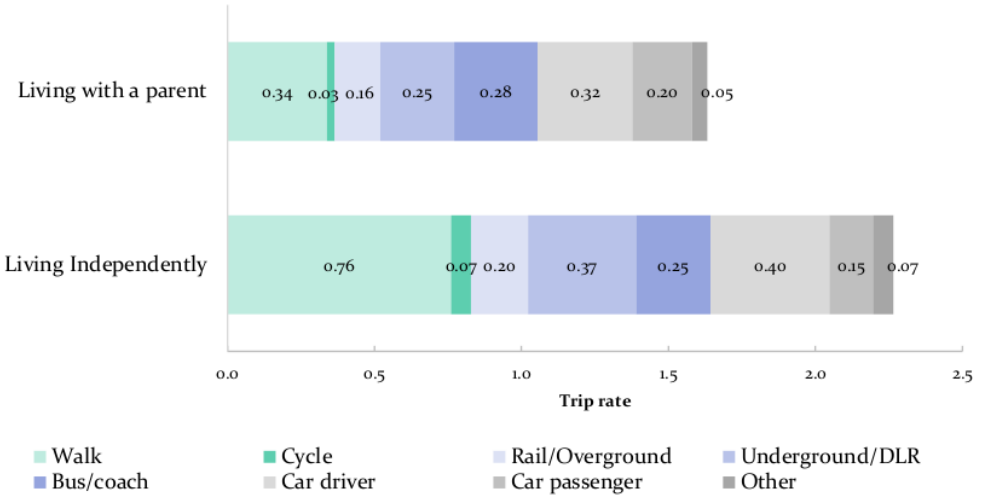
Analysis shows that those living at home also travel further in total, despite making fewer trips. This raises questions of time poverty (Kenyon et al., 2002) and social exclusion (Lucas et al., 2016) among millennials, particularly where living with parents interacts with ethnicity, class or another axis of disadvantage (Lykke, 2010, Hopkins, 2017). The pre-examined literature on social exclusion neglects consideration of the physical and social constraints faced by young adults co-residing with parents. This is, in part, because there are varied and complex reasons for co-residence. Some young adults live with a parent out of choice, using the family home as a 'launch pad' to save for the future, or to achieve a higher quality of life. For others, living at home is involuntary; a 'residence of last resort' (Roberts et al., 2016). In both cases, the agency of young adults is somewhat constrained (Evans, 2002) in that they are unable to choose their location in relation to work, friends or preferred leisure destinations. Visiting

friends who also co-reside with parents in a less accessible neighbourhood will probably require a car or taxi, and economically disadvantaged millennials may forgo this trip entirely. This indicates how delayed adulthood may interact with simultaneous social changes, e.g. the substitution of face-to-face interaction for digital communications. Although beyond the scope of this study, further research would be beneficial.

5.4. Active travel

Examining trip rates more closely, it is striking that millennials living with parents make considerably fewer trips by active modes. On the average day, independent millennials make twice as many walk and cycle trips as millennials who live with parents (Figure 19). This can be partly attributed to the concentration of multi-generational households in areas of lower density, which are less conducive to active modes (Kockelman, 1997, Ewing and Cervero, 2001, Van Acker and Witlox, 2010). But the socio-demographic and spatial variables included in model A explain a small part of the difference in trip rates by living arrangement. Identifying what is contributing to such divergent trip rates between the two millennial groups will be of particular concern to policy makers like TfL, as they seek to promote physical activity (TfL, 2018) amid growing recognition of the synergies between travel and health outcomes (BMA, 2012; Cavoli, 2015).

Figure 19. Trip rate mode shares by millennial segment



5.5. Car access

Interestingly, millennials who live with parents are more likely to have access to a car. 79% live in a household with a car, while only 50% hold a driver's license. Conversely, millennials who live independently are more likely to have a license than own a car. They display similar levels of license holding to the wider adult population (65%), but just half have access to a car (Figure 9). The difference in license holding between the two groups can partly be attributed to age, as both living independently and obtaining a license are associated with age.

The standardised results of path analysis found car access (-0.39) to be a stronger correlate of sustainable mode share than license holding (-0.28). It can be inferred that many of the cars accessible to dependent millennials belong to a family member. Despite lower rates of license holding, millennials who live with parents make more trips as a car passenger (Figure 19); 0.20 trips per day, compared to 0.15 for those living independently. Living with parents, and being driven by them, has the potential to undermine the 'peak car' hypothesis, even if millennials continue to delay license holding for economic reasons. These findings for London contrast with Chatterjee et al.'s UK study, which found that millennials living with parents were no less likely to be car drivers than those living independently. It also challenges their assertion that having access to the family car is unlikely to affect mode share. While these findings confirm the notion that the traditional association between independence and car use is not inevitable (Chatterjee et al., 2019), normalisation of dependent living may actually result in increase in car use in London, if young adults become accustomed to having access to their parent's car, or suburban lifestyles.

