**Clark, J** and Minton, J. Driving Segregation: Age, gender and emerging inequalities. Chapter for *Geographies of Transport and Ageing.*Palgrave.

**6-8000 words including references. End of April**

***Q: is the issue word count or space (ie a word equivalent per table or image)***

***Q: is there any online appendix we could link to? Would it be ok to include in image a link to colour versions***

**Mobility [inequality by age, class - implications]**

**Gender**

**Generation**

**Cohort (increasing equality followed by increasing inequality (moving equal high to equal low by gender….implications; convergence on lower mobility cohort, for the future?)**

**- sub-issue of conversion of license holding to driving**

1. **Schematic table?  (cohort,  gender, broad characterisation)**
2. **Numeric table proportion of driving licence by age…also conversion**

**Add urban space issue transport poverty/ forced car ownership/ pushed to the periphery**

**[rethink the ‘public’ aspect of public transport?] – implications of the sharing economy? Resource managed more efficiently used by more people**

**INTRO:**

**Establish mobility and inclusion, multiple conceptualization of ‘age’ and car as ultimate mobility**

**LIT:**

1. **Proxy for intergenerational disadvantage**

**RQs: key importance of mobility and accessibility in social exclusion; amplified in later years. Young people as old people in waiting and recursive relationship between urban space and transport implications. Infrastructure changes have long term implications**

**CORE DATA:**

1. **Schematic table?  (cohort,  gender, broad characterisation)**
2. **Numeric table proportion of driving licence by age…also conversion**

**DISCUSSION:**

* **Urban space and transport**
* **Q of Age and physical isolation**
* **£££ Funding of transport and spatial dispersion of amenities**

**THE FUTURE:**

* **Platform economics (blur of private and public) and sharing economy as potential cures (Under-utilisation of assets relative to full capacity; more self-driving cars?). Active travel and greater longevity**

# Introduction

## Cohorts and car society

Auto-mobility has long been the dominant transport mode in rich countries, to such an extent that the ‘car system’, or ‘automobile society’, is considered highly path-dependent and autopoietic (self-reproducing) qualities. (Urry, 2004) These qualities of societal ‘lock-in’ which may be strongly resistant to external factors which could otherwise bring paradigmatic change, resisting the development of a ‘postautomotive mobility paradigm’.(Beckmann, 2001) Using cars for travel exclusively, known as mono-modal car use, has been likened to an addictive habit, much like tobacco use, not least because car use can also induce dependency and damage to health of both users and those nearby.(Douglas et al., 2011) Preference for travel by car, like many other preferences, is culturally transmitted, and so it is important to understand the role of childhood socialization in the development of such preferences. (Baslington, 2008, 2009) Decades of expanding car use, and the development of extensive travel infrastructure for cars and vans, has both led and followed strong and often obdurate preferences for private car travel amongst much of the affluent world. For example, analysis of data from the British Social Attitudes survey in 2000 suggested high levels of car preference amongst working age men, people with higher incomes, people living in rural areas, and in particular in people with children; these groups were both most responsible for vehicle pollution, as well as least concerned about their impact. (Huby and Burkitt, 2000) Such concerns relate to broader issues of environmental and social justice, where households exposed to higher levels of vehicle-produced air pollution also tend to be less likely to be car-owning producers of such pollution.(Mitchell and Dorling, 2003)

There are complex but compelling links between life stage and car use, as well as with household wealth and other demographic factors like gender. In the USA, both type of residence and the life-stage of household members are shown to influence how often and how far people tend to travel, as well as each other. (Lin and Long, 2008) Car dependency tends to increase in households after the birth of a child; (Lanzendorf, 2010) households with no children are more likely to use bikes and other modes of active travel, and households with children more likely to be car users. (Fatmi and Habib, 2016) Further, households with high income tend to be ‘car loyal.’(Fatmi and Habib, 2016) An important life stage, affecting both mobility and auto-mobility, are residential relocations due to both starting at university and starting a new job; these change people’s social networks, influencing the cultural norms and expectations people are exposed to, including towards car use compared with other travel modes. (Sharmeen et al., 2014) In the UK it is more common than in many other European countries for people to relocate when starting university, meaning that this life cycle event in particular can influence transport mode preference through both changing social network composition, changing residence, and through this also changing urban form.

