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Inequalities in Mobility and Access in the UK Transport System

Future of Mobility: Evidence Review

Foresight, Government Office for Science

Inequalities in Mobility and Access in the UK Transport System

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Executive Summary

This study provides a rapid desk-based review of the evidence on the equity and inclusion outcomes of technological, behavioural and policy innovations in the UK transport system to 2040.

The report takes as its building block the report from the Social Exclusion Unit (SEU) (2003), which first identified the important links between unequal mobility and inability to access jobs, education, training, healthcare, affordable food and leisure opportunities in the UK.

The review has involved:

i) A review of the published literatures from 2002-2018 pertaining to a) current transport and accessibility inequalities in the UK and b) scenarios that consider potential future inequalities arising from the uptake of new mobility technologies and future transport systems.
ii) Basic trend analysis of relevant national survey datasets to identify current distributions of travel by income, age, gender and disability, and the accessibility outcomes of these distributions.
iii) Qualitative evaluation of the likely impacts of different future scenarios on the distributions of mobility and accessibility in the UK to 2040 based on a workshop with researchers at the Institute for Transport Studies at the University of Leeds.
iv) Recommendations about the potential for greater social inclusion within the UK transport system, based on evidence of good practices from elsewhere.

Our review has identified that the published academic and policy evidence for this specific topic is quite sparse. Much of the future scenario and visioning work that was reviewed for this report does not explicitly consider the consequences of future transport innovations on current inequalities.

This a serious problem because the review shows that many people in the UK may not be able to access important local services and activities, such as jobs, learning, healthcare, food shopping or leisure as a result of a lack of adequate transport provision. Problems with transport and poor links to opportunity destinations can also contribute to social isolation, by preventing full participation in these life-enhancing opportunities. The worst effects of road traffic can also lead to reduced quality of life due to high levels of exposure to pedestrian casualties and fatalities, and traffic-related air and noise pollution, especially in dense urban areas.

As such, we recommend that more evidence and dedicated research is urgently needed to assess the differential impacts of new and emerging transport technologies and innovations across different social groups and places. Based on the evidence we have reviewed, we recommend that carefully designed policy interventions are needed to ensure that the current inequalities in mobility and accessibility do not deepen and widen.

The report demonstrates that mobility and accessibility inequalities are highly correlated with social disadvantage. This means that some social groups are more at risk from mobility and accessibility inequalities, than others:

- Car owners and main drivers in households are least mobility constrained across all social groups. They make more trips over longer distance for all journey purposes giving them higher levels of access to activity opportunities;
- Lowest income households have higher levels of non-car ownership, 40% still have no car access – female heads of house, children, young and older people, black and minority ethnic (BME) and disabled people are concentrated in this quintile;
- In addition, there are considerable affordability issues with car ownership for many low-income households.

Beyond these accessibility inequalities, low income households and other vulnerable population groups, such as children, the elderly, people with mental disabilities or long-term illnesses are also more exposed to health-related externalities of the transport system:

- People living in disadvantaged areas tend to live in more hazardous environments, with greater proximity to high volumes of fast-moving traffic and high levels of on-street parking and, as such, they have higher levels of exposure to road traffic risk.
- Young people (11–15 years) from disadvantaged areas are more involved in traffic injuries than their counterparts living in other urban areas. The risk is highest on main roads and on residential roads near shops and leisure services.
- Traffic-related air pollution is associated with worse pregnancy outcomes and the risk of death and exacerbation of asthma and chronic chest illnesses in children.

Inequalities in the provision of transport services are strongly linked with where people live, and the associated differences in access to employment, healthcare, education, and local shops. This problem is more to do with land-use and public service planning, which determines the physical location and spatial distribution of these services in relation to low cost housing, than with deficiencies in the transport system itself. However, the lack of private vehicles in low-income households, combined with limited public transport services in many peripheral social housing estates, considerably exacerbates the problem in many parts of the UK.

There is an urgent need for policies to more explicitly recognise the important social value of transport. Public transport service limitations, combined with largely unregulated land-use development are driving a mobility culture that most advantages already highly-mobile and well-off sections of the population, while worsening the mobility and accessibility opportunities of the most socially disadvantaged in the UK.

We recommend that it is not too late for national and local policymakers to act to ensure that the maximum people benefit from these new technologies and

innovations that are emerging to make them more accessible to the groups who currently find it hard to access the transport system. But they need to act quickly and to do so from a firm evidence base of how they can maximise the benefits of the new transport landscapes, whilst also protecting the most vulnerable and disadvantaged from their worst effects, such as further social isolation and market exclusions.

1 Introduction

This study provides a rapid desk-based review of the evidence on the equity and inclusion outcomes of technological, behavioural and policy innovations in the UK transport system to 2040. These issues are important because unequal mobility, which is usually caused by an inadequate supply of local transport services, often leads to reduced access to jobs, goods, services and other activities. Overtime, a reduced ability to participate in these areas of life can seriously reduce wellbeing and quality of life. This situation is often referred to in policy literature as *social exclusion* (Schwanen et al., 2015).

The report takes as its building block the report from the Social Exclusion Unit (SEU) (2003), which first identified the important links between unequal mobility and inability to access jobs, education, training, healthcare, affordable food and leisure opportunities in the UK. It builds on the premise put forward by the SEU that a people-centric approach to understanding transport accessibility and inclusion is the key to ensuring socially sustainable transport futures for all.

The review has involved four key components:

i) A rapid synthesis review of a) the available published literatures from 2002-2017 in the areas of transport inequalities, accessibility to key activities, and transport-related social exclusion, and b) the scenario-based literatures that consider potential future inequalities arising from the uptake of new mobility technologies and future transport systems.
ii) Basic trend analysis of data pertinent to travel behaviours to understand transport and mobility in the UK, to identify current distributions by income, age, gender and disability, and the accessibility outcomes of these distributions. This involved desk-based analysis of publicly available national datasets, such as the National Travel Survey, Living Costs and Food Survey and the Department for Transport Accessibility Index.
iii) Qualitative evaluation of the likely impacts of different future scenarios on the distributions of mobility and accessibility in the UK to 2040. This was based on a workshop session with researchers and students from the Social and Political Sciences Research Group of the Institute for Transport Studies at the University of Leeds. The 15 workshop participants discussed the overarching findings from the literature review, reports and data analysis, and added their own expertise and ideas to the summary overview table in the Appendix. We also consulted with outside experts from the Department for Transport, local transport authorities and NGOs working in this area.
iv) Recommendations about the potential for greater social inclusion within the UK transport system, based on evidence of good practices from elsewhere.

2 Why do inequalities in mobility and access matter?

People may not be able to access services as a *result* of social exclusion. For example, they may be restricted in their use of transport by low incomes, or because bus routes do not run to the right places. Age and disability can also stop people driving and using public transport. Problems with transport provision and the location of services can also *reinforce* social exclusion. They prevent people from accessing key local services or activities, such as jobs, learning, healthcare, food shopping or leisure. Problems with transport and poor links to opportunity destinations can contribute to *social isolation*, by preventing full participation in these life-enhancing opportunities. The worst effects of road traffic can also lead to reduced quality of life due to high levels of exposure to pedestrian casualties and fatalities, and traffic-related air and noise pollution, especially in dense urban areas.

In 2003, the SEU report identified that differences in access to transport across social groups may not *always* be a problem, providing that people have good levels of access to jobs, goods, services and other essential activities in the local areas where they live. It is also important to recognise that people's needs and experiences differ by the type of area they live in (for example urban or rural), their household structure, and that some individuals might experience specific barriers to mobility and access e.g., disabled people.

A new problem that has emerged since the SEU report is the issue of obesogenic lifestyles and the physical environments and activity trends that contribute to this. In England figures show an increase in levels of obesity over the period 1993 to 2013 from 13.2% to 26.0% for men and 16.4% to 23.8% for women. The figures also show a rise in levels of child obesity (Health and Social Care Information Centre, 2015). Reductions in walking and other physical activities due to increasing car dependence within households can be part of the problem, especially for children, although it is recognised that the phenomenon is more complex than this.

As the evidence in this report will go on to demonstrate, mobility and accessibility inequalities are highly correlated with social disadvantage. This means that some social groups are more at risk from mobility and accessibility inequalities, than others:

- Car owners and main drivers in households are the least mobility constrained across all social groups. They make more trips over longer distance for all journey purposes giving them higher levels of access to activity opportunities;
- Lowest income households have higher levels of non-car ownership, 40% still have no car access – female heads of house, children, young and older people, BMEs and disabled people are concentrated in this quintile;
- In addition, there are considerable affordability issues with car ownership for many low-income households;
- Gender differences in car use are declining, but women are still less likely to be the main driver in households. People with mobility difficulties remain at

roughly 38% of households with car ownership, and they travel much less than the average population, but roughly twice the distance of their public transport counterparts.
- Public transport dependent groups in both rural and urban peripheral areas often have difficulties reaching key activities such as work, education and healthcare. For example, over half of the working-age population (57%) live in areas with low public transport access to jobs, i.e. within reach of 45 minutes travel time and 66% (7.8 million) of elderly people cannot reach a hospital within 30 minutes by public transport, with serious implications for a rapidly ageing society such as the UK.
- The 2003 Social Exclusion Unit report identified that two out of five job seekers could not get a job due to a lack of transport, 31% of people without cars could not access a hospital, 16% of households without cars found it difficult to access a supermarket, and 6% of 16- to 18-year-olds turned down training or further education because of travel costs.

Beyond these accessibility inequalities, low income households and other vulnerable population groups, such as children, the elderly, people with mental disabilities or long-term illnesses are also more exposed to health-related externalities of the transport system:

- People living in disadvantaged areas tend to live in more hazardous environments, with greater proximity to high volumes of fast-moving traffic and high levels of on-street parking and, as such, they have higher levels of exposure to road traffic risk.
- Young people (11–15 years) from disadvantaged areas are more involved in traffic injuries than their counterparts living in other urban areas. The risk is highest on main roads and on residential roads near shops and leisure services.
- Traffic-related air pollution is associated with the risk of death and chronic disease, including asthma and atopy in children, worse pregnancy outcomes, and exacerbation of chronic chest illnesses.

Transport can be a key barrier to employment

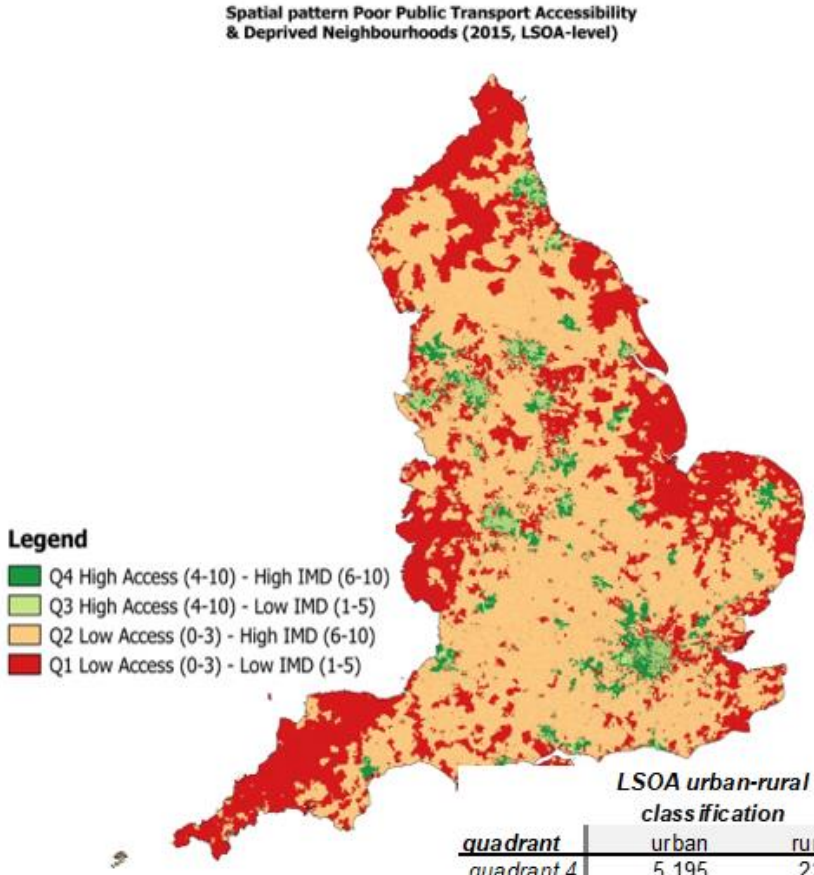
People on short-term or zero-hour contracts, or those who have to move home or workplace unexpectedly, cannot always predict or plan their travel patterns. This ongoing uncertainty can make owning a car a necessity for many on lower incomes, even when it is hard to afford one. Many people without a car report diminished job opportunities (DEMAND, 2015).

Job seekers from deprived backgrounds say it’s difficult to attend interviews when they are dependent on inadequate public transport services (Davis et al., 2012). It also constrains their job search horizons and prevents them from keeping a job (Patacchini, 2005).

Even where public transport is physically present, overcrowding and unreliable services as well as concerns over safety and security (particularly after dark) may pose barriers in travelling to employment opportunities (Transport for London, 2012).

Access to employment may be further constrained by the costs of transport. Low-income households often spend a relatively large proportion of their income on commuting costs (around 25% compared with the average of approx.13%), with an associated trade-off between expected income and travel costs (Cain and Jones, 2008).

Mapped analysis of the Department for Transport Journey Time Statistics data for 2015 (Department for Transport, 2015), as shown on the map below, identifies access to jobs by public transport in different areas of the UK, where there are larger employment centres. 45 minutes is the average journey to work time for the UK. This map thus reflects both the number of large employment centres (5000+ jobs), and the availability of public transport.



	LSOA urban-rural classification		*working age (age 16-74) population*	
quadrant	urban	rural	abs.	%
quadrant 4	5,195	220	7,114,598	17.81%
quadrant 3	8,544	47	10,038,675	25.12%
quadrant 2	7,221	3,786	13,166,264	32.95%
quadrant 1	6,286	1,545	9,635,859	24.12%
total	**27,246**	**5,598**	**39,955,396**	**100.00%**

Notes:
The index provides the number of reachable employment centres (0 to 10) with at least 5,000 jobs, and thus the map's focus is on larger urban areas.
The English Index of Multiple Deprivation (IMD) provides a decile score between 1 (most deprived) and 10 (least deprived) for all Lower Layer Super Output Areas (LSOAs).
The LSOAs are classified as urban or rural areas based on the ONS 2011 Rural-Urban Classification.
The analysis uses 2015 data, which was the latest available at the time of analysis.

Figure 1. Map of accessibility to jobs within 45 minutes by public transport

Source: based on DfT Journey time statistics (2015)

The data in the table above show that over half of the working-age population (57%) live in areas with lower access to jobs, i.e. a below average number of 5000+ job centres within reach of 45 minutes travel time by public transport. Nearly a quarter of the working-age population live in areas with both low access to jobs and high deprivation (Quadrant 1).

The distribution of employment centres also affects access to jobs. In England, for example around 99% of the population live within 45 minutes by public transport of an employment centre with 100-499 jobs, this falls to 82% for employment centres of 5000+ jobs (DfT, 2018). This partially reflects the lower number of employment centres.

When comparing the levels of job accessibility for 2015 with those from 2010 and 2007, the pattern of poor job accessibility has remained relatively constant. Although poor public transport accessibility to jobs is worse in rural areas, slightly less than half of the urban areas also present low access to jobs.

Limited community and public transport in rural areas can hinder participation in social and economic activities, thereby putting people at risk of exclusion from the labour market (Noack, 2011). Limited public transport services in disadvantaged (sub)urban neighbourhoods may also make a car necessary to search for jobs and take up employment (Curl, Clark and Kearns, 2017).

The car is often viewed as crucial in enabling women to participate in the labour market. Dobbs (2005) shows that many rural women are prevented from participating in employment activities due to their social roles in the household and poor public transport services.

While concessionary fares for older people are protected by national statute, those available for younger people are discretionary and their subsidy is limited by the amount of local authority funding available. This has happened in conjunction with the rising cost of public transport fares generally and reductions in reduced fares for these groups by many of the bus operators outside of London (Houston and Tilley, 2015). The cost of public transport fares is reported as the biggest issue for young people, making access to employment, education, training or their local communities more challenging (British Youth Council, 2012).

Access to a private car provides an advantage for low-income people and immigrants seeking work. Lack of access to a car can provide a barrier to taking up education and training opportunities for young people. A 2013 study of young low-skilled job seekers in Belfast found that people without private transport had more localised outlooks, reducing their employment and training opportunities (Bourn, 2013).

There is a significant relationship between job accessibility by bus and employment outcomes of job seekers. Based on modelled analysis Johnson, Mackie, and Ercolani (2014), a 10% decrease in bus travel times to jobs across England resulted in a predicted 0.2% increase in employment, which would amount to more than 50,000 extra jobs.

Targeted transport policies can also enhance the mobility of younger people, so that they become more experienced and confident in using available public transport to access new employment locations (Green, Shuttleworth and Lavery, 2005).