5.6. Limitations and further research

Path analysis has allowed the modelling of direct and indirect relationships between multiple independent and mediating variables. But despite its strengths, the outputs of this approach must be interpreted with caution. Path analysis tests for association between specified variables. But causality cannot be inferred from statistically significant correlations between variables (Hoyle, 1995).

Ralph and Delbosc challenge the heuristic basis of studies of millennial travel patterns, suggesting that transport planners have an ego-centric anchoring bias which leads to over-reporting of active and sustainable travel (Ralph and Delbosc, 2018). This is an important

caution in the design and interpretation of models. Similar to much of the seminal research in this area (cf. McDonald et al., 2015, Garikapati et al., 2016, Brown et al., 2016, Klein and Smart, 2017, Chatterjee et al., 2018), this study has analysed secondary rather than bespoke data to explore one potential determinant of the observed travel trends. The results also challenge some policy makers desired outcomes, concluding that reductions in car use, and achievement of sustainable, active and efficient mode share targets could stall if millennials continue to depend on parents.

This study aims to acknowledge the intersectionality of axis of identity, as identified in the literature. Path analysis was able to account for some inter-relationships between demographic and socio-economic groups. But statistical modelling of categorical variables required that many variables were modelled as simple dichotomies. In doing so, the models failed to account for more complex power relations that are reproduced through the daily interaction of age, gender, ethnicity, class and other factors which shape travel choices or the lack thereof (Lykke, 2010, Reyes and Mulinari, 2005, Levy, 2013). Despite their increasing complexity, statistical models such as path analysis 'struggle to capture the intricate nuances of people's everyday experiences of the transport system' (Lucas, 2011:3), particularly differences in preferences and attitudes within apparently homogenous socio-demographic groups (Van Acker et al., 2007, Van Acker and Witlox, 2009). This is an important issue for further research, which should contextualise the findings of this study by conducting qualitative interviews with a sample of millennial Londoners in a variety of living arrangements (cf. Clapham, 2019). A mixed-method approach could also explore nuances in the links between socio-demographic characteristics, living at home, residential preferences and car access in relation to theories of travel behaviour change.

Finally, travel demand is primarily a derived demand (Kitamura and Fujii, 1998, Mokhtarian and Solomon, 2001). For this reason, it would be helpful to analyse activity patterns alongside travel behaviour (Pas, 1984; Bowman and Ben-Akiva, 2000; Bhat and Singh, 2000). Both Maat and Timmermans (2009), and Ding and Lu (2016) found that adding activity participation as a mediating factor added explanatory power to their structural equation models of travel behaviour. To build on this research, future research investigating the impact of multi-generational living on travel behaviour should analyse trip activities concurrently (McFadden, 1974). It would be particularly interesting to understand the difference in time use of millennials by Inner and Outer London.

6. Conclusion

The average young adult travels substantially less today than they did 10 years ago, and is less likely to own or drive a car. Previous studies emphasise the contribution of a set of distinct millennial lifestyles to these emerging trends.

Individual travel choices are determined by a unique combination of needs, preferences, norms and constraints (McFaden, 1974, Oppenheim, 1995, Lyons et al., 2002). This thesis challenges the implicitly assumed homogeneity of the millennial cohort, revealing wide variation in the travel behaviours on young adults by living arrangement, focussing on the growing phenomenon of living with parents into adulthood. In doing so, it contributes evidence about the broader context in which millennials make travel choices (Chaterjee et al., 2018, Commission on Travel Demand, 2018). The results corroborate previous research that finds delayed transition to adulthood a causal factor in the changing travel patterns of young adults (Chatterjee et al., 2018).

Returning to the research question posed, this study has found that millennials who live with parents in London exhibit significantly different travel behaviours from those who live independently: travelling both less frequently and by less active and sustainable modes. Despite their theorised preferences for urban living, many millennials living with parents are constrained to lower density and less accessible locations. Additionally, millennials who live with parents are more likely to have access to a car, although they are less likely to hold a driving license than their independent counterparts.

London's housing market, with a relatively fixed housing supply and huge volumes of global capital inflows (Watt and Minton, 2016), provides a unique context to study the living arrangements of young adults, and resulting travel behaviours. While many global cities are facing similar housing affordability crisis, the extent to which similar findings would be found in other contexts depends on many factors. These include but are not limited to relative wage growth, the provision of housing subsidy, cultural norms relating to the transition to adulthood, the unique nature of the urban form and existing levels of car dependency.

Policy Implications

Millennials are now the largest living cohort (Delbosc and Nazin, 2018), making up 35% of London's population (ONS, 2018). Understanding future changes to millennial travel behaviour is crucial as transport planners predict travel demand (Chatterjee et al., 2018) and seek to encourage active and sustainable travel (TfL, 2014).