One reason why cohort membership is predictive of auto-mobility could be due to homophily, the tendency for people to affiliate and associate themselves with others who are in many ways like themselves, and one of the important ways people distinguish themselves is by cohort membership, as such membership may also be predictive of having broadly similar experiences at various stages in the life course, and broadly similar attitudes and beliefs. This suggests there may be a complementary role for social network analysis alongside cohort analysis. Indeed, an analysis of Dutch commuting behaviour based on a survey of around 750 people in 2011 suggested that both social network composition and life-cycle events, such as moving home or forming a partnership, influenced levels of active travel, as well as each other. (Sharmeen et al., 2014)

The places people live also affect car use, with many suburbs effectively only accessible by car, and so car dependent. More compact urban forms, which reduce the physical distance between trip destinations, encourage lower car dependence and greater use of multi-modal transportation. (Dieleman et al., 2002) People living in inner cities in Denmark tend to travel less by car to work, and less overall, but somewhat more at weekends for leisure purposes. (Næss, 2006) Similarly, policies to promote infill and redensification of urban places through re-use of brownfield sites may lead to more sustainable and less car dependent travel behaviour.(Donegan et al., 2007) Increasing urban density, as well as improving public transport, may both have a causative effect on reducing private vehicle use per capita, and that these effects may be stronger than reducing levels of car ownership or parking spaces. (McIntosh et al., 2014) It has been argued that much of the difference in auto-mobility between different cohorts in the UK and similar countries could be due to each cohort’s differential experiences and exposure to a range of multi-level forces, each operating over broadly different timescales. Faster-acting changes include periods of economic growth and recession, referred to as ‘period effects’; changes operating at intermediate rates include changes in technology, demography, and average household income and wealth, collectively referred to as ‘structural effects’; and changes operating over the longest timescales including changing gender roles, and changing cultures of mobility and social/familial relations, collectively referred to as ‘deep structure’. (Tilley, 2017)

Though it has been argued that the kind and scale of policies required to bring about substantial vehicle-based emission reductions may be untenable in the modern political climate both within the UK and the rest of Europe,(Gössling and Cohen, 2014) some recent academic commentary has suggested that we may be undergoing a long-term and large-scale paradigm shift in both levels of and preferences towards car ownership. (Jones, 2014; Lee-Gosselin, 2017) After many decades of increasing car use and auto-ubiquity, there has been something of a reversal since the 1990s. Falling levels of driving licence ownership have been identified in at least nine developed world countries, with the largest declines reported in Australia, one of the most car dependent countries in the rich world.(Delbosc and Currie, 2013) Long term trends in per-capita car use in France, Germany, Great Britain and the USA suggest car use increased from the 1970s to the mid-1990s in all four countries, before stagnating or decreasing from around 2000 onwards. In each country, sustained high levels of car use amongst older drivers have partially or wholly offset reduced levels of car use amongst young adults.(Kuhnimhof et al., 2013) (Stokes, 2013)

Rates of driving licence ownership and driving have not fallen equally for both genders. Within Great Britain and amongst young adults, increasing levels of female car use have partially offset falling levels of car use amongst males;(Le Vine et al., 2013) after many decades in which men tended to drive more than women, in recent years, young adult females now have greater weekly mobility than young adult males of the same age.(Tilley and Houston, 2016)

The starkest falls in starting to drive have been observed within cohorts born after the late 1970s, often referred to as the ‘Millennials’, who in car mobility terms have been described as the ‘Go-Nowhere’ generation. (McDonald, 2015) Although in the USA there have been some falls in auto-mobility from the mid 1990s onwards in many cohort groups, Millennial-specific factors such as changing attitudes to car use and increasing ICT use may also have a significant role in their declining auto-mobility. (McDonald, 2015) Comparisons in the USA between ‘younger millennials’ (born 1999-1994) and ‘older millennials’ (born 1979-1985) suggest that many important life events – such as finishing fully time education, marrying and having children – occur at later ages for this generation than earlier generations, but that once such events occur, auto-mobility increases. (Garikapati et al., 2016) However, analyses on UK data suggests that people who start driving at a later age then continue driving less than those who first started driving at an earlier age, suggesting that there will not be complete ‘catch-up’ in auto-mobility amongst Millennials compared with previous generations even once life event deferral has been taken into consideration.(Stokes, 2013)