An assessment of Transport to Employment (T2E), which offers subsidised on-demand community-based transport and shared taxi services in rural Scotland, was found to move people into employment, with social and economic benefits that outweighed the investment by 3:1 (Wright et al., 2009).

Lack of transport can reduce access to education and training opportunities

Public transport dependence is problematic when escorting children to a nursery or to school (Kenyon, 2010). In particular, lone parents are more likely to have lower incomes and to lack access to a private car. This can mean time-consuming and expensive child escort trips, which may reduce their children's access to good schools and participation in after-school activities (Titheridge and Solomon, 2008).

Transport problems have been linked to low participation in post-16 education and to college dropouts. A study in Kent found that students from low-income households didn't make many of the journeys they needed to fully participate in academic activities as the journeys were unaffordable. The opportunity to obtain a discounted travel card was not taken up by the students because a one-off payment was required, which low-income families were unable to afford. (Titheridge and Solomon, 2008).

Reduced support for post-16 transport to education is limiting the options of young people to access further education, and the removal of the Education Maintenance Allowance has further disadvantaged young people in rural areas who tend to be more reliant on higher-cost public transport trips. While being able to use and afford a car becomes increasingly essential, the costs – particularly insurance costs – are often prohibitive for young drivers (Commission for Rural Communities, 2012).

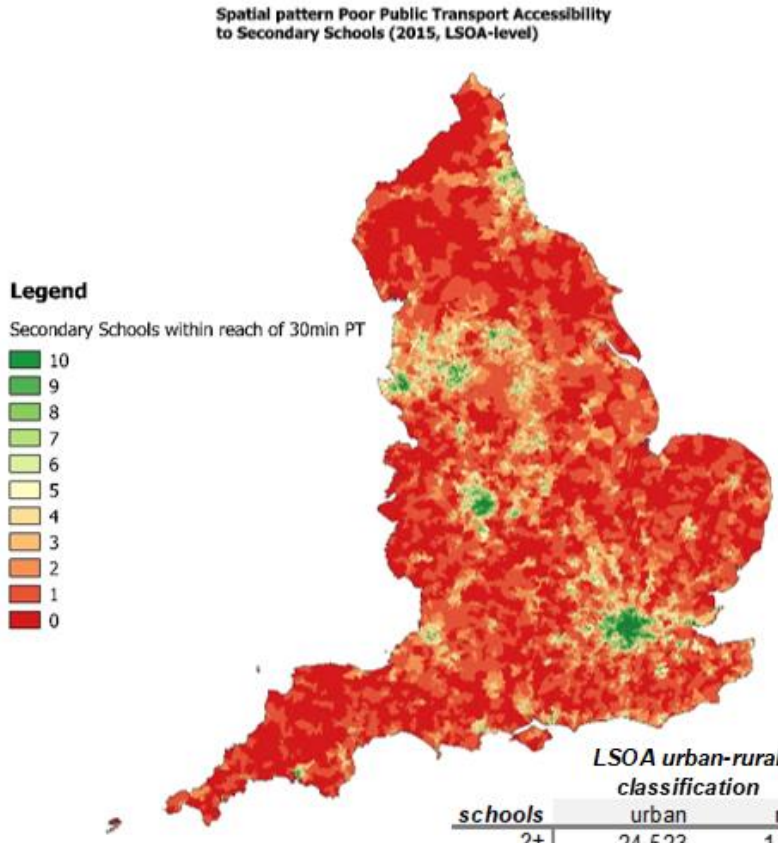
Not only transport but also the physical location of universities and colleges is an important aspect in the mobility decisions of students in higher education (Kenyon, 2010). Even when extensive public transport networks exist within the city centres, commuting into the city from the surrounding area, where many colleges and universities are located, can be restricted to private car and train, both of which are expensive options for students.

Analysis of public transport accessibility to secondary schools is based on the number of schools within 30 minutes by public transport (30 minutes is the average minimum journey time[1] to school). These figures are then matched to the number of children (aged 11 to 18). The data show that 5.49% of the children (282,069) cannot reach a

[1] The average minimum journey time is measured as the shortest travel time from a single point in the Output Area to a given service by a particular mode of transport. This single point is where the average person lives in a region (i.e. the population-weighted centre of the output area). For more details see Accessibility Statistics: Travel time calculation methodology (Department for Transport, 2014)

secondary school within 30 minutes by public transport. This spatial pattern is mainly visible in more rural areas.

The map below shows that a further 15% of the children (779,498) are able to reach *only one school within 30 minutes* by public transport. This constrains their educational choices, and may also result in a reduced quality of education, as not all schools have the same performance levels or curricular activities. The mapped analysis obviously doesn't take account of transport affordability, while costs of public transport fares and car use are found to be major barriers to education (e.g. British Youth Council, 2012).



	LSOA urban-rural classification		children aged 11-18	
schools	urban	rural	abs.	%
2+	24,523	1,639	4,072,236	79.32%
1	2,493	2,417	779,498	15.18%
0	230	1,542	282,069	5.49%
total	27,246	5,598	5,133,803	100.00%

Figure 2. Map of accessibility to schools within 30 minutes by public transport

Source: based on DfT Journey time statistics (2015)

The lack of affordable transport can be also particularly exclusionary for young people living in rural regions, where the two key cited factors affecting access to opportunities and key activities were having a driving licence and being able to afford a car (Shergold and Parkhurst, 2012).

Evidence from Edinburgh and the Lothians, Scotland, shows that many students who lived outside the city had switched from the bus to a private car by the end of their first year, as it provided increased individual flexibility to be at class on time, to get to work in the evenings and weekends, and to engage in social activities (Christie, 2007).

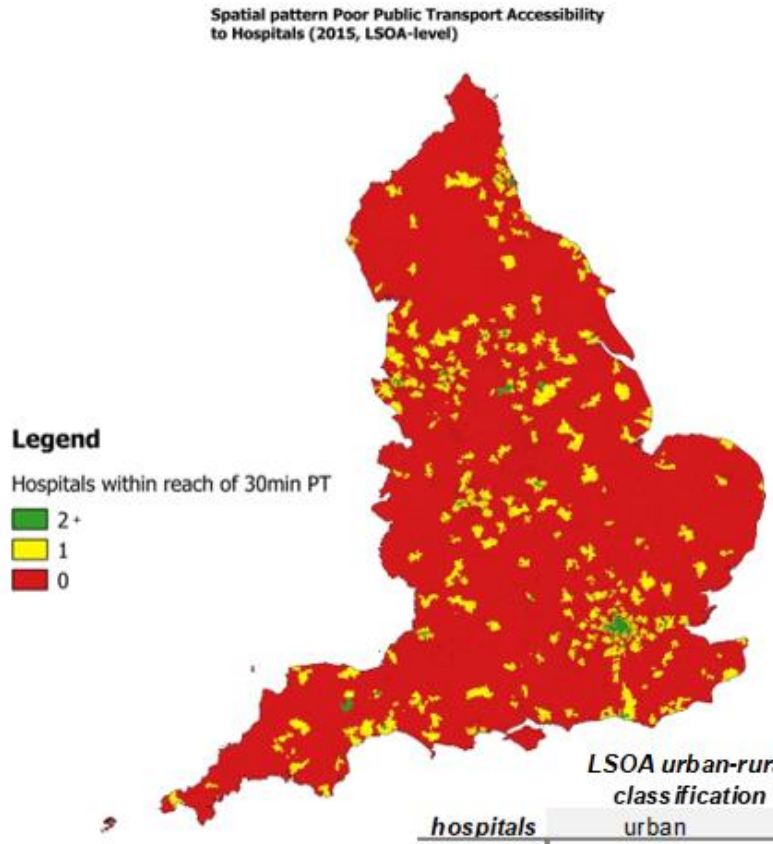
As such, engagement in training and education opportunities often involves long journeys by public transport and can thereby constrain skills development and the take-up of learning and training opportunities (Owen, Hogarth, and Green, 2005).

Limited transport options reduce access to healthcare

Getting to hospitals is particularly difficult for people without a car or who are living in places with inadequate public transport options. This lack of access can lead to missed health appointments and associated delays in medical interventions (Lucas, Tyler and Christodoulou, 2009). An estimated 10% of hospital outpatient appointments are missed due to transport problems, thereby putting people's health and wellbeing at risk (Brand et al., 2004) and causing unnecessary costs to taxpayers.

Analysis of public transport accessibility to hospitals calculates the number of hospitals within 30 minutes journey time (30 minutes is the average minimum journey time to a hospital for people living in the UK). This is matched to the number of elderly people (aged 60 and over). Older people have been selected in this example because they are more likely to need health care services and are less likely to have access to a car. However, the relationship would hold for all social groups who are public transport dependent in these same areas.

The accessibility map below clearly shows that shows that 66% (7.8 million) elderly cannot reach a hospital within 30 minutes by public transport. Inaccessibility of hospitals is a problem in both rural and urban areas.



	LSOA urban-rural classification		people aged 60+ years	
hospitals	urban	rural	abs.	%
2+	2,063	5	507,836	4.29%
1	10,174	521	3,556,288	30.03%
0	15,009	5,072	7,779,258	65.68%
total	**27,246**	**5,598**	**11,843,382**	**100.00%**

Figure 3. Map of accessibility to hospitals within 30 minutes by public transport

Source: based on DfT Journey time statistics (2015)

A study of population access to Derriford Hospital in Devon, England (Martin, Jordan, and Roderick, 2008) found significant levels of ill-health, particularly in areas with more elderly populations and in the rural areas that were poorly accessible by bus.

A study of how people access hospitals in Oxfordshire and GP services in West Oxfordshire and Cherwell District found that many public transport trips required an interchange in Oxford city centre, resulting in longer and more expensive journeys (Brand et al., 2004). There are often eligibility restrictions on voluntary and community transport services, as well as service capacity issues. The study recommended that improved reliability of transport to hospitals was likely to yield significant financial savings by lowering the number of missed health appointments.

Transport problems may constrain access to healthcare in rural areas. In particular, low-income elderly people without cars face both financial limitations and physical difficulties, both of which limit their ability to access public transport and to travel longer distances to reach specialised health services and hospitals (Shergold and Parkhurst, 2012). Physical isolation and a lack of public transport to healthcare can

therefore combine to the detriment of older people in remote rural settings (Dwyer and Hardill, 2011).

The British Concessionary Travel Pass Scheme offers free off-peak bus travel for all older people. Studies show that the concessions have produced various social benefits for older people in terms of access to healthcare services, social activities and improved quality of life (Mackett, 2014). However, the off-peak nature of the passes means that older people cannot travel for free to early morning appointments at the GP surgeries, which has been reported as a problem for some.

Inadequate transport limits access to shops and services

Approximately 70% of the population can access up to three or more food stores within 15 minutes by public transport. Over 6% of the population (roughly 3.34 million) cannot reach any food stores within 15 minutes, and 10% can reach only one food store within this journey time. The situation is marginally worse for people living in rural areas, although their higher levels of car ownership means that they may have better overall access.

Evidence about mobility among elderly people in three rural regions in England showed that, in the context of insufficient public transport services, ownership of a car and the ability to drive brought supermarkets and other services within reach (Dwyer and Hardill, 2011).

Concessionary bus schemes for older and disabled people have improved their access to local shops and services (Oxera, 2009). Although these bus passes are often mainly taken up by low incomes, access to a car, rather than income, is found to be the critical factor in determining take-up (Humphrey and Scott, 2012).

Older people confronted with infrequent and irregular bus services also used their passes much less than those provided with a good service level, which suggests that concessionary travel schemes need to go hand-in-hand with reliable public transport services (Last, 2010).

Nevertheless, a London study investigated mode choice decisions for shopping trips among older and disabled people (Schmöcker et al., 2008). Disabled people preferred not to use public transport, while healthy older people preferred to use it. Also, preference for travelling by taxis increased with age, in particular when there was a disability.

Spatial variations in accessibility to key services

Inequalities in the provision of transport services are strongly linked with where people live, and the associated differences in access to employment, healthcare, education, and local shops. This problem is more to do with land-use and public service planning, which determines the physical location and spatial distribution of these services in relation to low cost housing, than with deficiencies in the transport system itself. However, the lack of private vehicles in low-income households,

combined with inadequate public transport services in many peripheral social housing estates, exacerbates the problem in many parts of the UK.

Accessibility to services has decreased over time in places where there have been the most significant reductions in bus services (Campaign for Better Transport). These have been most prevalent in rural areas and small towns, but have also occurred in the urban periphery, and are especially noticeable in the off-peak and weekend services.

Lack of transport leads to social isolation

A study in rural Durham and Northampton found that many older people do not leave their homes more than once a week due to lack of private transport (Age UK, 2012). This has resulted partly from reductions in bus services without suitable alternatives, as well as from the closure of local shops, post offices and local medical services.

A study of disadvantaged groups in rural Northern Ireland found that low-income households and young people without a car were limited to participating in activities within their local area, which were often not adequate for their needs (Kamruzzaman and Hine, 2012). The reliance on public transport limited their ability to deviate far from the main public transport route, due to financial constraints and the poor connectivity of transport services. This made it more difficult to reach opportunities outside their local area, thereby increasing their risk of social exclusion.

Evidence from three regions in rural England (Dwyer and Hardill, 2011) shows that geographical isolation, limited mobility due to physical impairments, and the cost of car ownership combined with a lack of public transport, excluded many older people from routine participation in their communities. Immobility, leading to isolation, was a strong, recurrent issue among the older people. This reduced opportunities for access to social services and everyday social interaction, bringing increasing loneliness.

In rural southwest England and Wales, it is estimated that 5-10% of the older population (60+) experience some degree of exclusion from social activities due to lack of access to a private car and limited ability to access public transport and travel longer distances (Shergold and Parkhurst, 2012). While social networks can provide the elderly with an alternative to public transport, those without this “transport asset” may find themselves locked out from full social participation (Rajé, 2007).

Community transport schemes can function as a social space for older citizens in London. Free bus travel has also opened up an important public space (the bus network itself) as a site for socialisation, as a way of mitigating loneliness, and for simply feeling “part of the community” (Green, Jones and Roberts, 2014).

These benefits echo the findings for younger people, for whom free bus travel in London also provided both a physically and socially active experience (Jones et al., 2012). Travelling by bus provided opportunities for meaningful social interaction, a sense of belonging and visibility in the public arena, and helped to alleviate chronic loneliness in the city.

Cost of transport constrains access to key activities

In 2012, problems with affordability of daily car mobility costs, or 'car-related economic stress', were estimated to affect between 6.7% and 9% of households in Great Britain, corresponding to between 1.7 and 2.3 million households (Mattioli, Lucas and Marsden, 2016). Figures for household expenditure in the UK for 2017 reveal that transport expenses now account for the greatest proportion of household budgets (Crisp, Gore and McCarthy, 2017).

Low-income households are often found to lack sufficient resources to purchase and insure a private car, and to pay for fuel costs (Taylor et al., 2009). An investigation of the spatial distribution of households that are vulnerable to fuel price increases in Yorkshire and the Humber, UK, found that fuel price increases are most likely to affect people in rural areas, where lack of public transport services may force people to use a car to access key services (Lovelace and Philips, 2014).

Public transport fares have also steadily increased making the cost of using public transport relatively expensive for low-income households. For example, bus fares have followed a steady upward trend since the deregulation in 1986, whereas the cost of rail fares during peak hours have increased more than fourfold and so are particularly expensive for this group, which further limits their travel options (PTEG, 2013).

Concessionary bus passes are mainly taken up by pensioners on low incomes, but lack of access to a car is found to be the critical factor in this uptake, rather than income levels per se (Humphrey and Scott, 2012). Older people living in areas without regular bus services used their passes much less often than their counterparts in areas with good bus service levels (Last, 2010). Concessionary travel schemes thus need to go together with an adequate supply of public transport services.

An assessment of the potential impact of road pricing on low-income car drivers in Scotland found that this group already spend a high proportion (40%) of their income on motoring costs (Cain and Jones, 2008). As a consequence, it was predicted that additional cost of road pricing, without policy intervention to mitigate this, would cause further financial hardship, and that regular congestion charge payments could undermine the potential for job uptake.

Forced car ownership can lead to economic stress

Where there are few public transport services, people may be forced into car ownership, despite the high costs, to access employment and essential services (Sustrans, 2012). This can be a particular problem in rural areas where lack of public transport services forces car dependence, hence higher transport costs (Crisp, Gore and McCarthy, 2017).

Inadequate public transport services in rural areas often make low-income households highly dependent on cars to access services. This reliance on cars is

expensive: affected not only by rising fuel costs but by the overall cost of running a car (Smith, Hirsch, and Davis, 2012).

The British National Travel Survey shows that there is also a significant number of carless people who depend on cars to reach jobs and services, and therefore often rely on car lifts and taxis for their travel needs. Older non-drivers, the majority of whom do not have a driving licence, can be very dependent on the car for their daily activities, in which case they are often dependent on others to gain access to services (Mattioli, 2014).