Should a growing proportion of millennials continue to live with their parents for longer (Clapham et al., 2019), the lower rates of active travel observed will have implications for the health of young Londoners, for whom daily travel is the primary source of physical activity (TfL, 2014). Additionally, suburbanisation of young adults due to high housing costs, and growing car acces, facilitated by multi-generational living, pose threats to the established trend of reduced car use among young adults. This could hinder the transition towards sustainable mobility (Banister, 2008), even if millennials continue to delay learning to drive.

The longevity of these effects depends on the extent to which London's housing market continues to price young adults out of accessible, urban neighbourhoods, and back into their family homes (Watt and Minton, 2016). Trends in travel behaviour may be inelastic, even if some of the causal factors reverse (Chatterjee et al., 2019). Attitudinal changes are more likely to endure than those that result from economic necessity (Ralph, 2018, Klein and Smart, 2016). But the development of norms and habits will preserve some behaviour changes. Increasing use and attachment to the car, and normalisation of multi-generational or suburban living may endure beyond economic recovery as millennials age and get wealthier. Future growth in inverse multi-generational living is also foreseeable, given the mounting need to care for parents into old age (Tapper, 2019).

The findings of this study highlight close inter-relationships between economic, housing and transport outcomes in London, confirming that 'causes of the changes in young people's travel lie largely outside transport' (Chatterjee et al., 2018: 1). Accordingly, transport planners must look beyond traditional determinants of travel demand, and adopt a multi-disciplinary outlook to consider uncertain and wide-ranging forces that fundamentally alter the constraints, norms, needs and preferences under which young adults make travel choices. Similarly, policy makers must also look beyond traditional transport solutions to encourage active and sustainable travel in the future. For example, subsidised models of shared housing may assist young adults to follow the trajectories towards urban living that helped facilitate earlier declines in car travel. This research also points towards the need for higher quality public transport provision in outer London, where a growing population of young adults are

living at a formative and habit-forming life stage (Scheiner, 2018), before the grip of car dependency tightens.

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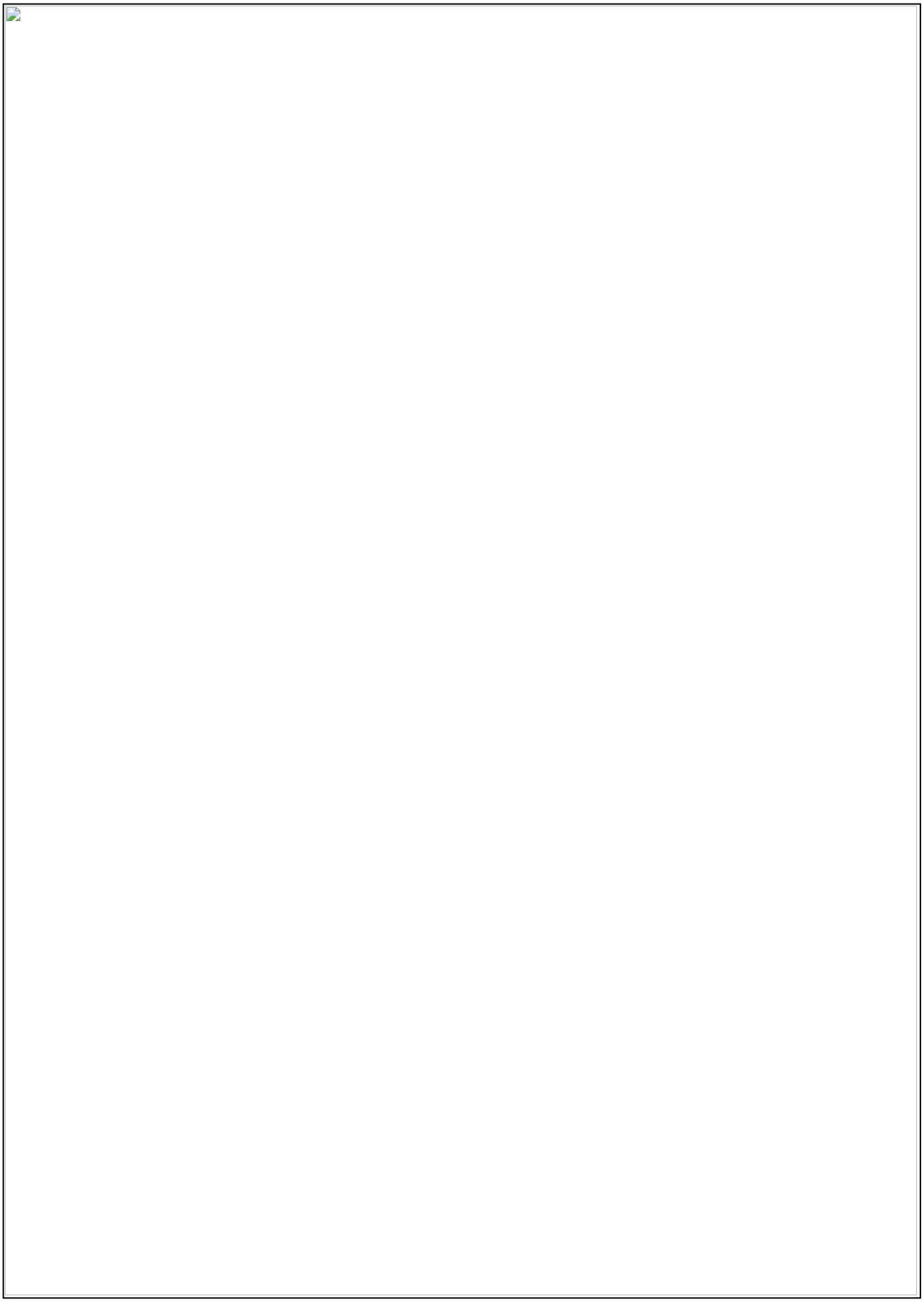