There are also important differences in attitudes to car use, and alternatives to car use, both within and between countries. A survey of nearly 900 individuals with cars in Norway found that perceptions about the social status of different transport mode users was important, with car users who did not consider public transport users to be of low social status also more likely to use public transport themselves. (Nordfjærn et al., 2016) A comparison between Germany and the USA, both countries with very high vehicle ownership, shows that Germans travel less by car and much more by other modes, and that American preferences to drive persist even for those living in dense, mixed use areas with close public transport. (Buehler, 2011)

Despite these long-term trends, England and Wales remains car dependent, with 67% of commuters using cars or vans as their main commute mode in 2011.(Goodman, 2013) The cost of car or van ownership and use leads to a socioeconomic gradient in modality, with those from more deprived areas more likely to walk or use public transport, but not to cycle, than those from less deprived areas.(Goodman, 2013) In the USA, falling levels of driving levels in the 2000s have not been accompanied by commensurate increases in use of alternative travel modes, leading to reduced mobility overall. (Manville et al., 2017) While car use is reducing in much of Europe and North America, it is increasing substantially in China, (Mao et al., 2016) creating competing demands on urban land currently used for walking and cycling. (Feng et al., 2013) In Beijing, China, most people use public transport rather than private vehicles to travel to work, although car use is increasing rapidly. (Mao et al., 2016)

## Health, wellbeing and mobility

The relationship between car ownership and car use, and health and wellbeing, is complex, and it is especially important to distinguish between the associations that exist between different populations in terms of both health/wellbeing and car use, and the causative effect of car use on health and wellbeing over various timescales. In terms of association, car ownership has been shown to be a more consistent predictor of quality of life in European cities than home ownership amongst older people. (KNESEBECK et al., 2007) In Western Scotland, lack of car access remains associated with poorer general health, and in particular with increased prevalence of depression and anxiety. (Ellaway et al., 2016) Conditions experienced in both midlife and childhood can strongly affect outcomes at older age, including physical mobility and risk of depression. (Groffen et al., 2013) A decades long longitudinal study of nearly 5,000 people in Reykjavik, Iceland, found lack of car ownership in middle aged predicted depressed mood thirty years later. (Groffen et al., 2013) Similarly, older residents of Mediterranean islands were also assessed to have better levels of ‘successful ageing’ including lower prevalence of obesity and hypertension, as well as higher rates of physical activity, if they were regular car users, than similarly-aged residents without car access. (Tyrovolas et al., 2017)

Despite these positive correlations between car use and well-being amongst older populations, there is also evidence that walking, travelling by train, and cycling are more satisfying modes of travel than driving, travelling by bus, or travelling by underground. (St-Louis et al., 2014; Thomas and Walker, 2015) However, in China, where most people are not car users, there is evidence that both driving and walking have amongst the highest satisfaction levels, whereas travelling by bus or underground amongst the least. (Mao et al., 2016) Regarding the causative role of car use on health, multivariate analysis of the UK Household Longitudinal Study (UKHLS), which through its study design allowed socioeconomic confounders to be controlled for, has shown public and active travel to be associated with lower BMIs for both males and females. (Flint et al., 2014) Longitudinal analysis of individuals in the British Household Panel Survey (BHPS, the precursor to the UKHLS) found that, after controlling for SES, switching from private car use to public transport or active travel was associated with reduced BMI (-0.32 kg/m2), and converse switches to private car use associated with increased BMI of almost the same magnitude (0.34 kg/m2).(Martin et al., 2015)

## Aim of chapter

The aim of this chapter is to graphically explore the complex roles and interactions between generational membership, age, gender and education in explaining both rates of learning to drive (‘driving licence ownership’), and car use and access amongst those with driving licences (‘drivers who drive’). We use a large-scale longitudinal household panel survey based in the UK for our data, and Lexis surfaces – a method often used in demography but rarely for survey data – for our visualisations. Our use of this data and method is exploratory rather than confirmatory, and does not involve formal statistical hypothesis testing, but instead to become more familiar with a large quantity of data, to note and discuss patterns within this data, and to consider the broader sociological, economic and epidemiological implications of these patterns for advancing our understanding of how car society is changing, and important ways in which inequalities in auto-mobility are either narrowing or expanding.