A study among people living in disadvantaged (sub)urban neighbourhoods in Glasgow, found that car ownership was not always a matter of choice. The results indicated that, because of limited public transport services, forced car ownership was a growing phenomenon in deprived parts of the city where people, especially those with children, faced particular challenges due to the complexity of their overall household mobility demands, as well as the additional costs of travelling with children. Lack of public transport services therefore made a car necessary for people to search for jobs and take up employment (Curl, Clark and Kearns, 2017).

In Scotland, households on a low income were found to have much lower levels of car ownership (37%) if they had access to a frequent bus service (one every 10 minutes) compared with low-income households who had to wait more than an hour for a bus (93% car ownership) (Barker and Connelly, 2005).

When lower-income households do have access to a car, this can tip them into economic stress. Mattioli et al.'s analysis of the Living Costs and Food Survey (2018) has shown that, in 2012, 9% of all UK households experienced car-related economic stress, with low income and high cost of running a car (see figure below). This may be the case for as many as 67% of car-owning households in the lowest income quintile.

Figure 4. A low income-high motoring cost indicator of car-related economic stress for the UK.

Source: Mattioli et al., 2017

Further research developed an index of vulnerability to fuel price increases for England using a combination of MOT car registration data, Experian income data, and the Department for Transport Journey Time Statistics. It demonstrated that transport poverty – a combination of transport affordability, lack of motorised transport, access to key services, and negative exposure to the transport system – is experienced differently across different metropolitan areas (Mattioli et al., 2017).

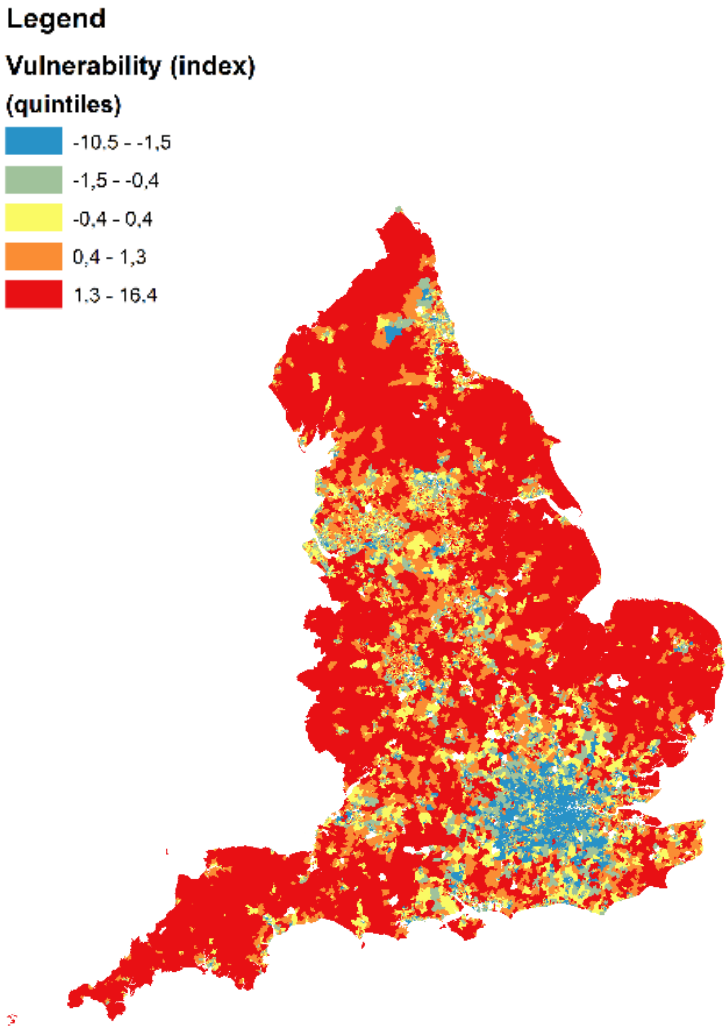


Figure 5. Map of variations in the composite indicators of vulnerability to fuel price increases in England (2011) by LSOA

Source: *Mattioli et al., 2017*

Three components of vulnerability were used in this analysis – Exposure, Sensitivity and Adaptive Capacity – are shown in the maps below. This conceptualisation of vulnerability originates in social analysis of climate change and has more recently been applied in a transport context (Leung et al., 2015). The components of the indicator are calculated as follows:

- Exposure is the ratio of the average expenditure on fuel to average household income, also known as the cost burden of motor fuel. Expenditure on fuel has been calculated using data derived from MOT certificates, vehicle registered keeper records and reference to fuel consumption data (Chatterton et al., 2016).

- Income is an indicator of sensitivity to changing circumstance widely used in studies of vulnerability based on the Index of Multiple Deprivation data.
- Adaptive capacity in this context uses an indicator of the ability to reach destinations using modes other than car. The data for this indicator is derived from the UK Department for Transport travel time accessibility data. The indicator uses travel time by public transport and or walking to the nearest provision of eight key services.
- Each of these three components have different units so they are converted to z-scores so that they have equal weights (Mattioli et al., 2017).

The regional maps below use the same index. Although there are high concentrations of low-income populations living in London, they have access to high levels of low-cost buses, and as such tend not to as vulnerable as low-income populations in other metropolitan areas. In West Midlands and Great Manchester, transport poverty is widely dispersed across the whole region but is more concentrated in urban peripheral areas, whereas in West Yorkshire it is highly concentrated in Bradford, Wakefield, Calderdale and other smaller urban centres. Even Leeds city centre demonstrates quite high incidences of transport poverty.

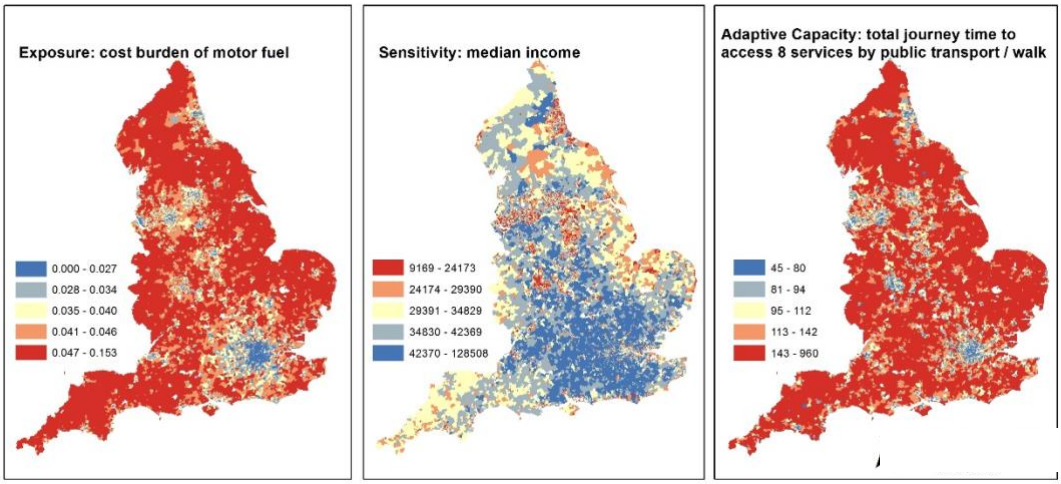


Figure 6. Maps of variations in the components of the vulnerability index in England (2011) by LSOA

Source: Mattioli et al., 2017

The maps in the upper half of the figure presents values of vulnerability to fuel price increases for the four main English city-regions, based on national quintiles (from very low to very high). The histograms in the lower half of the figure present corresponding histograms showing the distribution of the vulnerability index across LSOAs, for each city region.

Disadvantaged road users are at higher risk of injury and death

There is a significant causal relationship between increased motorised transport and increased road casualties and deaths: people from deprived neighbourhoods are more likely to be injured or killed as road users (Ward et al., 2007). People in the highest socio-economic groups (SEGs 1 & 2) were found to be substantially less at risk of death as car occupants than people in the lower groups (SEGs 4 & 5).

An exploration of the root causes of the high risks of traffic injury in deprived areas in England found a strong relationship between deprivation and pedestrian casualties among all age groups. In particular, children (11–15 years) and young people from disadvantaged areas were found to be involved in traffic injuries, for whom the risk was highest on main roads and on residential roads near shops and leisure services (Christie et al., 2010).

Despite the fact that rates of death from injury among children have fallen in England and Wales over the past 20 years, serious inequalities in injury and death rates remain, particularly for pedestrians and cyclists (Edwards et al., 2006).

People living in disadvantaged areas tend to live in more hazardous environments, with greater proximity to high volumes of fast-moving traffic and high levels of on-street parking. As such, they have higher levels of exposure to road traffic risk, which is exacerbated by their reliance on walking, and the lack of safe spaces for children and young people. In addition, high levels of hazardous and illegal driving behaviour posed a risk to people living in disadvantaged areas (Lowe et al., 2011). Children's exposure to higher risks of traffic injury is mainly related to few safe, secure, and well-maintained public spaces and costly leisure venues (Christie et al., 2007).

Health risks and environmental impacts of transport

It is estimated that road transport accounted for approximately 26% of greenhouse gas emissions in 2016, of which the main source is from petrol and diesel vehicles (BEIS, 2018). Furthermore, human exposures to other traffic-related pollutants place a significant burden on people's health. Traffic-related air pollution is associated with the risk of death and chronic disease, including asthma and atopy, in children, worse pregnancy outcomes, and exacerbation of asthma and chronic chest illnesses (Schwartz, 2004). Nitrogen dioxide (NO_2) and particulate matter ($PM_{2.5}$) are principal sources of pollutants that impact on health. It is estimated that NO_2 and $PM_{2.5}$ (also emitted from vehicle exhausts) contribute to 40,000 premature deaths per year (Royal College of Physicians, 2016).

Evidence from London shows that air pollution caused by car-related emissions and particulate matter have a significant negative impact on the health of all Londoners (Greater London Authority, 2015). The adverse effects range from worsening respiratory symptoms to premature deaths from cardiovascular and respiratory diseases. Traffic-related air pollution has contributed to widening health inequalities in London, as emissions tend to be more concentrated in the most heavily trafficked roads, which are used more by disadvantaged people as places where they live, work and shop (Walton et al., 2015).

Poor quality urban environments with high levels of motorisation and little space for walking and cycling have further been described as ‘obesogenic’ in that they are a barrier to active travel, and potentially cause sedentary behaviours which compound the health of people living in deprived areas where obesity levels are the highest (Law et al. 2007).

Physical as well as mental health conditions are also influenced by the stress associated with living in neighbourhoods where the environment is seen as threatening, such as high volumes of fast-moving traffic, where the quality of the housing is poor and where public transport facilities are lacking (Department of Health, 2002). A study of the relationship between transport-related emissions (such as NO_2) and social deprivation the city of Leeds, UK, found that environmental impacts disproportionally negatively affect people living in deprived neighbourhoods (Mitchell, 2005).

3 Differences in travel across social groups

This section of the report provides an overview of how travel behaviours differ across the different social groups in the UK[2]. It especially concentrates on inequalities in mobility across the key social determinants of income, gender, age, and disability. The information provided is based on bespoke analysis of the combined data from National Travel Survey 2002-2016, considering travel trends in England only[3].

Car owners and drivers are most travel included overall

Car drivers make more trips, spend more time travelling and cover longer trip distances than all other modes of transport but this also varies significantly within the household depending on whether a person is the main driver or not (as shown in the graph below). Households with no car make roughly 30% fewer trips and cover almost 60% less trip distances than households with a car (i.e. the average).

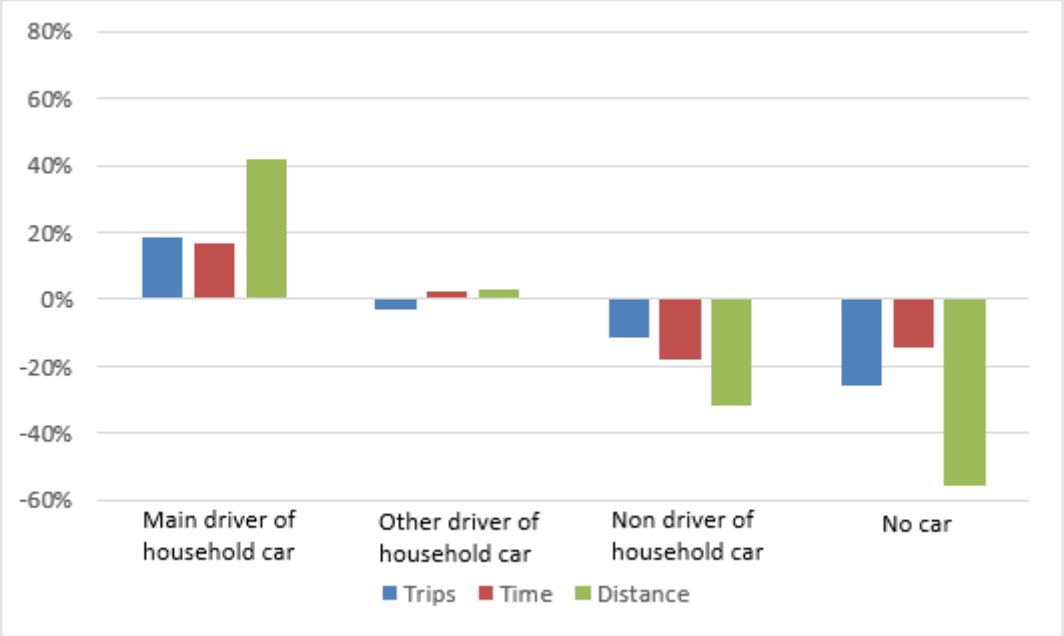


Figure 7. Access to a car in households 2002–2016 (% below and above the average)

Source: based on DfT National Travel Survey 2017

Low-income households have lower levels of access to a car than households with higher incomes. Although the level of non-car ownership in the lowest income households has been steadily decreasing over the last 30 years, approximately 40% of the lowest income households still do not have access to a car. This is largely to do with affordability, although factors such as

[2] This analysis of the UK National Travel Survey was undertaken specifically for this report by Gordon Walker (independent consultant).
[3] Scotland, Wales and Northern Ireland conduct separate surveys under their devolved administrative responsibilities.

the availability of good public transport and a household's need for a car can also play a role (for example, in central London).

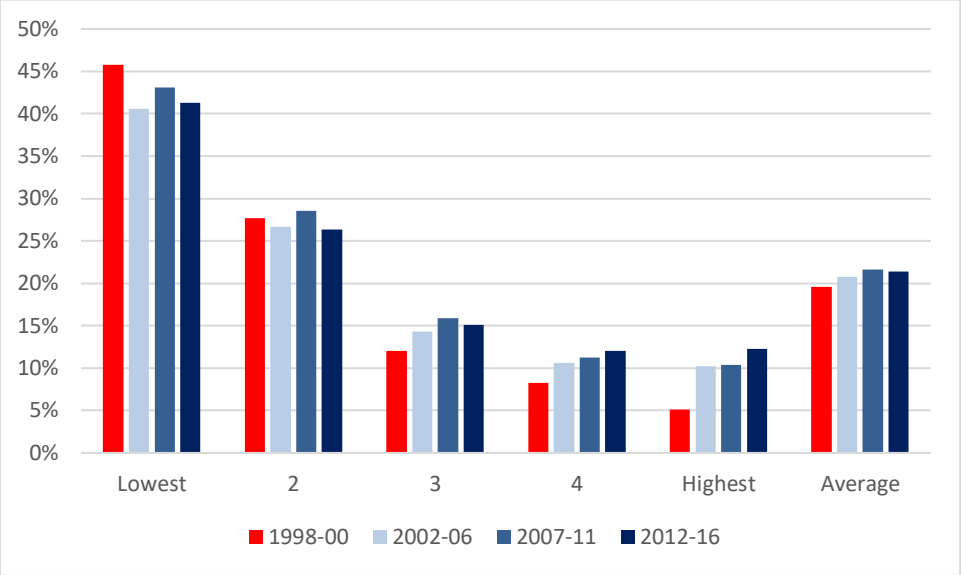


Figure 8. Households without a car by income quintile 1998-2016

Source: based on DfT National Travel Survey 2017

In contrast, levels of non-car ownership have been slightly *increasing* among higher income groups. This could be for a number of reasons relating to changing patterns of vehicle ownership and use over this period. For example, more people are now main drivers in lower income households, whereas this has fallen for those in the highest income households, which also reflects their patterns of car ownership. The proportion of non-drivers has reduced most rapidly in the 2nd income quintile. It suggests that people in higher income households are giving up driving out of choice, whereas more people in low income households need to drive to reach their daily activities, as was evidence in the previous sections of this report.