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Appendix 1: Data tables

Table 1. Model A results: Trip rate

Variables	Std. estimate	Standard Error	z-value
Unemployed~			
White	-0.10	0.01	-7.33
Male	-0.17	0.01	-13.2
Live with parents ~			
Male	0.06	0.01	4.78
White	-0.16	0.01	-13.8
Age	-0.042	0.00	-36.4
PTAL ~			
Live with parents	-0.28	0.05	-20.9
Age	-0.19	0.01	-13.6
Unemployed	-0.05	0.06	-3.90
Trip rate ~			
Live with parents	-0.13	0.05	-9.27
White	0.05	0.06	4.06
Male	-0.04	0.04	-2.79
Age	0.04	0.01	3.27
Unemployed	-0.07	0.07	-5.11
PTAL	0.03	0.01	2.17
Variances			
Unemployed	0.96	0.00	37.6
Live with parents	0.79	0.00	64.6
PTAL	0.93	0.04	70.7
Trip rate	0.96	0.07	41.9

Table 2: Model B results: sustainable mode share

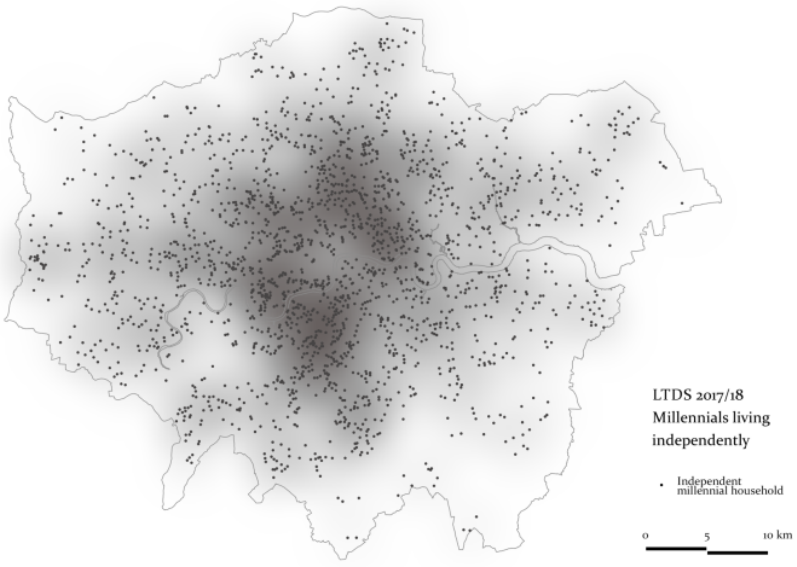
Variables	Std. estimate	Std.Err	z-value
Unemployed ~			
White	-0.09	0.01	-5.74
Male	-0.17	0.01	-11.6
Live with parents ~			
White	-0.17	0.01	-12.3
Age	-0.40	0.00	-28.4
Male	0.05	0.01	3.74
PTAL ~			
Live with parents	-0.26	0.06	-17.3
Age	-0.21	0.01	-13.3
Unemployed	-0.04	0.08	-2.85
Car access ~			
Live with parents	0.29	0.02	19.2
PTAL	-0.29	0.00	-20.1
White	-0.03	0.01	-2.06
Age	0.17	0.00	11.7
Unemployed	-0.06	0.02	-4.15
Sustainable mode share ~			
White	0.06	0.01	4.14
Age	-0.05	0.00	-3.65
Car access ~	-0.39	0.01	-28.5
PTAL	0.09	0.00	6.33
Variances			
Unemployed	096	0.00	26.8
Live with parents	0.82	0.00	52.7
PTAL	0.93	0.04	61.16
Car access	0.80	0.00	71.8
Sustainable mode share	0.80	0.00	59.2