# Methods

## Data

The British Household Panel Survey (BHPS) was a large longitudinal panel survey first carried out in 1991, and then in every subsequent year up until 2009. In the first year, known as a ‘wave’, a representative series of over 5 000 households were selected for interview from the postcode address file, producing a total sample size for individuals of over 10 000. In each subsequent wave attempts were made to interview all adult (16+) members of the initially selected household; if original sample members moved to form new households then attempts were made to interview them and all members of their new households. Additionally, from wave 9 (1999) a ‘booster’ sample was conducted of additional households living in Scotland and Wales; and in wave 11 (2001) a booster sample was collected for households living in Northern Ireland. (Taylor et al., 2011)

Because a different set of questions was used to elicit information from individuals about driving licence ownership and car access in the first two waves compared with all subsequent waves, all results and analyses presented begin with the third wave (1993). The questions used are discussed below.

## Questions used

The BHPS variables DRIVER and CARUSE were used to establish firstly whether an individual possessed a driving licence, and subsequently whether they had access to a car. From the third wave of the survey onwards adults are first asked “Do you have a full driving licence” (the DRIVER variable), and subsequently asked “Do you normally have access to a car or van whenever you want to use it” (the CARUSE variable) only if they respond to the DRIVER question in the affirmative. Within the first two waves respondents were first asked “Do you have a full driving licence?”, and then “Have you got a car or van, or is there one you have use of?”. This slightly different phrasing, along perhaps with a paper-based rather than computer-based interview system, meaning more individuals may have been asked the second question even if they answered ‘no’ to the question on licence ownership, led to very notable differences in the proportions of people who reported both owning a licence and having car or van access.[[1]](#footnote-1) Because of this inconsistency only data from the third wave onwards were used.

The International Standard Classification of Education (ISCED) classifications were used to produce a three-fold grouping of populations by highest educational qualifications. Being an international classification system, this allowed people who had not received their education within the UK to be included in the analyses. Throughout the period in which the BHPS was run, ISCED used a seven-tier grouping of educational classifications, with the following designations: 0: pre-primary education; 1: primary education or first stage of basic education; 2: lower secondary education or second stage of basic education; 3: upper secondary education; 4: post-secondary non-tertiary education; 5: first stage of tertiary education; 6: second stage of tertiary education.[[2]](#footnote-2) The seven-fold ISCED groups were categorized into the following three groups for the purposes of this analysis: groups 0, 1 and 2 were collapsed into the category ‘no further’ education (‘Low’); groups 3, 4, and 5 were grouped into the ‘further vocational’ education group (‘Med’); and 6 and 7 were grouped into the category ‘further non-vocational’ (‘High’).

## Lexis surfaces

We explore the data graphically, by arranging either rates of driving licence ownership, or car access amongst those with driving licences, as a large matrix of shaded cells or tiles in a levelplot. Each row in these matrices is a different age, and each column a different year based on BHPS wave. This particular arrangement of data is known as a Lexis surface, and is used relatively often within demography, and increasingly in public health, but much more rarely in the broader social sciences. (Minton et al., 2013; Schöley and Willekens, 2017; Vaupel et al., 1997) The shades of each of the cells in the levelplots indicates the proportions either of sample members of that age and in that year with a driving licence; or the proportion of those sample members with driving licences that also have access to a car. Darker shades indicate higher proportions and lighter shades indicate lower proportions. Colour versions of the levelplots are also available online. Lexis surfaces contain a lot of information, which can be uncovered by identifying patterns of shade within the levelplot. To facilitate discussion of these patterns we include pedagogic versions of the plots with labels and other annotation; these are referred to throughout the results section.