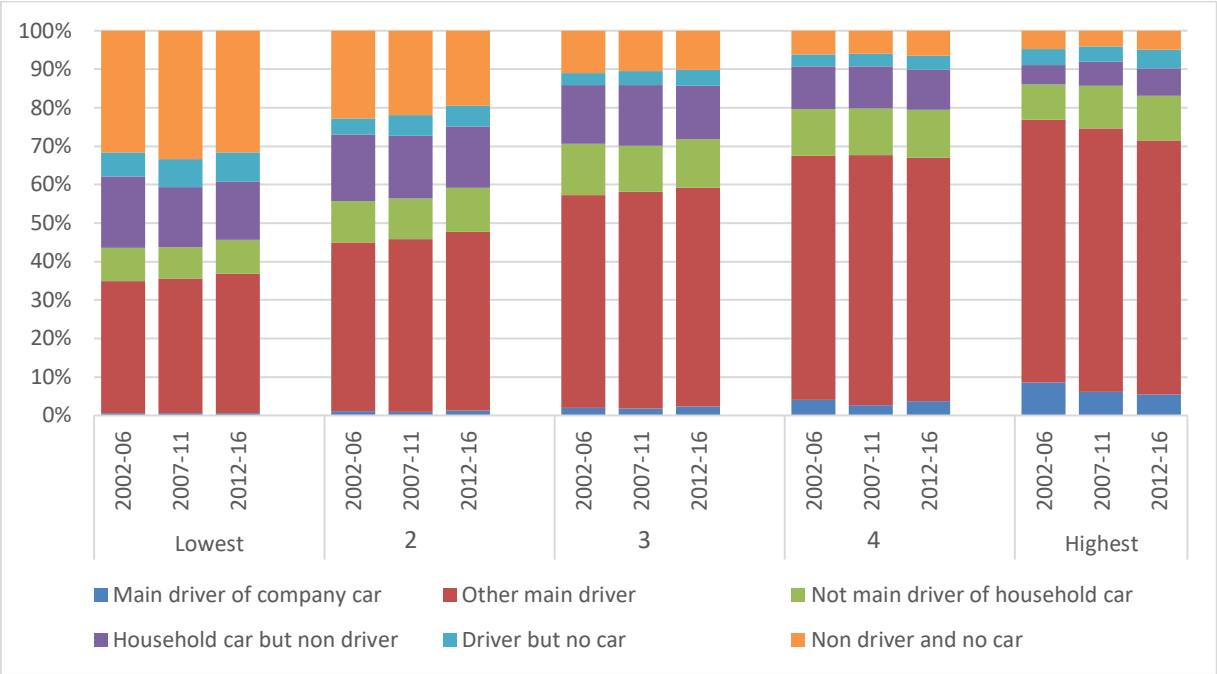


Figure 9. Access to a car by income quintile 2002-2016

Source: based on DfT National Travel Survey 2017

Lower income households travel less overall

As the lowest income households have fewer cars, and fewer drivers, it is not surprising that they also travel much less and travel over much shorter distances than higher income households. They make nearly 20% fewer trips and travel 40% less distance than the average household. The second quintile households, which also fall below the median level of income in the UK, also make noticeably less trips than the higher quintiles when compared with the average. It is clear that income is a significant constraint on the ability to travel for people in lower income groups, as evidenced by the literature review.

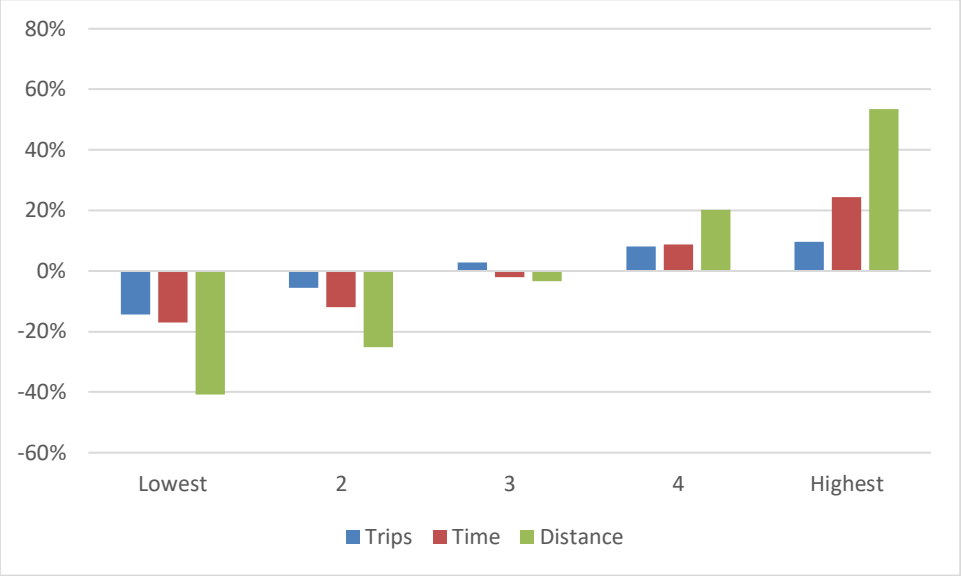


Figure 10. Travel patterns by income quintile 2016 (% point difference from the average)

Source: based on DfT National Travel Survey 2017

Gender differences are declining

Since 2002, there has been little change in access to a car by men: approximately 60% of males in households are the main driver and 20% are without a vehicle. There has been a steady increase in the number of older women as a main driver in households over the same period, from approximately 45% to 50%, and a corresponding fall in the percentage of women without access to a vehicle.

It should be noted that single parent houses tend to make more trips and that roughly 90% of all single-parent households are headed by women and so the increased travel in this sector is highly gendered in its nature (Office for National Statistics, 2014).

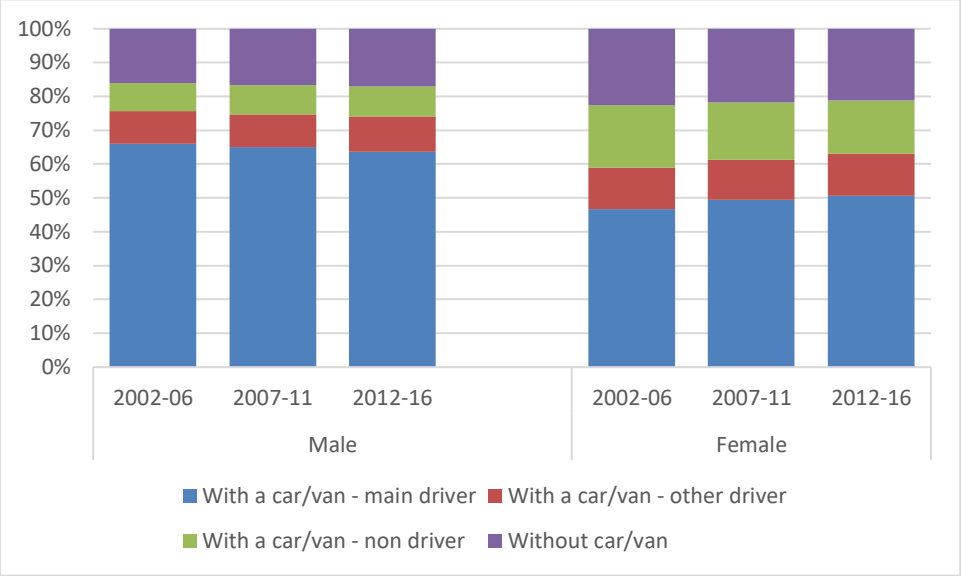


Figure 11. Access to a car by gender 2002-2016

Source: based on DfT National Travel Survey 2017

Disabled people are still constrained in their travel options

Approximately 38% of all people with mobility difficulties are main drivers, while approximately 40% have no access to a private vehicle. Probably as a consequence of the lack of a private vehicle, and the resulting reliance on public and voluntary transport, drivers with mobility difficulties make 40% less trips than the average driving population, spend less time travelling and travel shorter distances. This is likely to be more often out of constraint than by choice both in terms of their travel options but also as a result of destination constraints in terms of physical access to services, etc..

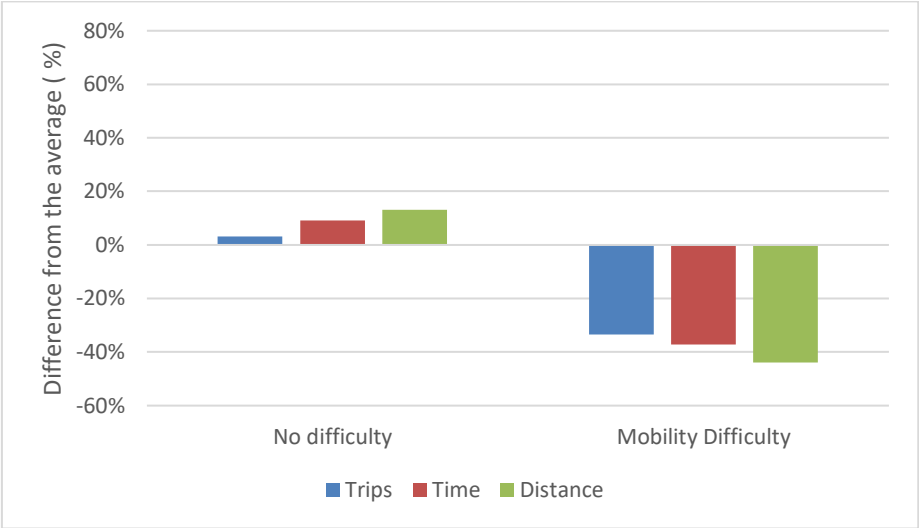


Figure 12. Travel patterns of people with a mobility difficulty 2016 (% below and above the average)

Source: based on DfT National Travel Survey 2017

Employment status still dominates people's travel activities

Over the last 15 years, there has been little change to levels of car access for full-time workers, but a slight increase for part-time workers. There has also been a noticeable rise in car access for retired and long-term sick people as illustrated in Figure 13 by the decreasing proportion of those economically inactive without a car or van.

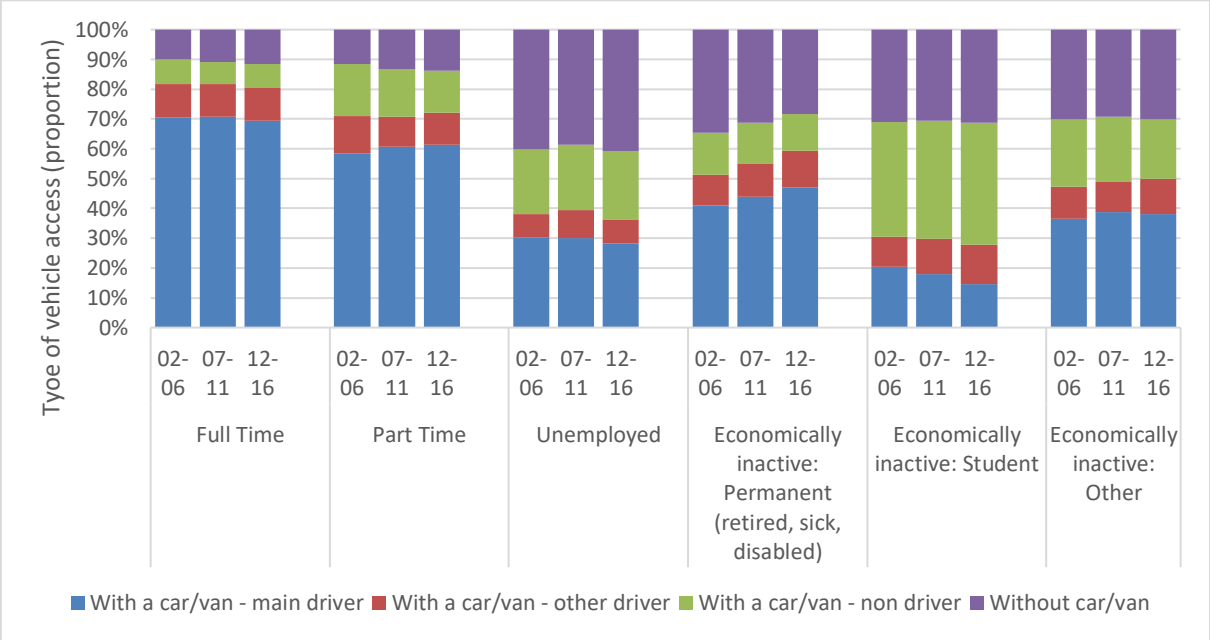


Figure 13. Access to a car by economic status, 2002-2016

Source: based on DfT National Travel Survey 2017

Full-time workers tend to travel further than part-time workers, but part-time workers make more trips overall. This is probably because they often need to make more additional trips (over shorter distances) to facilitate their flexible working patterns and multiple jobs. It may also be because more women with children undertake part-time work, and so also make more journeys relating to childcare and household shopping.

Figure 14. Travel patterns by economic status 2016

Source: based on DfT National Travel Survey 2017

Looking across all the journey purposes, we can see that commuting and shopping trips are by far the most frequent across all the income groups, followed by escort trips (i.e. adult accompanying either a child or a disabled person) personal business and trips to visit friends and relations in their own homes. Most of these trip-making trends have remained relatively stable, with a slight decrease in the number of trips made across all income groups.

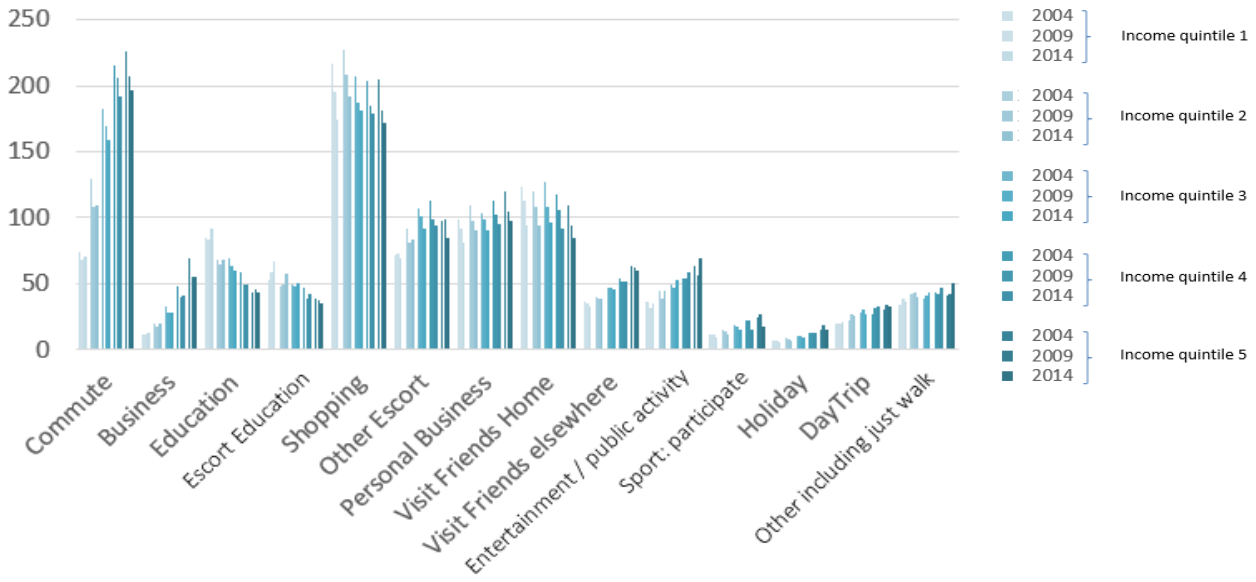


Figure 15. Trips per person per year by journey purposes by income quintile 2002-2014

Source: based on DfT National Travel Survey 2017

It is unsurprising that lower income households make less commuting and in-work business trips than higher income ones, because they tend to be less economically active. However, it is interesting to note that the lowest income households make significantly more education and educational escort trips than the other quintiles. It is unclear why this travel trend should emerge (e.g. it could be due to more students in this category or because of more children in these household), but it would bear further investigation from an education policy perspective.