Table 3. Path analysis model fit summary

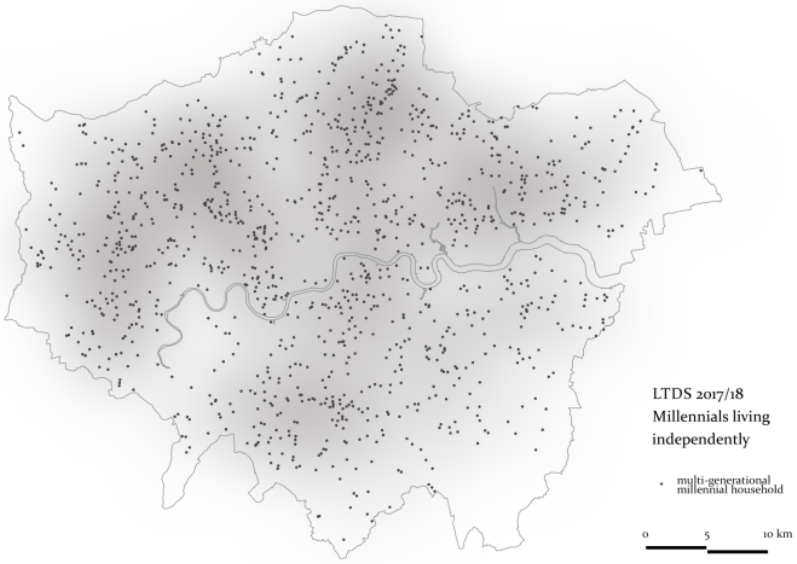
	Model 1: Trip rate	**Model 2: Sustainable mode share**
Number of observations	6438	4717
χ^2	13.6	13.2
χ^2/df	3.40	1.65
df	4	8
P-value (χ^2)	0.01	0.11
Comparative Fit Index (CFI)	0.996	0.998
Tucker-Lewis Index (TLI)	0.980	0.995
RMSEA	0.020	0.012
SRMR	0.008	0.008
R^2		
Unemployed	0.037	0.037
Live with parents	0.207	0.185
PTAL	0.071	0.072
Car access		0.201
Sustainable mode share		0.198
Trip rate	0.037	

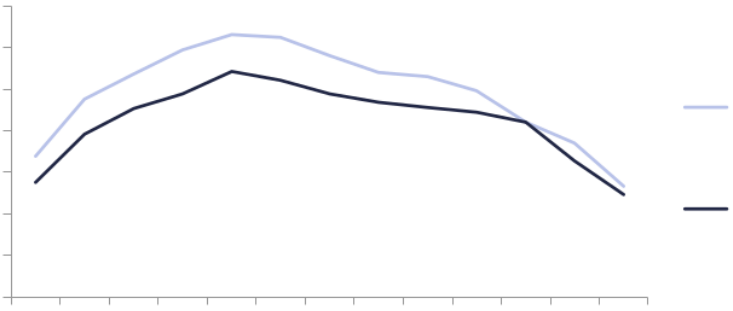
Appendix 2: Maps

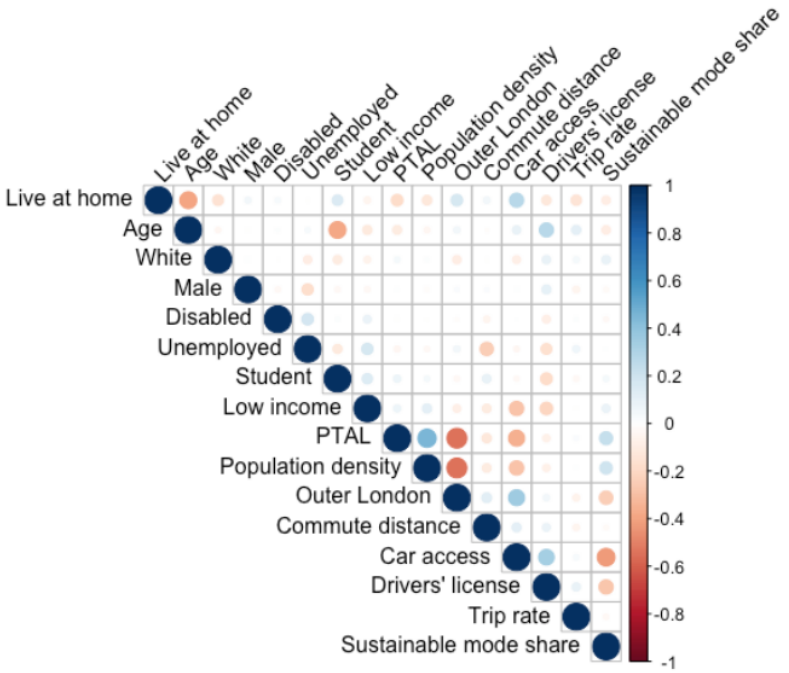
Map 1. Concentration of residential locations, millennials who live with a parent