# Results

Figure 1 shows Lexis surface level plots for both the proportion of BHPS sample members who have a driving licence (subfigures A, B and C); and the proportion of those BHPS sample members with a driving licence who also have access to a car or van (Subfigures D, E and F). Subfigures A and E show levelplots separately for each gender (females on the left and males on the right), whereas subfigures B and E show the levelplots further subdivided by highest educational qualification. Subfigures C and F contain a number of simple labels and divisions, indicating different regions within the Lexis surfaces, which will be referred to in this discussion of the results. Within each levelplot the shade of a cell indicates the proportion, with black indicating 100% and white cells indicating less than 50%.

## Driving Licence Ownership by gender and generation

Figure 1A shows the proportion of the adult BHPS sample who report having a driving licence, from 1993 to 2008, and for all ages from 17 to 80 years of age. It is clear from the difference in the shade of the right sub-panel (males) compared with the left sub-panel (females) that, historically, a larger proportion of adult males tend to have driving licences than females. A more subtle pattern in this figure is suggested by noting that in both panels, and in particular for the female panel, the cell shades tend to be darker near the bottom of the panels than at the top, when looking at both panels from the top to around one third of the way from the bottom. This indicates that, above around the age of thirty years, younger adults tend to be more likely to have a driving licence than older adults. As largely the same panel of individuals are being followed each year, and only a very small proportion of people possessing driving licences then have these licences revoked and have to take the test again, this difference in shades is suggestive of changes in driving licence ownership rate by cohort, with successive cohorts being more likely by a given age to possess a driving licence than earlier cohorts at the same age. By comparing similar regions (combinations of age and year) in the male and female panels it is also apparent that levels of driving licence ownership between males and females have tended to converge over successive generations. To look at this further, consider the region indicated by the letter A in figure 1C, and above the first diagonal dashed line in the figure; this broadly demarks cohorts born before around 1940. Within this broadly defined region of the Lexis surfaces, the cells are much darker for males than for females, with the proportions of males with driving licences around 90%, and the proportions of females with driving licences from similar cohorts ranging from around 55% to 70%. Next consider the region indicated by B in figure 1C, demarcated by the first dashed line above and another parallel diagonal dashed line below. This broadly indicates cohorts born between around the early 1940s and the late 1950s. The figures. The difference in the cell shade in this region between the male and female panels has reduced, with the proportions of males with driving licences increasing slightly from around 90% to 95% and above, and the corresponding female driving licence ownership rates increasing from around 70% to over 80%. The region indicated by the letter C in the Figure 1C indicates cohorts born from around the early 1960s to around 1975. For these cohorts the proportion of males with driving licences has remained high, at around 95% or above, whereas the proportion of females with driving licences has increased further, from around 80% to around 90%. Finally, we can consider the bottom right corners of the panels, indicated by letter D on figure 1C. This shows driving licence rates for people born after around 1975. What is striking about these younger cohorts is that driving licence rates have fallen for both genders compared with earlier generations, reversing a trend towards higher driving licence ownership which had been continuing for many generations. It is also noteworthy that these falls in licence rates have been in both genders, reaching around 75-80 for some of the newer cohorts within this Lexis surface region.

The complex patterns can to an extent be simplified into a series of broad generational ‘pen portraits’, each differing in terms of auto-mobility and gender equality. From the BHPS sample it appears that generations born before the Second World War (the region A in Figure 1C) tended to have mixed mobility and high gender inequality, with around 90% of males from this generation possessing a driving licence but only around 70% or so of females likely to have a driving licence; put another way, by the time this generation had reached old age, women were around three or more times more likely not to be able to drive than men of the same age, with important implications for how reliant both older women and older men are on either public transport or friends and relatives with access to a car to travel substantive distances from their homes. The implications of this historically high disparity in auto-mobility by gender are likely to have been felt both during working life, with women less able to travel without (in many cases) the support of their husbands, and in old age, where the shorter life expectancy of men means many elderly women from this generation would have outlived their husbands, and because of this experienced not just profound personal bereavement, but also a sharp fall in their capacity to travel far from home. Differential auto-mobility and differential longevity therefore created the conditions for the loss of a husband to be both a primary and a secondary cause of isolation for elderly women from this generation.