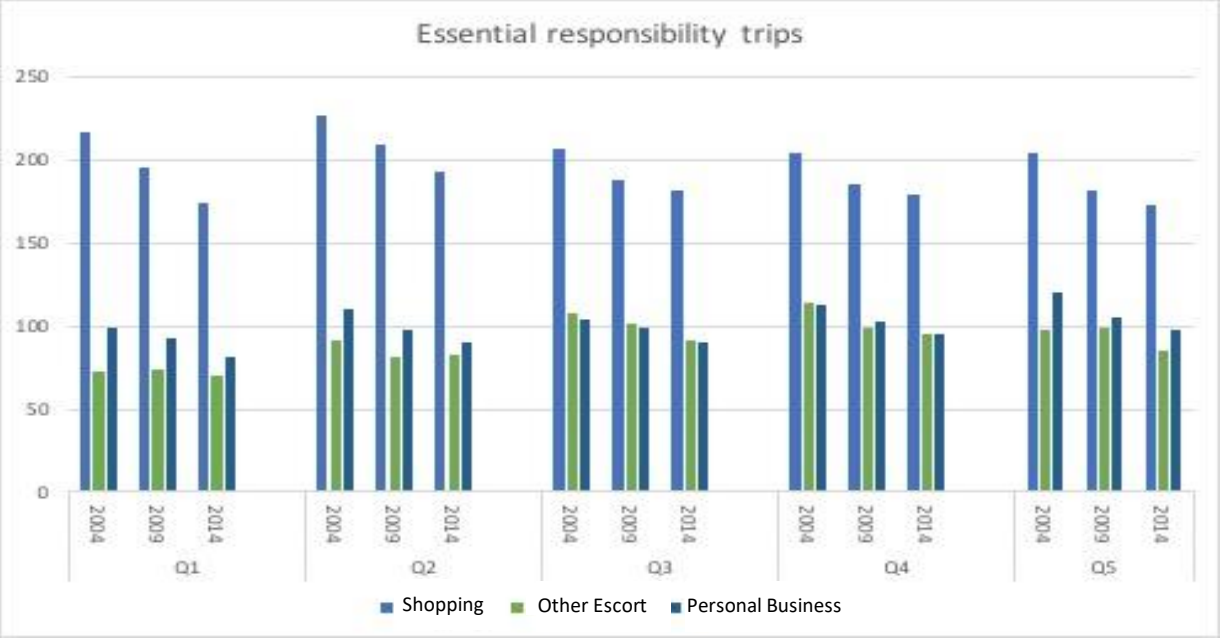


Figure 16. Essential responsibility trips per person per year by journey purposes by income quintile 2004-2014

Source: based on DfT National Travel Survey 2017

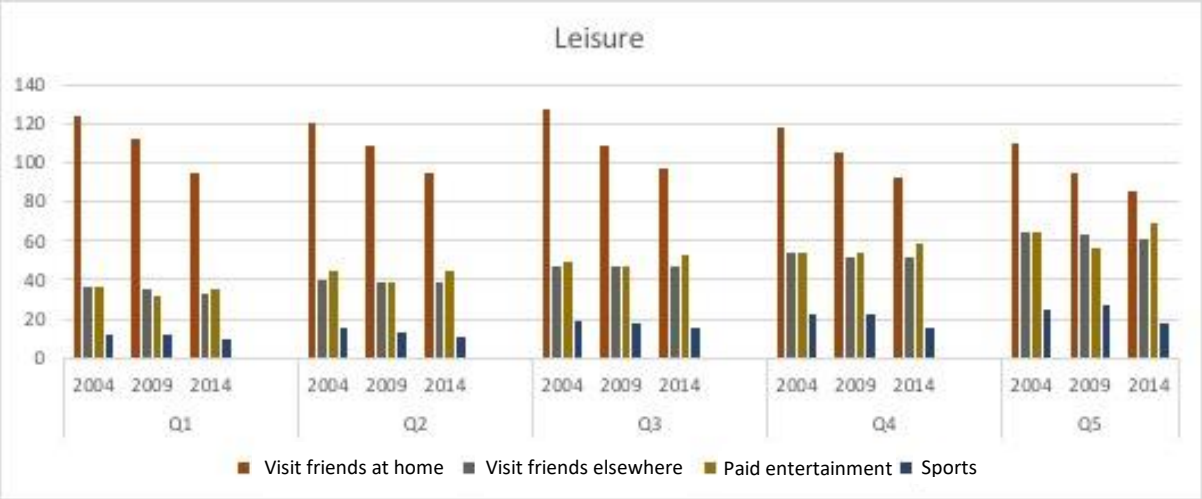


Figure 17. Leisure trips per person per year by journey purposes by income quintile 2004-2014

Source: based on DfT National Travel Survey 2017

Visiting friends in their own homes is by far the most important form of leisure travel but the overall level in these trips has significantly declined over the past 10 years across all income quintiles. Sports activities feature more strongly in the trips of higher income groups, with possible negative implications for the health and fitness of lowest income quintile, for whom these trips appear to be declining. It is also noticeable that the lower income quintiles 1 and 2

generally also take far fewer paid leisure trips than the higher income quintiles 4 and 5. This is probably largely to do with their income constraints.

Household structure is also a key factor in determining levels of travel

There has been a rise in the travel of single-parent households since 2002, and a slight rise for two-adult households (without children), but a slight fall for two-adult households with children. The difference between household groups is also evident; single adults and single parent families display significantly higher levels of non car ownership than households with more than one adult.

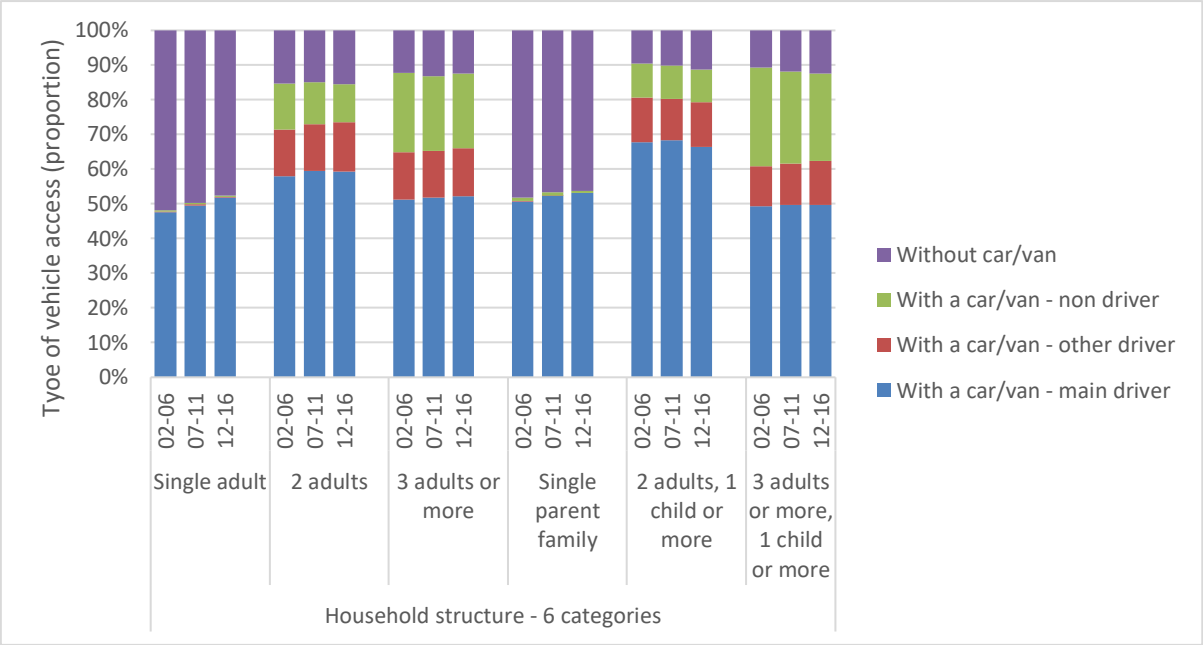


Figure 18. Travel behaviour by vehicle access and by household structure, 2002-2016

Source: based on DfT National Travel Survey 2017

People in rented accommodation make less trips and have shorter travel distances than home owners. This is because they tend to live in denser urban areas, but it is also a function of income constraints, and other limiting social factors, such as age and disability.

Figure 19. Travel patterns by housing tenure 2016 (% below and above the average)

Source: based on DfT National Travel Survey 2017

Where people live makes a significance difference to their car access patterns

There are also differences in vehicle access trends across the different types of settlements. There has been a noticeable rise in car access in rural towns and urban fringe areas, whereas in denser urban areas and rural villages levels have stayed fairly stable. This could be explained by the decline in bus services in these less commercially-viable fringe areas, over time.

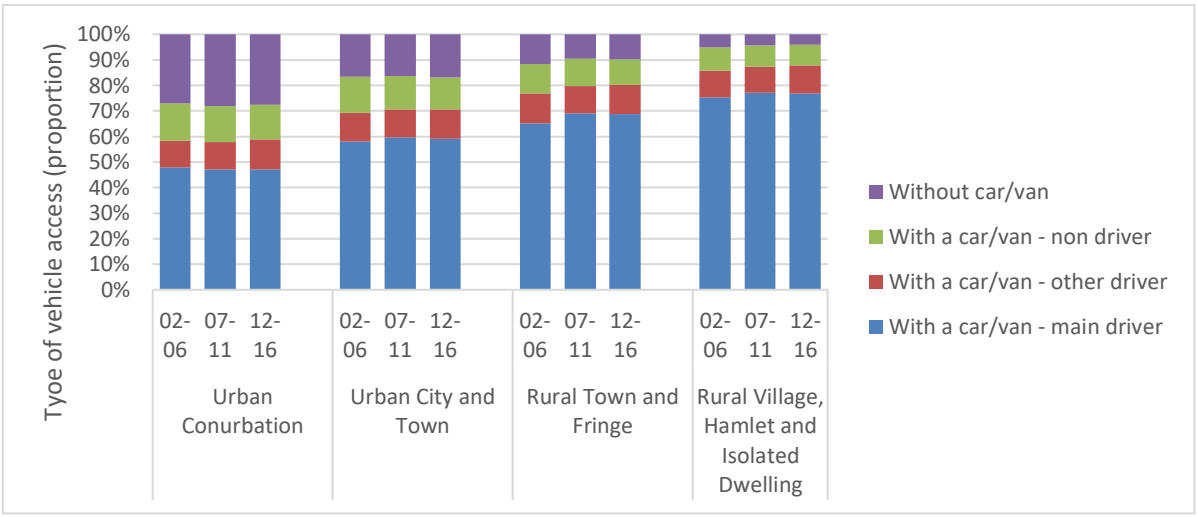


Figure 20. Settlement pattern changes by vehicle access, 2002-2016

Source: based on DfT National Travel Survey 2017

The importance of different social determinants of travel

If we hold all the social determinants of travel in balance with each other by using a simple regression analysis, we can identify the relative influence of each on travel behaviour. This exercise shows us that being in a lower income group, experiencing a mobility difficulty, being a younger adult (aged 17-29) and being retired or long-term sick all act to suppress people's travel behaviours, reducing the number and distance of trips they make. Living in a rural area significantly increases the length of time people travel (DfT, NTS9913). Those in rural areas also make more trips on average (DfT, NTS9903).

In contrast, being in a higher income category and being a full-time worker both act to increase journey times and distances. Being female, in a household with children or a single parent serves to increase the number of trips made, but not necessarily the time spent travelling or the distances travelled.

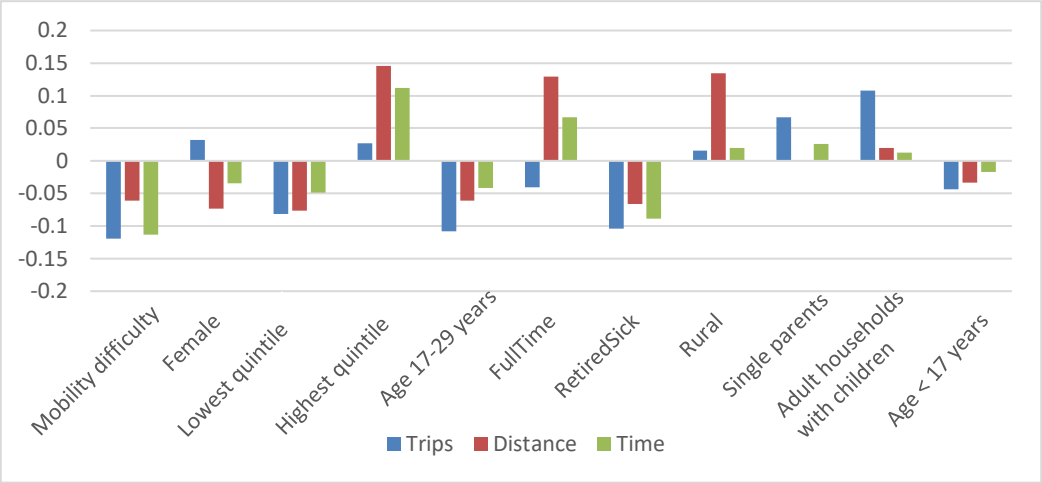


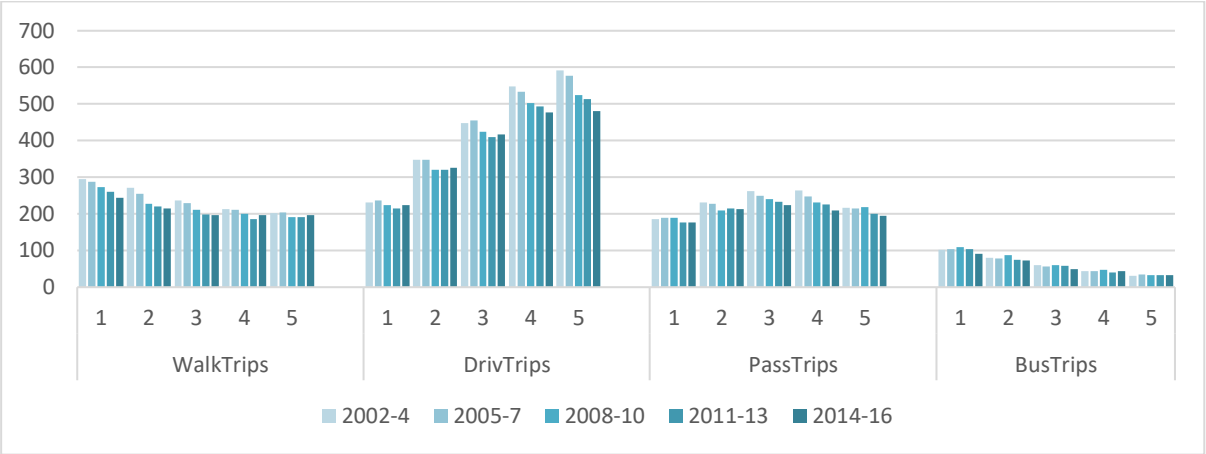
Figure 21. Regression analysis of travel patterns by different social determinants[4]

Source: based on DfT National Travel Survey 2017

Understanding future behaviours

By thinking about the use of different modes across the different income and social groups, we can develop a picture of how future changes might influence different people in different places. There have been some important changes in travel trends across different social groups, which are important to bear in mind when considering likely future trends.

[4] The vertical axis uses a beta value of between -0.2 and +2 to offer a standardised measure of the importance/ strength of the effect of each variable, controlling for its numeric effect.



Key: WalkTrips = walking trips; DrivTrips = driving trips; PassTrips = car passenger trips; BusTrips = bus trips. Income quintiles 1 = Lowest 20% income group in the overall population, 2 = 20-40% income group, 3 = 40-60% income group, 4 = 60-80% income group, 5 = Highest 20% income group.

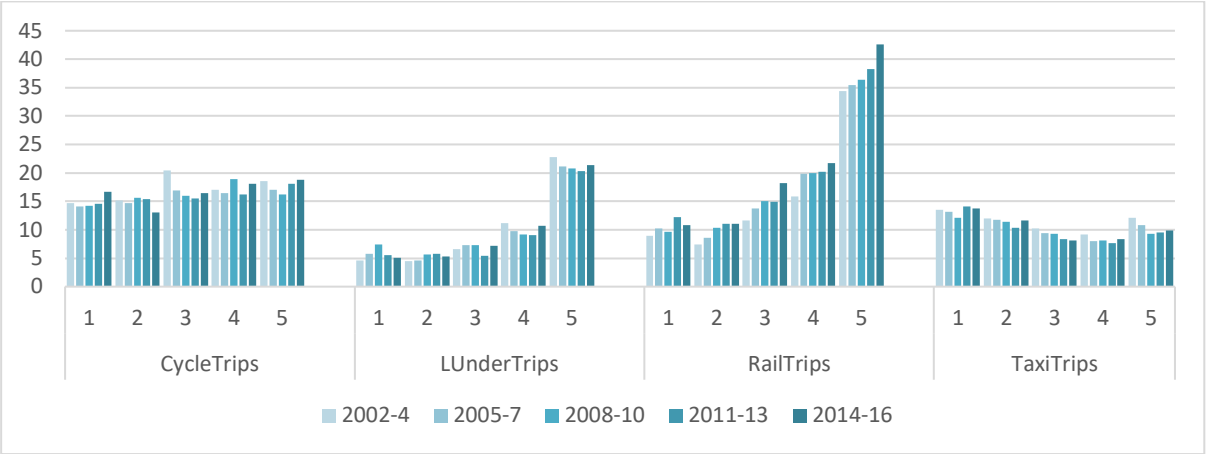
Figure 22. Number of trips per year by mode and household income quintile (1-5) 2002-2016

Source: based on DfT National Travel Survey 2017

Drivers' trips are decreasing for all income groups except for people in the lowest income quintile. This decrease in per capita travel is more broadly referred to as the 'peak car' hypothesis, which is keenly debated. This observed trend in declining car travel would therefore suggest that lowest income households have not yet reached the saturation point in their need for travel.

Bus use is in decline for all but the lowest income groups, who remain bus dependent to a much greater extent. The lower income groups are also more reliant on walking, although walking is in decline across all groups.

The number of cycle trips is increasing with peaks in more recent years among all but the middle-income quintile. It would also appear that the lowest income groups are becoming increasingly reliant on taxis. It is unclear whether this is due to the advent of on-demand taxi services, or due to the decline of bus services in many peripheral urban areas.