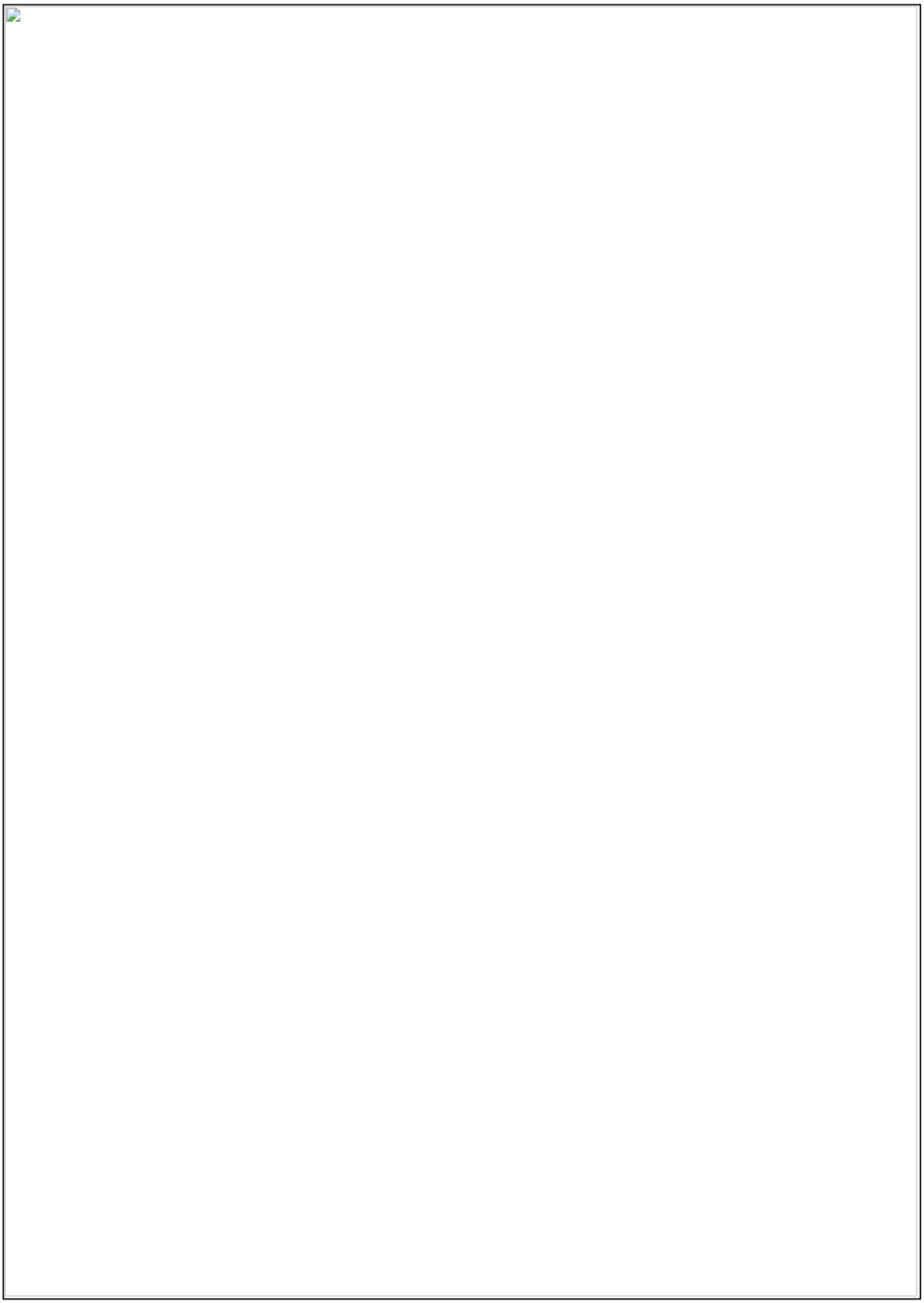


Map 2. Concentration of residential locations, millennials who live independently






Live at home
Age
White
Male
Disabled
Unemployed
Student
Low income
PTAL
Population density
Outer London
Commute distance
Car access
Drivers' license
Trip rate
Sustainable mode share
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1



```
millennialsamplev2$caraccess <-ifelse(millennialsample$hhcars >=1, 1,0)
millennialsamplev2$unemployed <-ifelse(millennialsample$pwkstat >=6, 1,0)
millennialsamplev2$white<-ifelse(millennialsample$pegroup <=3 |
```

Query 3. T-test

```
#Trip rate t-test
t.test(triprate ~ LAH, data=millennialsample)

#Sustainable mode share t-test
t.test(modeshare ~ LAH, data=millennialsample)
```