For generations born after the Second World War, and up until the start of the 1960s (region B in Figure 1C), there was a catch-up in auto-mobility between the genders, with both genders more likely to own a licence by the time they reached middle age, but with greater increases in women’s auto-mobility than men’s. The decades after the Second World War can, from the perspective of UK households, be considered an extended period of inclusive economic growth, with successive governments committed to broadly Keynesian economic programmes of investment in people and places, with relatively high levels of economic growth per capita, increasing median wages, and falling income inequality. Though the 1950s are considered by contemporary standards to have high levels of structural and cultural inflexibility regarding gender norms and female participation in the workplace, increasing affordability of car ownership at household level, due both to rising household incomes and falling vehicle costs through greater industrialization, led to both ‘two licence’ households and then ‘two car’ households becoming increasingly common. With increasing rates of female auto-mobility, as well as higher social mobility more generally, the costs of moving to the car dependent suburbs from denser and less car dependent urban core fell, and opportunities for increasing female participation in the labour force increased, leading to both less female dependence on males for auto-mobility and economic security. Within the household there was a movement away from conditions of gendered dependence in the fields of mobility and earnings, and towards equality and interdependence.

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| A) The proportion of BHPS sample respondents with a driving licence, by gender | B ) Driving licence ownership, by gender and highest qualilfication. | C) Driving licence ownership. Annotated. | D) The proportion of driving licence owners with access to a car or van, by gender | E) The proportion of driving licence owners with access to a car or van, by sex and highest educational qualification. | F) Drivers who drive. Annotated. |

Figure 1 Lexis surfaces showing the proportion of BHPS sample members who have driving licences (A-C); and, of those sample members with driving licences, who also have access to a car or van (D-F). In all figures year runs horizontally from left to right, and age runs vertically from bottom to top. Within each levelplot the shade of a cell indicates the proportion, with black indicating 100% and white cells indicating less than 50% or missing values.

If the generation born from after the Second World War to the start of the 1960s can be characterized by both increasing mobility and increasing equalization of auto-mobility between genders, the generation born from around 1960 to the mid 1970s (area C in figure 1C) may be thought of representing an end point in this journey towards a high mobility and high auto-equality society. Within this high mobility, high auto-equality generation both males and females were highly likely to possess driving licences, though the proportion of females with licences still remained somewhat lower than for males. This high mobility, high auto-equality generation experienced both the tail end of a decades’ long social democratic commitment to high quality while being educated in primary and secondary school as children, then the transition and embedding of neoliberalism under Thatcher and Major while of working age; put another way, this generation (or at least the start of this generation) both gained from the relatively high tax and high social investment policies of the post-War post-Keynesians while economically dependent children, and to some extent from the low tax and low regulation policies of Thatcherism while income-generating and tax-paying adults. Increasing job insecurity, or ‘flexibilisation’, after Thatcher therefore made traditional single-earner households less economically stable, and so less common, so creating both the opportunity and the necessity for dual-earner households to proliferate. This was both enabled by and helped consolidate the previous generation’s progress towards high female auto-mobility rates, as both the ability to work, as well as to balance work with other commitments, can depend on auto-mobility, and so on possessing a driving licence.

For the generation born after 1975 (Region D in figure 1C), the trend towards increased auto-mobility seems to have gone into reverse, more quickly than it rose for either gender over previous generations. Although we cannot know the proportions with driving licences in old age, the proportion of both genders with driving licences around the age of 20-25 years is falling, and does not appear to be increasing as this generation enters their thirties. Interestingly, though the fall in driving licence rates occurred in both genders, and from levels that were around 5% points higher for males than females, it appears they may be falling to similar levels for both genders, of around 80%. This nascent generation therefore appear from the BHPS data to be characterized by both low auto-mobility and high gender equality in this domain.