Key: LUnderTrips = Trips by London Underground. Income quintiles 1 = Lowest 20% income group in the overall population, 2 = 20-40% income group, 3 = 40-60% income group, 4 = 60-80% income group, 5 = Highest 20% income group.

Figure 23. Number of trips by mode and income quintile 2002 - 2016

Source: based on DfT National Travel Survey 2017

4 Identifying future social trends in the UK

Inequalities in transport and accessibility are highly correlated with wider social trends and inequalities. Here, we offer a very basic background overview of the key predicted social trends in the UK as they are widely reported, which we believe *are most likely to exacerbate mobility and accessibility inequalities* to 2040.

This information is intended *to provide a baseline* from which to gauge how different sectors of the population might be affected by the anticipated mobility futures and their supporting technologies proposed in the other evidence reviews published by the Government Office for Science[5].

Demographic projections

The UK population is projected to increase by 3.6 million (5.5%) over the next 10 years (Office for National Statistics, 2016) from an estimated 65.6 million in mid-2016 to 69.2 million in mid-2026, rising to 72.9 million in 2041[6]. By mid-2041 the population of England is expected to increase to 62 million (12.1% increase from 2016), Scotland to 5.7 million (5.6% increase from 2016), Wales to 3.3 million (6.5% increase from 2016), and Northern Ireland to 2 million (5.3% increase from 2016).

- Over the full 25-year period from mid-2016 to mid-2041 the proportion of growth resulting from the balance of births and deaths is projected to be 39%.
- International migration will account for 77% of the projected UK population growth between mid-2016 and mid-2041.
- Because migrants are concentrated at young adult ages, the impact of migration on the projected number of women of childbearing age is especially important over this period.
- There will be an increasing number of older people; the proportion aged 85 and over is projected to double over the next 25 years, to 3.2 million by 2041.
- The UK's projected growth of 16% between 2015 and 2040 is well above the EU average. It is also the highest growth rate among the four largest nations in the EU.

Housing and settlement patterns

Government projects predicted that the *housing stock* will not change much over this 23-year period (Office for National Statistics, 2014, and Joseph Rowntree Foundation, 2014).

[5]A full list of these trends can be found in Annex 1, which is based upon the associated reports that can be found at https://www.gov.uk/government/collections/future-of-mobility

[6]Due to both immigration management and reduced fertility rates population growth projections have also been significantly reduced 2 million less than previously predicted to 2041.

Research shows that poverty is suburbanising in the larger cities, across Europe, in that there are now more lower income people living in the urban periphery, although poverty still remains over-represented in inner-city locations. This suburbanisation is occurring through both the reduction in low-income populations in inner locations and the growth of richer groups in the inner cities, consistent with a process of displacement. The primary drivers of this change have been the fundamental shift in urban economies and labour markets under globalisation, and gentrification as a global urban strategy for inner-city regeneration (Hood and Waters, 2017).

The reform of the social welfare system, including changes in social housing provision, is further accelerating the change through the recommodification of housing stocks. If these trends continue, the logical outcome will be an 'urban inversion' of cities, with affluent and exclusive cores, from which lower income groups have been largely displaced.

Income inequalities and poverty projections

The Office for National Statistics (2017) reports that in 2016 7.3% of the UK population were experiencing persistent poverty, equivalent to roughly 4.6 million people. Persistent poverty is defined as experiencing relative low income in the current year (living in a household with an equivalised disposable income that falls below 60% of the national median), as well as in at least two out of the three preceding years. From 2012 to 2015, roughly 3 in 10 (30.2% of the population) were at risk of poverty for at least one year.

A higher proportion of women (8.2%) were persistently poor than men (6.3%), a trend that has continued since data became available in 2008. The gap between male and female persistent poverty rates (1.9 percentage points) and in 2016 was the largest it had been since data began in 2008.

The Institute for Fiscal Studies reports that income inequality is projected to rise between 2015-16 and 2021-22 as working-age benefits are reduced and real earnings growth boosts the income of higher income households (Hood and Waters, 2017). This is despite the predicted growth in real median incomes of around 5.1% between 2012-16 and 2021-22.

Although absolute poverty is projected to remain roughly unchanged between 2015-16 and 2021-22, absolute child poverty is projected to rise by 4.1%, primarily due to the impact of planned changes to working-age benefits.

Those regions where low-income families are less reliant on earnings (and therefore more reliant on benefits) are projected to see a larger increase in absolute poverty. As such, absolute poverty is projected to rise in the North East, North West, Wales, Northern Ireland and the Midlands, and to fall in the South, the East, Yorkshire and Scotland.

Health inequalities

In general, poorer and less educated people are most likely to experience above-average levels of infant and maternal mortality, to experience higher levels of disease, and to die prematurely. Health outcomes and life chances are also closely associated with gender and ethnicity.

- In England, people living in poor neighbourhoods live, on average, seven years less than people living in the richest neighbourhoods. (Marmot et al., 2010).
- Low job status is associated with higher risk of heart, lung and gastrointestinal diseases, some forms of cancer, and depression (Wilkinson and Pickett, 2010).
- Minority ethnic and low-income groups in the UK have been found to make less use of the NHS for the same given level of illness as other groups (Barry, 2005).
- Women also experience deeper disadvantages in access to resources to health (OECD and World Health Organization, 2003).
- Low-income groups also make less use of health services. In the UK, higher income groups are 13 times more likely to use a health service than people in low-income groups (Warwick-Booth, 2013).

Education levels and digital literacy skills

Currently, around 15 per cent, or 5.1 million adults in England are functionally illiterate. This means that they would not pass an English GCSE and that they have literacy levels at or below those expected of an 11-year-old (National Literacy Trust). They can understand short straightforward texts on familiar topics accurately and independently, and obtain information from everyday sources, but reading information from unfamiliar sources, or on unfamiliar topics, could cause problems.

This statistic is particularly important in relation to media literacy when considering mobility as a connected service (MaaS), because it means that many people are unable to manage content and communications of ICT and online services, or to protect themselves and their families from the potential risks associated with using these information tools.

A further issue is the skills gap that is likely to occur at the individual and collective business level in accessing and effectively utilising a range of digitally based technologies and services that will underpin the UK's future economy (BIS, 2016). This is more than likely to include development of skills needed for intelligent mobility uptake.

The Adults' Media Use and Attitudes Report (Ofcom, 2017) identifies that, although 97% of internet users have used search engines as a source of online information, there is a continuing lack of understanding about how search engines work, and just under half of all adults do not know how search engines are funded (47%).

There is a well-reported urban/rural digital divide, and there are no plans for fixed infrastructure improvements for the 5% of hard-to-reach populations located in the most peripheral locations (Philip et al., 2017). These areas are particularly prevalent in rural Scotland.

5 Potential inequalities arising from the future mobility landscape

It is against this wider socio-economic context that we have considered the potential inequalities that might arise in the future mobility landscape. Our observations are based on an overview of the evidence reviews commissioned by the Government Office for Science as part of the Future of Mobility project[7], and a workshop with the Social and Political Sciences group of the Institute for Transport Studies, as described in Section 1.

As an overview, the main trends have been identified as most likely to include:

- Electrification of the vehicle fleet using battery power, plug-in hybrid and/or other new technologies, combined with a smart energy distribution grid;
- A move towards fully automated vehicles that do not require control by any of the passengers, and which enable all occupants of the vehicle to focus on other tasks while they are in motion;
- Increasingly 'intelligent' infrastructure, including connected vehicles, which provides feedback in real-time to influence traveller behaviour and optimise system performance;
- A shift towards Mobility as a Service (MaaS), whereby new context specific, user-generated and user-centred information integrates mobility and non-mobility service provision, drawing on crowd-sourced and real-time data;
- Shared mobility services, where individuals' ownership of vehicles is increasingly replaced by the ability to purchase access rights to flexible mobility services (car, taxi, bus, rail, bike share) owned by others – currently most usually corporate providers.

The following section of this report now reviews the *available published evidence* concerning the likely inequalities that might emerge from this new mobility landscape to 2040.

Overall social inequalities

Regulatory penalties such as emissions charging in the transition to a low carbon economy in the domestic transport sector could impose costs on all passengers, and are likely to be disproportionate across market segments. Additionally, these could potentially benefit only the more affluent in society if the tax revenues generated from the regulatory penalties are used to subsidise alternative-fuel vehicles, which are favoured by the wealthy.

A study of the overall short-term effects of transitioning to a low carbon fleet by 2020 in California, found that the introduction of low carbon vehicles may have unequal social impacts, whereby the opportunity and affordability of car ownership in lower income groups are not implicitly ensured through the introduction of low-carbon vehicles (Harrison and Shepherd, 2014).

[7] An overview of our equity evaluation of these other reports is available in Annex 1.

Gender and migration

Mobility and accessibility should be viewed as important rights of all citizens, but these rights are at times compromised for women who face physical, economic, cultural and psychological constraints.

Design and policy responses and technological advances that seek to close the gender gap in mobility would not only enhance women's access to city resources but would also improve their lives and those of their families. Incorporating women's voices in policy development is important. Safety and gender impact audits should be tailored to the particularities and needs of local contexts (Loukaitou-Sideris, 2016).

Immigrants to the UK on average travel less than the UK citizens (Marsden et al., 2016). If the number of immigrants increases, per person the average travel time in the UK will decrease. Exactly how an increase in the number of immigrants will affect travel patterns in the UK, will be highly dependent on the availability of other modes of transport, especially within peripheral urban areas where many new migrants are likely to be housed.

Changes in young people's travel patterns are likely to persist, with fewer drivers and more urban living (Chatterjee et al., 2018).

Ageing populations

An ageing population will be a key driver of increased demand for public transport and decreasing demand for car-based transport over time, as older people cease driving. This will be a differentiated trend, with rural dependency on the car likely to be higher than urban dependency (Marsden et al., 2016) and so too will people's abilities to use new travel technologies vary depending on their skills, physical contexts and capabilities (Hubers and Lyons, 2013).

Even in urban areas, the development of assistive driving technologies will help respond to the growth in visual, physical and auditory disabilities associated with ageing (Marsden et al., 2016).

The number of commuting trips made by older people may increase as they work later in life to fund assistive technologies or care. An older person's dwelling may shift from being a source of trip generation to a greater source of trip destination – for example, home delivery or meals on wheels (Curl, Clark and Kearns, 2017).

The extent to which an ageing population – more people living longer and the doubling of the number of people aged 85 plus in the UK – will impact travel demand depends on living arrangements, and the amount of care needed and the way care is provided. It will also depend on the ability of services to adapt to people physical flexibilities and personal choices in relation to their discretionary travel.

It is likely that the car will remain important if older people remain in their own home, particularly if they live alone. However, many will have to choose between spending on a car and spending on assistive technologies. It is possible that assistive technologies might help prolong safe driving and promote independence.

For older people who live communally, journeys may be made jointly, leading to the shared ownership and use of vehicles. This may offer companionship and inclusion, as well as financial benefits for older people. Opportunities for public transport use range from relocalised lifestyles enabled by ICTs, to new assistive planning tools for public transport use (Curl, Clark and Kearns, 2017).

A Dutch study found that older households in the Netherlands are likely to remain driving in old age and most have money available to spend on transport (Jeekel, 2015). It also found that older people are keener on safety than on information technology services about travel conditions as they tend to drive more outside the peak periods. There is less congestion and delays to traffic flows during off-peak periods and so the real-time travel information provided by information technology services is less necessary (Jeekel, 2015).

Mobility services will rely more on digital infrastructure and services. Some sectors of an ageing population might experience difficulties navigating the digital world, while others will be more digitally savvy.

Impacts on jobs and employment skills

In the US, it is predicted that 40% of all workers will work remotely by 2030 (Zmud et al., 2013). Particularly younger people have sought alternatives to travelling to work, leading to increases in telecommuting. Similar figures were not available for the UK.

Technology has continued to evolve, so rather than just talking on the phone and sending texts while driving, in-vehicle cameras and windshield displays allow telepresence, so drivers can conduct in-vehicle meetings (Lovelace and Philips, 2014).

The use of driverless autonomous vehicles (AVs) and connected autonomous vehicles for taxi and bus services could transform the cost model. Currently, more than 50% of costs are labour costs associated with the driver. The change in costs could shift the competitive balance back in favour of public transport for some trips (Nellthorp and Marsden, 2017). However. disabled passengers report that they are wary of non-staffed services and would prefer human in-vehicle attendance to meet their specialist needs.

Freight and delivery services also stand to see large cost savings due to automation. While autonomous vehicles may lead to some job losses (PTEG, 2013), it is expected that humans will still be needed for delivery packing and unloading in the smaller van fleets.

Taxi drivers also lost business in scenarios testing when AVs could beat them in price per mile (Lovelace and Philips, 2014). This could have a serious equity implication, as low-income households are more reliant on taxi services and disabled people prefer personal assisted taxis.

Rural differences in the future mobility landscape

A study by the Commission for Rural Communities (Shaw and Stokes, 2016) identified three future policy directions for maintaining rural lifestyles in the UK to 2030:

1. Acceptance that the car will remain the dominant form of travel in rural areas, but that there should be no 'need' for households to have more than one car. Car travel should also be available – perhaps predominantly through lift-giving – to those who have no, or limited, access to their own car.
2. A credible rural and inter-urban public transport network that enables intermodal links to local walking, cycling, taxi, demand-responsive transport and other transport options should be a policy priority.
3. The maintenance of retail and service outlets in rural areas is important, not least because ICTs are likely to remain an incomplete solution for those rural residents experiencing social exclusion through "poverty of access".

Without such protections, it was predicted that rural, especially poorer and older, households would become increasingly marginalised and excluded from mainstream society.

Walking and cycling

The *Visions for Walking and Cycling Project* envisaged that people who are favourable to walking and cycling will migrate to the city, while those city dwellers who feel attracted to their cars will move in the opposite direction. The overall impact of this relocation might lead in fact to an increase in fuel use (Tight et al., 2011).

In an optimistic vision of the future, rather than active travel being the mode of necessity for those who are unable to afford motor vehicles it would become the mode of choice (Banister and Hickman, 2013). To achieve this vision would require greater enforced restrictions on car travel in some areas to ensure that walking and cycling is the safest, most convenient, most pleasant, and quickest way to reach destinations. The reallocation of space for pedestrians and cyclists is of particular importance.

It was suggested that the potential to increase cycling and walking symbiotically relates to active ageing, with the use of assistive technology. Three potential planning and policy scenarios for facilitating this in the UK were offered:

1. Shorter journeys facilitated by the re-localisation of activities into the community.
2. The sharing of household tasks across families in multi-generational households, or neighbours in co-housing.
3. The use of such modes needs to be seen as beneficial to health and to successful ageing. In addition, obesity levels in the future are likely to significantly influence engagement in active travel (Shergold, Lyons and Hubers, 2015).

Diversification from car only options is predicted in the EU car-sharing market, with a further growth in bike-sharing, among younger, well-paid, well-educated Caucasians living in inner urban areas. There are limits to the scale at which these can be deployed in a cost-effective manner, but their use will grow in the coming decade as more providers and different systems are introduced (Marsden et al., 2016).

Shared mobility and mobility as a service (MaaS)

The sharing of services, including mobility, social and work services, is predicted to become a ubiquitous part of everyday lives, with people focusing on “usership” rather than ownership (Hunter, 2016). Cars will be seen as just commodities, replacing public transport where it fails to deliver mobility (Jeekel, 2015).

A fleet of neighbourhood electric vehicles for rent may provide a more affordable alternative than having a second car in the household. Neighbourhood bike-sharing programmes may also be appropriate for some cities.

However, a car-dependent transport system may still exclude many of the people who cannot access these shared services for reasons of cost (for AVs and associated falling costs, access may plausibly increase), physical or cognitive ability, and other factors such as prejudice against the access of some population sectors.

Bike-sharing schemes in deprived areas may remove certain barriers (e.g. access to a bike, fear of theft). Nevertheless, these areas may still not be preferred by private operators and the schemes themselves may not be considered to benefit the community and consequently, they may face public opposition and vandalism. Bike share equity schemes, such as the Bikes for All Glasgow that aim to remove barriers such as the ability to ride, the access to a bike and the high cost and requirement for a bank account to gain membership may help normalise cycling among under-represented groups (Carplus Bikeplus, no date).

Apps and other digital platforms could make it easier the seamless integration of various means of transportation and to share both cars and rides for individual trips. City dwellers and younger people in particular will be more likely to use these shared modes, as is currently being witnessed with Uber and LIFT services in the USA (Zmud et al., 2013).

Assistive technologies are likely to significantly influence travel patterns, but specific insights into the travel demand consequences are difficult to pinpoint. It is possible that younger generations will transform their travel patterns, away from car ownership towards on-demand services and social networking (PTEG, 2015).

A study from the Netherlands notes that most middle-aged drivers will need mobility in increasingly fragmented networks, i.e. not necessarily during the current peak periods of travel or in the same concentrated spatial patterns as we currently see. This suggests they will prefer flexible cars that are easier, more reliable and predictable. Younger drivers will also see driving as “not-connected time” (although this may plausibly change upon introduction of AVs), which may support more innovative, sustainable solutions for car ownership, such as sharing options (Leung et al., 2015). Experts have expressed some concerns about the ability of older or disabled people to book and summon publicly operated automated vehicles, since they may not be as digitally literate as required by the booking technologies (London Assembly, 2018).