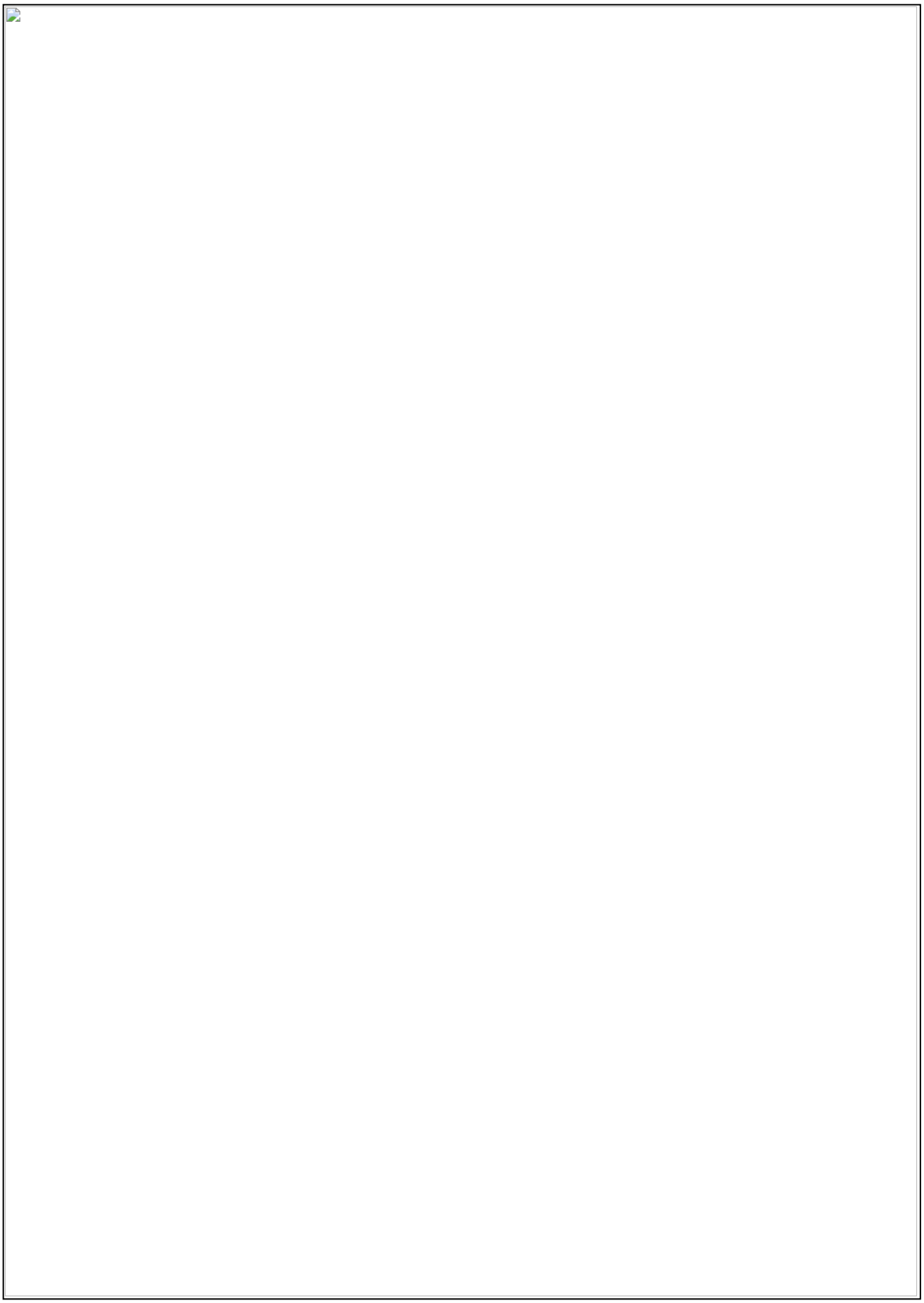
Query 4. Structural Equation Model

```
#Trip rate SEM
triprate<- '
unemployed~p1*white+p2*male
LAH~p3*male+p4*white+p5*age
PTAL~p7*LAH+p8*age+p9*unemployed
triprate~p10*LAH+p11*white+p12*male+p13*age+p14*unemployed+p15*PTAL'

fit1<-sem(mtriprate, data=millennialsample, estimator="MLR")
summary(fit1, fit.measures=TRUE, standardized=TRUE, rsq=TRUE, )

#Sustainable mode share SEM
unemployed~p1*white+p2*male
LAH~p3*white+p4*age+p5*male
PTAL~p6*LAH+p7*age+p8*unemployed
caraccess~p9*LAH+p10*PTAL+p11*white+p12*age+p13*unemployed
modeshare~p14*white+p15*age+p16*caraccess+p17*PTAL'

fit2<-sem(mmodeshare, data=millennialsample, estimator="MLR")
summary(fit2, fit.measures=TRUE, standardized=TRUE, rsq=TRUE)
```



EQUIPMENT	Is equipment used?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. clothing, outboard motors.	Examples of risk: inappropriate, failure, insufficient training to use or repair, injury. Is the risk high / medium / low ?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for equipment is followed
☐	participants have been provided with any necessary equipment appropriate for the work
☐	all equipment has been inspected, before issue, by a competent person
☐	all users have been advised of correct use
☐	special equipment is only issued to persons trained in its use by a competent person
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