There is a related risk with making shared mobility and public transport services more convenient and cheaper because it can mean that people substitute trips that would otherwise have been made by active travel. The limited experience from Finland and Whim shows that App users reduced the car use and increased their public transport but also taxi use (London

Assembly, 2018). Without clarity about the regulatory role of the state and the position of authorities in managing the transition, delivering ICT-led mobility options will be difficult and there may be some unwanted and difficult to manage downsides, including equity effects (Marsden and Docherty, 2017).

Electric and hybrid vehicles

Electric mobility is a "double basic innovation," sweeping both the transport and electric power sectors and driven by digitisation. It is predicted that electric vehicles (EVs) will be the norm in the UK by 2030. We can expect to see the costs of motoring declining slightly again, after a period of real terms growth over the last 20 years, due to this electrification of the domestic vehicle fleet (Nellthorp and Marsden, 2017). Financial subsidies have already made battery electric vehicles comparable in price with conventional vehicles in the UK – taking into consideration purchase and operational costs (Palmer et al., 2018). But the costs of running *second-hand* electric cars may increase due to battery maintenance costs (Mullen and Marsden, 2016).

However, the policy focus on EV technology to reduce emissions may exacerbate the previously highlighted concerns in this report about the affordability of private transport. There could be financial advantages for people who have access to EVs in emission charging zones, who will use less of their income on motoring costs as a result (Mullen and Marsden, 2016) and for people who can afford electric cars if proportional tax deduction systems based on CO_2 emissions are implemented (Boussauw and Vanoutrive, 2017) .

Although the cost of electric vehicles (either referring to the total, including purchase and operation costs, or even in the future the upfront) may reach cost parity with conventional petrol and diesel cars, low income households may still be unable to afford them and benefit from the lower motoring costs. Many households in the UK opt to buy cheaper, second hand vehicles and it is uncertain how the market for second-hand electric cars will develop (Mullen and Marsden, 2016).

The location of charging stations can also be an issue of equity among different road users, in case these take up space on pavements from pedestrians obstructing their movement and causing difficulties in the accessibility of people with physical impairments.

Other potential equity issues relate to how the increasing cost of household energy will be distributed (across electric car users or all customers and households), the potentially limited access to charging stations for those that do not have off-road parking, and for people living in houses that are unsuitable for plug-in cars (Mullen and Marsden, 2016b).

Finally, the possible decline in the revenues from fuel duty may necessitate taxing measures for electric vehicles with differential impacts among different social segments.

Automated vehicles

There is high uncertainty around the time period in the UK context, the extent to which and the types of automated vehicles that will penetrate the market, and how regulation and public acceptability will influence these. It is currently predicted that the share of fully automated

vehicles (AVs) will remain very low in the UK to 2030, but advanced driver assistance systems functions are already increasingly available in newer vehicles.

In the USA, it is predicted that AVs will be widely available by as early as 2030, but they will be largely unavailable to poorer households at this time. A novel pricing structure (for example, through shared public hire and if car sharing becomes a usual mode of travel) could make them less expensive than taking traditional taxis but still more expensive than owning traditional private vehicles (Zmud et al., 2013).

Additionally, there is a great deal of uncertainty around the direction and scale of the impacts of AVs on traffic flow and congestion, safety of different road users and how they will influence land use, individual car-ownership and a shift to walking, cycling and transit. Much of the research around AVs focuses narrowly on these technological issues and there is an assumption that any public concerns and resistance will dissipate in the future, with many knowledge gaps about how they may affect people and mobility (Cohen et al., 2017).

This uncertainty around the potential impacts of AVs in many cases inhibits planners, and the public sector in general, to act proactively and integrate this technology in their long-term visions and decisions about their road and public transport investments, in spite of the recognition of its transformative role (Guerra, 2015).

The predictions for vehicle miles travelled by AVs vary significantly depending on assumptions around automated mobility costs, adoption of shared AVs in comparison with privately owned AVs, future policies, the impact on parking demand and urban sprawling, the use of travel time in productive ways, the impact on the accessibility of non-drivers, the youth, the elderly and disabled groups (Litman, 2017).

How these technologies develop and roll-out in practice will have important consequences for the personal and shared mobility choices made by non-driving sectors, such as older and disabled people. However, the extent to which these technologies will impact the non-driving sectors depends on the same factors, namely cost and access, identified above with assistive MaaS technologies (Curl, Clark, and Kearns, 2017). Fully automated vehicles may open up new markets for automotive companies to sell to older people or those with physical or mental impairments (PTEG, 2015).

Scenario-based research in the US (which is obviously quite different in its car use behaviours to the UK) predicts that by 2028 the ability to drive will fade among the new driving generation, due to an increase in AVs. It also suggests that older people will be able to remain independent, because loss of a driving licence no longer means reliance on taxis, buses or relatives. “Super-commuters” (90 mins or more travel each way) are likely to increase as vehicles will turn into a true mobile office. Mobile devices will allow seamless transition from home to car to office (Zmud et al., 2013).

Fully automated vehicles may open up new markets for automotive companies to sell to older people or those with physical or mental impairments (PTEG, 2015). How these technologies develop may have important consequences for the personal and shared mobility choices made by older people, albeit subject to all the same caveats of access and cost seen with assistive technologies (Curl, Clark, and Kearns, 2017).

In the UK context, it is worth noting that it is unsure if market-led development of the AVs technology would ensure that these vehicles will be as accessible and affordable to different income segments and currently non-driving vulnerable groups such as the elderly and disabled people. Clearly, they would need to be adapted to meet the specialist needs of these specific groups, and there are still open questions around the possible regulation regimes in which they could safely operate for the drivers who would be unable to take over their controls manually when needed (Cohen et al., 2017).

Freight automation and robotic deliveries

There are very few studies of the current or future social effects of freight automation and so it is difficult to assess their impacts on accessibility and social exclusion. As such, many of the claimed benefits and disbenefits for currently excluded groups are largely based on speculation.

One rare Swedish scenario study[8] has identified a number of potential scenarios for automated freight for the future with some interesting findings in relation to the social implications of their introduction.

Truck platooning (using AVs) is predicted to increase traffic safety by reducing the number of head-tail collisions due to the autonomous cruise control and/or emergency braking functionality. This would be of most benefit to traffic vulnerable pedestrians in the most congested urban areas and on arterial rural roads, although it is more likely to be introduced for motorway driving in the first instance.

The use of AVs in freight transport and deliveries may reduce the labour costs if drivers are no longer required. However, some of the current staffing time of truck and van drivers is used in loading and unloading, which would not necessarily be automated. This suggests that any claims over their contribution to reduced product and food costs, which would be of benefit to low-income households, is speculative at this stage.

The extent to which these benefits would accrue to small and middle-sized operators in these sectors depends on their upfront cost, which is highly uncertain, also the financial benefits might not accrue to the customer.

The advent of robot and drone curb-side and last mile delivery could be of potential benefit to people who are unable to be at home to receive parcels but also present a certain risk to pedestrians, and especially blind people and wheelchair users due to the potentially *ad hoc* and largely unregulated nature of their operations. If robots and drones will use the pavement space as drop-off points, they will represent a hazard for the other users of these public spaces.

[8] As yet unpublish by Professor Michael Brown at Gothenberg University

6 Recommendations for promoting more socially inclusive mobility futures

In this section of the report, we attempt to synthesise the key issues that have arisen from our rapid review of the available evidence, together with discussions of this evidence with colleagues in the Institute for Transport Studies and at other UK universities, the Department for Transport, and local NGOs.

We have attempt to draw out the key inequality issues identified within the evidence base, which is neither comprehensive nor exhaustive. We consider first some general issues, and then look at issues for each of the specific modes identified as most relevant to the mobility of socially disadvantaged population groups, who will be the most vulnerable to future changes.

Our observations are entirely subjective and so cannot be taken as robust or fully representative of state of the knowledge on this important issue of future inequalities arising from the mobility landscape in the UK to 2040. This would require a comprehensive and dedicated programme of research, which is outside the scope of this current report to provide.

General issues

More evidence and research on the differential impacts of new technologies for different groups is urgently needed. The published academic and policy evidence for this specific topic is sparse and much of the future scenario and visioning work that was reviewed for this report did not consider social inequalities, or paid only passing attention to this issue.

There are likely to be ***fundamental changes to the overall mobility landscape*** as a result of the new technologies and mobility services. There is a need for ***dedicated and targeted research of these issues*** if we are to understand the effects of these changes on already disadvantaged and marginalised groups.

The EU has recommended ***wider public engagement with future transport issues***, in order to provide integrated policy approaches and to understand the socio-cultural and structural determinants of future transport demand (Whitmarsh, Haxeltine, and Wietschel, 2007). We would stand by this recommendation, with the added suggestion that ***all future mobility landscapes should be subject to a full social impact and equity assessment*** to understand how they will affect different social groups and geographical locations and to develop suitable mitigation measures where damaging inequities are identified.

The Governance of UK Transport Infrastructures (Marsden and Docherty, 2019) study conducted for the Future of Mobility Foresight project suggests that:

"Without clarity about the regulatory role of the state and the position of the different authorities in managing different parts of the transition, delivering the benefits of smart mobility will be difficult and there may be some unwanted and difficult to manage downsides".

A ***key challenge will be managing the inequalities in access to these new technologies*** that are likely to arise due to their non-affordability and physical unavailability in certain locations (for example, rural and urban peripheral locations).

Based on the evidence we have reviewed in this report, we recommend that ***carefully designed policy interventions are needed to ensure that the current inequalities in mobility and accessibility do not deepen and widen***. However, there are several tensions in the current governance of the transport system that run counter to the equitable delivery of a fair and inclusive future mobility landscape. These issues will need to be directly addressed if a more inclusive approach to mobility is to be achieved:

- People on low incomes are increasingly living in peripheral urban areas where housing is cheaper but where it is most difficult to provide economically efficient public transport options. As such, they are bearing the burden of increased travel costs;
- Failure to explicitly recognise the important social value of transport within transport, land-use and public service planning is driving a mobility culture that most advantages already highly-mobile and well-off sections of the population, while worsening the mobility and accessibility opportunities of the most socially disadvantaged in the UK;
- There has been a general decline in subsidies for community transport, in particular for buses, leading to a reduction in services in peripheral areas and outside peak operating hours. Poorer people are more reliant on these services and so their loss particularly affects already struggling households;
- New revenue sources, e.g. road user charging, could be regressive, depending on their design, and so poorer people may not gain the benefits of many of these new technologies, and this will drive further inequalities in access to life-affirming opportunities; and
- The UK concessionary fares system and other price subsidies are poorly targeted in terms of benefiting those who are most in need of reduced travel costs and cheaper travel alternatives.

Mode-specific challenges and opportunities

Walking is generally the healthiest, cheapest and most environmentally sustainable future mobility option. However, the people (mostly low-income) who currently are most reliant on walking tend to tolerate poor environmental conditions and feel that they have no rights to challenge this (unlike the cycle lobby, for example) (Pooley et al., 2014). Many of the inequalities in mobility and accessibility could be reduced with ***greater attention to the promotion of walking options and the advancement and enforcement of pedestrian rights within local travel plans***. This would also require tighter local planning regulations and control over the location of housing in relation to jobs and services to make walking access a more viable option.

The City of Bogota in Columbia is widely noted for its adoption of policies which have promoted walking through its ***Street as Places campaign***[9]. Barcelona is a good example of a city that has recently begun to adopt this “streets for people” approach in Europe.

[9] Street As Places Website https://www.pps.org/article/streets-as-places-champion-gil-penalosa-to-talk-this-september

Cycling has not been a popular alternative to the car for low income populations. The most often reported barrier to cycling by low-income households is a lack of safe storage space. This is particularly relevant for people living in high-rise accommodation and social housing estates, and in places where there is high incidence of crime. In London, recent research found that people living in poorer areas participate less in cycle sharing (TfL, 2011; TfL, 2016); the reasons are fear of crime, anti-social behaviour, and concerns about image (TfL, 2011).It has been suggested that the advent of ***e-bikes might provide a cheaper mobility option*** but these safety and image barriers would need to be addressed to make them more popular with current non-users.

Public transport, especially the bus, is the most important travel option for all people who cannot or do not drive, and is the mode of transport that is used by the majority of low-income households for meeting most of their travel needs. The potential loss of these services in favour of more ***demand-responsive and flexible, Uber-style services*** can seem an attractive option for the development of a more inclusive urban transit network as these services can operate over a wider network and offer much more flexible door-to-door services. However, this expansion could largely depend on subsidies, as there is an additional cost associated with their operation outside dense urban areas and outside of peak travel times.

Recently in the Press, ***private companies have announced their intention to expand their operations to the provision of flexible public transport services*** and bike sharing options in order to fill gaps in the current market and to bring down the cost of fixed transport more efficiently and reduce car ownership.[10] The inclusivity of these services would hinge on their ***strict regulation and scrutiny so that they operate in a socially optimal way, and not simply for profit***. Fares, frequencies, coverage across sub-optimal operating areas and off-peak hours, and driver training will be needed. They should also be carefully integrated with fixed route services so that they do not compete for custom in profitable mass transit corridors.

The current system of ***shared mobility*** (for example, car and bike hire schemes) is based on the assumption that everyone has access to a bank account and a credit card. Although most people now have the former, largely due to the demands of the welfare benefits and wages system that payment must be made to a personal account, ***a large number of low-income and older individuals do not own a credit or debit card*** and can only use their bankcard to withdraw money from the bank or ATM, up to their financial limit. Currently, this excludes them from the use of some of these shared mobility services, such as Uber, bike hire schemes at stations, and any other mobility service where a bank card is needed to sign up.

Related to this issue, ***some people cannot get access to car insurance***, either because it is prohibitively expensive (for example, for low-income households and young drivers), or because they have a poor driving record, for example previous endorsements on their license. This means these individuals also might find it difficult to hire a car or join a car-sharing scheme.

There is a related risk with making shared mobility and public transport services more convenient and cheaper because it can mean that ***people substitute trips that would otherwise have been made by active travel***. The limited experience from Finland and Whim shows that App users reduced their car use and increased their public transport but also taxi use (London Assembly,

[10] https://www.theguardian.com/cities/2018/mar/29/public-transport-transit-private-companies-citymapper-uber-whim-smart-buses
https://www.citylab.com/transportation/2018/04/uber-pivots-to-on-demand-everything/557528/

2018). A related issue with ***MaaS*** is the possible exclusion of some sectors of the population ***due to digital divides, lack of appropriate skills and literacy, and other cognitive and cultural barriers***, which may affect their ability to interact with the new technology systems. This is most likely to affect older and younger people and new immigrants to the UK, who may not have experience of these new systems.

However, ***new electric vehicles are expensive***, and so lower income households may be trapped into owning and driving lower priced and more polluting vehicles, and so, they are also more susceptible to the additional cost of pollution charging in cities. Although low-income households are increasing their levels of car ownership, they ***will not automatically reap the benefits of these new electric vehicle technologies***, or not until much later than higher income households, under a market-led penetration model. Current policy approaches to reducing transport energy and emissions are promoting the adoption of low emission and electric vehicles. Incentive schemes to purchase these vehicles more cheaply are still out of the price range of these households, which usually buy second-hand cars. It is possible that the option to move to a shared mobility economy could overcome this price barrier to some extent.

In a similar way, under current models of ownership, ***automated vehicles are unlikely to become available to low-income households*** until they become ubiquitous in the second-hand market. This means that many people who are currently unable to drive for a variety of physical and cognitive reasons are also most likely to be excluded from automated vehicle uptake over the shorter term. However, it is possible that alternative models of access or "usership" may reduce these effects. ***Many disabled people are also reporting fears about their physical safety*** as pedestrians in shared space environments where these vehicles might be operating.

When ***revenues generated from a tax on conventional fuels are used to finance subsidies for electrical and alternative fuel vehicles***, the richer households that own such vehicles will experience welfare gains, but overall the policy will increase income inequality and decrease social welfare (Reanos and Sommerfeld, 2018). In future, the people who can afford these vehicles will benefit from lower per mile costs of travel, they will be more insulated against rising fuel prices, and will avoid the planned road user and emission charging penalties that are being introduced by local authorities.

A key barrier to cycling is related to people's health and physical capacity (Philips, Watling and Timms, 2018). As previously noted, lower income groups experience higher levels of ill-health, and have higher concentrations of older and mobility-impaired people, lone parent households and carers. This means that they are more constrained in their ability to cycle.

We have not given wide consideration of ***passenger rail or air travel*** in this report because socially disadvantaged populations do not generally use these modes. The obvious conclusion from this observation is that these groups ***will also not benefit from the new High-Speed Rail investment or airport expansions projects that are planned for the UK***. The perhaps less obvious conclusion is that the more overall mobility speeds up and longer travel distances become the social norm, the less the people who are excluded from this hypermobility will be able to access everyday activities due to the friction of distance.