LONE WORKING	Is lone working a possibility?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. alone or in isolation lone interviews.	Examples of risk: difficult to summon help. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for lone/out of hours working for field work is followed
☐	lone or isolated working is not allowed
☐	location, route and expected time of return of lone workers is logged daily before work commences
☐	all workers have the means of raising an alarm in the event of an emergency, e.g. phone, flare, whistle
☐	all workers are fully familiar with emergency procedures
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

ILL HEALTH	The possibility of ill health always represents a safety hazard. Use space below to identify and assess any risks associated with this Hazard.
e.g. accident, illness, personal attack, special personal considerations or vulnerabilities.	Hazard: Medical conditions resulting from extended display screen equipment use Risk: LOW

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	an appropriate number of trained first-aiders and first aid kits are present on the field trip
☐	all participants have had the necessary inoculations/ carry appropriate prophylactics
☐	participants have been advised of the physical demands of the trip and are deemed to be physically suited
☐	participants have been adequate advice on harmful plants, animals and substances they may encounter
☐	participants who require medication have advised the leader of this and carry sufficient medication for their needs
X	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

Take sufficient breaks to ensure I vary posture, and change visual demands.
Use workstation with sufficient lighting levels to reduce reflection and glare.
Work in quiet, temperature and humidity controlled office environment to avoid distraction or impaired concentration.

TRANSPORT	Will transport be required	NO	X	Move to next hazard
		YES		Use space below to identify and assess any risks
e.g. hired vehicles	Examples of risk: accidents arising from lack of maintenance, suitability or training Is the risk high / medium / low?			

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	only public transport will be used
☐	the vehicle will be hired from a reputable supplier
☐	transport must be properly maintained in compliance with relevant national regulations
☐	drivers comply with UCL Policy on Drivers http://www.ucl.ac.uk/hr/docs/college_drivers.php
☐	drivers have been trained and hold the appropriate licence
☐	there will be more than one driver to prevent driver/operator fatigue, and there will be adequate rest periods
☐	sufficient spare parts carried to meet foreseeable emergencies
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

DEALING WITH THE PUBLIC	Will people be dealing with public	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. interviews, observing	Examples of risk: personal attack, causing offence, being misinterpreted. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	all participants are trained in interviewing techniques
☐	interviews are contracted out to a third party
☐	advice and support from local groups has been sought
☐	participants do not wear clothes that might cause offence or attract unwanted attention
☐	interviews are conducted at neutral locations or where neither party could be at risk
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

WORKING ON OR NEAR WATER	Will people work on or near water?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. rivers, marshland, sea.	Examples of risk: drowning, malaria, hepatitis A, parasites. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	lone working on or near water will not be allowed
☐	coastguard information is understood; all work takes place outside those times when tides could prove a threat
☐	all participants are competent swimmers
☐	participants always wear adequate protective equipment, e.g. buoyancy aids, wellingtons
☐	boat is operated by a competent person
☐	all boats are equipped with an alternative means of propulsion e.g. oars
☐	participants have received any appropriate inoculations
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

MANUAL HANDLING (MH)	Do MH activities take place?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. lifting, carrying, moving large or heavy equipment, physical unsuitability for the task.	Examples of risk: strain, cuts, broken bones. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for MH is followed
☐	the supervisor has attended a MH risk assessment course
☐	all tasks are within reasonable limits, persons physically unsuited to the MH task are prohibited from such activities
☐	all persons performing MH tasks are adequately trained
☐	equipment components will be assembled on site
☐	any MH task outside the competence of staff will be done by contractors
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

SUBSTANCES	Will participants work with substances	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. plants, chemical, biohazard, waste	Examples of risk: ill health - poisoning, infection, illness, burns, cuts. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangements for dealing with hazardous substances and waste are followed
☐	all participants are given information, training and protective equipment for hazardous substances they may encounter
☐	participants who have allergies have advised the leader of this and carry sufficient medication for their needs
☐	waste is disposed of in a responsible manner
☐	suitable containers are provided for hazardous waste
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

OTHER HAZARDS	Have you identified any other hazards?	NO	If 'No' move to next section If 'Yes' use space below to identify and assess any risks
i.e. any other hazards must be noted and assessed here.			

CONTROL MEASURES	Give details of control measures in place to control the identified risks

Have you identified any risks that are not adequately controlled?			
	NO	X	Move to Declaration
	YES		Use space below to identify the risk and what action was taken

Is this project subject to the UCL requirements on the ethics of Non-NHS Human Research? NO

If yes, please state your Project ID Number

For more information, please refer to: http://ethics.grad.ucl.ac.uk/

DECLARATION	The work will be reassessed whenever there is a significant change and at least annually. Those participating in the work have read the assessment.

Select the appropriate statement:

X	I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
X	I the undersigned have assessed the activity and associated risks and declare that the risk will be controlled by the method(s) listed above

NAME OF SUPERVISOR Emilia Smeds, 9.4.2019

**** SUPERVISOR APPROVAL TO BE CONFIRMED VIA E-MAIL ****