Ultimately, the social inclusiveness of the transport system could be improved through effective and ***integrated land-use and service planning and by supporting structural and policy-led demand-restraint measures (such as parking controls, and workplace and school travel***

plans). As long as house building and rental policies remain largely in the realm of the private domain to dictate their locations and supply levels, with insufficient consideration of residents' ability to easily, safely and affordably connect to jobs, health and education services, and other amenities, access to will be constrained.

No amount of innovation in new mobility technologies and services can overcome the current or future social divides in mobility and accessibility in isolation from a more tightly regulated and controlled land-use regime. A first step could be to encourage local transport authorities to ***use accessibility planning[11] as a way to assess their ability to adapt to the new mobilities landscape*****,** and how this might affect different social groups in their local administrative areas.

A shared vision to promote future equity in mobility and access

A group of key international NGO stakeholders has identified 10 "shared mobility principles for liveable cities" (Chase, 2017) for the promotion of sustainable and inclusive urban mobility futures, which they are promoting with cities worldwide. We would recommend that a similar set of principles could be adopted and promoted with policymakers and NGOs in UK cities with special additional attention to the following points for maximum social inclusion:

1. Planning cities and mobility together – with particular attention to the provision of low cost accommodation in areas with high levels of walking and public transport access to employment and other key activities.
2. Focus on people not cars – especially thinking about the needs of already disadvantaged and vulnerable social groups.
3. Make efficient use of space and assets – and evaluate the distribution of these assets across of different social groups, with attention to green and public spaces.
4. Engage stakeholders in decision-making – and ensure that everyone has a voice in the decision-making process.
5. Design for equitable access – and recognise that some population sectors may need additional support to be able to secure access to facilities and services.
6. Seek fair user fees – based on clear standards for assessing affordability and offering subsidies to people who cannot afford mobility services.
7. Transition towards zero emissions – but ensure that people who are unable to afford new low carbon technologies are not disadvantaged by this transition.
8. Deliver public benefits through open data – and ensure that all population groups have the resources and skills to access these data resources.
9. Provide integrated and seamless connectivity – but also first ensure that everyone has the basic level of mobility needed to access their livelihoods and everyday activity needs.

[11] Accessibility planning was the key recommendation of the 2003 SEU report. It was introduced in 2006 by the Department of Transport (DfT) within Local Transport Planning Guidance to local authorities and has subsequently been reinforced and mainstreamed for the assessment of the public transport accessibility of new major transport schemes in WebTAG. It is not, however, g
enerally used by local authorities in the way that was originally recommended by the SEU, which was to determine where there is a shortfall in the accessibility and inclusion of their current transport provision, and to determine future policies to address transport inequalities.

10. AVs must be shared – inclusive access to these shared vehicles should be ensured, and their use should be heavily restricted in areas where they may pose a threat to vulnerable road users.

Appendix

Summary overview of predicted transport futures by mode and social/distributional impacts

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Walking	Overall trend has been a decline, but future of walking is less clear. Visions mainly focus on types of conditions that walkers would value in the future.	Improved street lighting and security systems would make women feel safer walking at night.	The safety of older people and children will improve if walking facilities were to improve.	Improved walking environments are also beneficial to wheelchair users. Street furniture can be an issue for blind people.	No obvious issues.	There may be unforeseen equity issues, as lower income household are forced out of central urban areas through gentrification. Walking environments are generally worse in deprived areas, despite more people walking there.	Loss of school crossing patrol jobs as local authorities reduce expenditure. Increase in parking officers as local authorities introduce tighter on-and off-street parking control measures.	Remains an off-road leisure activity. Rural roads are unlikely to have improved walking infrastructure.	If urban areas continue to gentrify, it might improve pedestrian facilities and contribute to traffic calmed neighbour-hoods.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Cycling & E-bikes	Limit to which 'traditional' cycling (without power) can be increased. A shift towards active modes is unlikely without some intervention e.g. the introduction of e-bikes.	Most popular with young males 16-30. 'Traditional' bikes remain less attractive for women because of journey needs and psycho-logical factors. E-bikes preferable for women, with take-up more likely.	Take-up of 'traditional' cycling by the elderly is unlikely. E-bikes could appeal to most age groups, especially 'young' elders. Increase in non-disabled older people may make them a target market, impacting on older driver numbers.	Increase in numbers of disabled people may result in lower cycle rates. Increase in cycle trailers with disabled people, especially if E-bikes uptake is as predicted.	Cycling is less popular with some BME groups, especially Muslim women, due to cultural factors.	Cycling could be a good future low-cost option but is currently less popular with lower income groups, due to lack of safe storage space in the home, poor cycling infrastructure in deprived areas, and attitudinal factors – 'Get on your Bike' aversion.	Increase in road traffic accidents due to speed, inexperience and lack of training. Increase in cycle trailers with children if e-bikes uptake goes as predicted.	Leisure cycling will remain a popular rural pursuit. E-bikes may be less attractive due to longer journey distances and trip durations.	Increases in cycling are most likely in urban centres where dedicated infrastructure can be installed. E-bikes might take patronage from some walking and PT, though unclear.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Buses & coaches	No radical change to 2040 predicted. Existing downward trends likely to continue. Future demand seen largely as that of population change, especially for older and younger passengers.	Women are more likely to use buses than men.	Potential growth in use by older and younger people, but demand is for more flexible, on- demand, door-to-door services.	Potential for growth due to improved physical access of stops – raised curbs etc.	Issues for some BME women using buses when travelling alone. More bespoke services could encourage greater bus use by Muslim women.	Improved connectivity perhaps an attribute of this cohort to attract users?	There is a predicted decrease in bus driver jobs and related maintenance and production trades due to the introduction of AV/PHVs and MaaS. Adult working age car drivers could switch to buses, if speeds and reliability is improved as a result of Park and Ride and dedicated busways.	Rural bus services will continue to decline. Potential for growth in taxi/PHV supply and use in rural areas as an alternative to buses in areas/times of low demand.	Declining car ownership and factors affecting specific trips (such as shopping) could increase demand for buses in dense urban areas. Cash-less systems may improve boarding times and reduce dwell time at stops, speeding up services and improving reliability. Continued fleet replacement should increase fuel efficiency and emission reductions. Little evidence of alternative fuels attracting users.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Passenger rail	Passenger demand likely to increase up to 2040, with different forecasts for unconstrained and constrained visions linked to supply limitations. Passenger growth figures ambiguous, with disparity relating to delays and overcrowding. Passenger growth likely to be slower to 2040 than in previous 20 years.	No obvious issues	Shift by 'millennials' away from car ownership and suburban living predicted to continue. Complexity of ticketing and fare system may be a barrier for those less competent, typically the elderly.	Some rail companies (e.g. Northern) are encouraging rail use for disabled passengers. Continuance of DDA compliance at stations could encourage more disabled users.	No obvious issues.	Lower income groups remain largely priced out of the mainline commuter rail market. Investment in improved local rail connectivity and fare subsidies could enhance use by lower income populations, where routes offer new connectivity to jobs and services.	Trade union and consumer resistance has prevented the spread of driverless operations and trade union resistance has made driver only operation problematic. Investment in High Speed Rail mostly benefits high-end commuters. Potential for new service sector job growth in and around new and upgraded stations.	Walking to rail stations expected to decrease as car-based commuting increases in rural and fringe areas.	Saturation in some markets may have already been reached which will impact growth. Overcoming ticket purchase barriers might encourage rail use as a MaaS offering, though fragmented nature of industry is a barrier.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Mobility as a Service (MaaS)	Shared mobility and shared modes will continue to grow in significance. MaaS is seen as an opportunity for government to encourage behavioural change in transport. There will be a trade-off between maximal individual freedom to travel and the efficient operation of the transport system.	No obvious issues.	Rising population of elderly people no longer able to drive may benefit. Younger people increasingly excluded from car ownership and use might benefit. Barriers exist for less technically able around reselling tickets, and the openness of Application Programming Interfaces (API) undergirds services.	Potential benefits for high functioning disabled people from MaaS.	Shared transport is not popular with some BMEs due to fears of racism.	Rising transport costs could be a core driver in pushing shared mobility options The ideal for implementation of MaaS would be fully inclusive for all travellers. However, it should avoid pricing households out of transport options (thus creating “the MaaS and the Maas-nots).	There are likely to be impacts on various employment sectors, especially traditional taxis and public transport services but the final outcome is unclear.	Low population density setting makes MaaS difficult to deliver, so private car remains important. How do you then integrate it with traditional transport services for inter rural-urban trips?	Car ownership far less important in a high-density environment, with far more shared services. MaaS potentially offers a paradigm shift from transport being fundamentally provider-led to being a fully user-led system MaaS may be superseded if driverless AVs become universally adopted.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Roads	Growth in number of road vehicles not matched by increased road space will lead to increased urban congestion. Strong potential for road user charging to be introduced.	Female driving parity with males. Congestion charging in towns could adversely affect women, as they make more home-based trips.	Longer driving into older age. Less young people owning cars.		Increased migrant populations living in urban locations can result in lower levels of car ownership.	Effect on low income households with cars as driving is likely to be become more expensive with introduction of AV/EVs and road charging.	Loss of jobs for road construction workers and in associated trades.	Rural road maintenance could become an issue, especially on secondary routes.	Congestion charging is likely in most major cities combined with greater parking restrictions and traffic management systems.

Mode	Predicted Trends	Likely social distributional impacts							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
AVs (Future Roads)	The main predicted issues with AVs are: i) whether they will become fully automated (driverless), ii) integration with existing vehicles, iii) safety for other road users, especially pedestrians, iv) cyber hacking. Lack of trust a key factor in limited support for AVs. Risk averse people are very pessimistic about AVs- technology could isolate those who are uncomfortable with it and roll out is likely to be highly unevenly distributed across the population.	Women tend to be late adopters of new technologies, but many women report they prefer driving semi-automated vehicles.	AVs might be less dangerous than having elderly drivers on the road. Reducing isolation amongst the elderly if they could use more automated services. AVs being used to transport vulnerable individuals that were not able to take control of the vehicle if needed (e.g. children, disabled people or the elderly).	The industry affirms that AVs will allow disabled people to drive, but the disabled people themselves are sceptical. AVs would not be able to assist disabled people and those with mobility problems. Disabled people fear exposure to more dangerous environments as AVs are introduced.	Risk averse people are very negative about AVs. AVs could isolate those who are not comfortable with it.	AVs would be expensive to own, and so prohibitive for low income groups.	AVs may result in job losses in certain sectors. AV industry would create higher skilled jobs which may marginalise the less educated or immigrant groups. Taxi drivers concerned with full automation and saw pods as direct replacement.	People would live further away from work if able to work well en-route.	Operation in dense urban areas is questionable for reasons of safety but also provision of infrastructure. Parking was also raised as an important lever for local authorities to influence mobility choices, with AVs likely to seek out areas with the cheapest parking rates, which may lead to a loss of revenue. Full automation considered alien and distant, with struggle to imagine this as feasible.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
EVs (Future Roads)	Likely to not alter use of roads, as it would mainly affect fuelling. Journey planning and time taken to do so likely to increase, reducing spontaneity and jarring with notion of freedom given by car driving.	No obvious issues.	Quieter vehicles can be a problem for on street safety	Quieter vehicles can be a problem for on street safety, especially for deaf people.	No obvious issues.	Purchase cost of EVs expensive for low income households. Interest in purchasing EVs if cost-savings in the future could be demonstrated and reassured about range and reliability concerns. Electric Vehicles (EV) are a good economic proposition for transport in that fuel costs are low, but the infrastructure is lacking. Concern that charging through mains electricity would impact on ability for lower income households to budget properly.		Range of vehicles likely to be a barrier to uptake. EVs most associated with in-city driving.	Time to recharge discourages potential uptake, even at low as 20 minutes. Cyclists expressed concern about the risk of quieter cars and increase in accidents. EVs might encourage greater use of shared vehicles or public transport.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Domestic aviation	Two potentially disruptive / transformative changes envisaged – HS2 and development of other competing surface transport modes, and airline business modes and practices. Overall increased fares and reduced consumer choice may impact users.	No obvious issues.	Increase in elderly and infirm populations which have additional needs that require adaptive tech. to access air transport services – imposing additional costs.	Increase in elderly and infirm populations which have additional needs that require adaptive tech. to access air transport services – imposing additional costs	No obvious issues	Mostly applies to high income commuters.	Increase in experienced and trained staff required.	Airport expansions could affect some rural areas.	Future trade relationships likely to impact air traffic demand. HS2 may impact domestic aviation demand in the UK.

Mode	Predicted Trends	Likely social distributional impacts							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Freight last mile	Growth in e-commerce due to new demand through an internet connected population. Expected growth in last mile delivery as a result. Drones delivery will become prevalent with concerns about person safety at drop off venues. Large savings in journey times and emissions over conventional transport due to drone and droid use. Crowd-shipping – a new informal logistics network - enlisting people travelling from points A to B to take a package.	No obvious issues.	Ability to use new technology is perhaps a constraining factor for older people. Younger people driving demand through technology – smartphones etc.	Ability to use new technology is perhaps a factor for some disabled people	Possibly some cultural issues.	Concern for status of workers and delivery drivers, most notably in gig-economy – expected to rise	Increased adoption of personal deliveries to the workplace that might reduce wasted mileage during the working day. Though not explicit, drones and droid use could impact on employment, particularly retail and distribution.	Possible increase in accessibility for goods. Collaborative delivery between logistics providers for difficult to serve rural areas.	More freight delivery and private car activity into certain postcodes due to click and collect outlets and collection points. Use of Unmanned Aerial Vehicles (UAVs) (‘drones’) is emerging as a threat, including against aviation.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Rail freight	Changing nature of industry and retailing is leading to smaller volume, more dispersed flows. Flexible freight initiatives may use technology to enable rail to better cater for small volume, time-sensitive freight flows.	No obvious issues	No obvious issues	No obvious issues	No obvious issues	High-fixed costs and long-life assets make it challenging to change operating practices in the short term. Non-bulk users more price sensitive than bulk users.	No obvious issues	No obvious issues	The success of network performance and decarbonisation are closely related to government policy.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Maritime freight	Should be continued demand in line with increase in world population. Increased urbanisation, rise of megacities, rising living standards in some developing countries will lead to new trade patterns.	No obvious issues	No obvious issues	No obvious issues	No obvious issues	No obvious issues	Changes in supply chain architecture may limit these from becoming too stretched. Self-thinking supply chains in a connected global economy may lead to ships acting as rolling warehouses and floating factories with capacity to process/customise products on board and react to demand in real-time.	No obvious issues	Emerging structural change, with shipping companies looking to vertically integrate the multiplicity of actors in order to capture more customer value. Additive printing (3D and 4D) may impact shipping volumes. Major disruptive change due to technological change is unlikely.

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Data and ICT	Increasing amounts of data flow through the transport system. Clear ownership and conditions of use are key to enabling data sharing. Public attitudes to data sharing have relaxed, as long as there is a clear benefit. Despite the increase in data generated by transport, there are several areas where industry felt that more data would be beneficial.	Less connected people may not show up in the data, leading to withdrawal of services on which they rely.	No obvious issues	No obvious issues	No obvious issues	Parity of access to new mobility services will be an issue – what about those without access to smartphones?	Likely to see AV roll out first in private hire cars (‘robotaxis’), with fully autonomous personal vehicles taking longer.		No obvious issues

Mode	**Predicted Trends**	**Likely social distributional impacts**							
		Gender	*Age*	*Disability*	*Ethnicity*	*Income*	*SEG*	*Rural*	*Urban*
Planning and place (Stakeholder round table)	Ubiquitous connectivity will be seen as a utility, and will act as a facilitator (for MaaS) and an enabler (for remote working), though rural areas will need particular attention in order to achieve nationwide connectivity. Transport for the North (TfN) analysis suggests an increase in rail use of 500% and in road use of 50%, out to 2050. Opportunity is also not equally distributed between car owners and public transport users. Transport providers can use data for demand-responsive transport.	*No obvious issues*	Better understanding what drives millennials in their choice of where to live and the contrast with other generations would provide useful insights. Further emphasis needs to be placed on active travel and related infrastructure, enabling mobility of people of all ages	*No obvious issues*	*No obvious issues*	The design of transport around deprived areas can contribute poorer public health and there is an issue in the valuing of health in the appraisal of projects. Mixed messages about active travel are being sent out.	It is important to recognise that segments of society may not want to be connected and do not embrace new technologies, and that these people must not be excluded. Long-term planning between local authorities and housing developers would ensure a joined-up approach and guaranteed investment in infrastructure for local areas. Relationships between spatial configuration, population and employment ought to be explored and mapped with economic activities and character spaces within cities. This would illuminate mobility opportunities.	Rural areas are often isolated and the vulnerable must not be excluded. Good digital access is crucial, acting as a facilitator (e.g. for CAVs, MaaS) and as an enabler (e.g. remote working).	There is an opportunity with demographic data to better understand where there exists a high need for special access.

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