## Driving licence ownership by gender, generation, and highest educational qualification

Figure 1B shows how rates of driving licence ownership vary by year and age, and further by both gender and highest educational qualification class. The top row shows rates for those with the highest educational grouping (‘Further non-vocational’, labelled ‘High’); the middle for intermediate qualifications (‘Further vocational’, labelled ‘Med’) and the bottom row for those with ‘no further’ education (labelled ‘Low’). As before, the left panels show the rates for females and the right panel shows the rates for males. Though each panel is smaller than before, and so it is harder to make out the details of each panel, a number of broad trends and differences between panels are clear, revealing important information about the complex relationship between gender, generation and income.

To learn more about the moderating influence that higher qualifications appear to have on gender differences in auto-mobility, we can compare the overall shade of the left and right hand panels in each row. For the top row, for those whose highest educational qualification is a degree, there is very little difference in shades between these two panels, indicating very little difference in auto-mobility by gender within this high educational subpopulation. The overall shade also tends to be uniformly darker than in any of the other panels, indicating higher driving licence rates overall, which are close to 100% for either gender, at almost all ages, and in almost all years. There are, however, notably more missing values (blank, white cells) for older females than older males, because historically fewer females than males attended university, and so for particular combinations of age, year, gender and educational qualification there were simply no observations in the sample.

By contrast, within the lowest educational qualification group (bottom row panels), there is both a lower proportion of people with driving licences overall than in the other panels, as well as the greatest difference between male and female rates of driving licence ownership. Historically, male levels of driving licence ownership tended to be at around 90%, increasing steadily up to around 95% or above for those cohorts born up to around 1970-75; by contrast female rates in the earliest cohorts were only slightly above 50%, rising to around 80% by the end of the ‘Catch up’ generation (bottom of region B in figure 1C).

Within the intermediate qualifications group (middle row panels), there is both an intermediate level of overall disparity in gender mobility (difference in shade between left and right panels) as well as perhaps clearer diagonal ‘striation’ then in the other panels, suggesting that cohort effects are particularly important in explaining mobility in people with intermediate level qualifications, and that the generational patterns and changes described above for the whole BHPS sample are particularly the case for the intermediate qualification sub-population.

It is worth noting that the fall in auto-mobility seen for post-1975 cohorts (triangle D in figure 1C) is very clear for both the Low and Med qualification panels, but not very pronounced for the High qualification panels. This could partly be because this trend covers younger ages, and the time taken to complete university degrees mean almost no one in the High group is under 20 years of age, so there are fewer observations with which to try to discern this pattern in High educational groups than in the other groups. A more substantively important implication, however, is that whatever changes have occurred that have led to less auto-mobility overall have had less of an impact on those with degrees or above. By comparing the shades of the bottom right triangles for males and females in the Med panels, with males and females in the Low panels, it also appears that gender differences in auto-mobility have further equalized for those in the former, whereas they have remained or become exacerbated for the latter, with a fall to lower levels for females with the lowest qualifications compared with males.

## Drivers with access to a car or van

We will now look at trends and patterns in the proportion of the BHPS sample with a driving licence who also state they have access to a car or van (‘Drivers who drive’). For the whole of the relevant BHPS subsample this is shown in figure 1D, with the female panel on the left and the male panel on the right. Figure 1E labels some of the regions within the panels, A to E, which will be referred to in the discussion of Figure 1D and figure 1E. As with Figures 1A-1C, the shade of cells within the panels indicates proportions, with proportions below 0.5 represented by white cells, and higher proportions ranging from 0.5 to 1.0 by successively darker shades.

We will begin by considering the region A, representing those (now elderly) cohorts who were around 50 years old or older in 1993, and therefore cohorts born either before or during the Second World War; the very earliest cohorts visible in region A are persons aged 80 years in 1993, and so region A includes some cohorts born from the 1910s to the 1940s. Region A in figures 1D-F therefore covers a similar range of cohorts to region A figures 1A-C, and a somewhat similar pattern of change is seen.

For women and within region A there is evidence of successively higher proportions of those with driving licences also having access to a car or van, but with higher proportions of males than females of the same age and in the same cohort. For cohorts born in the 1910s, around 20% of women with driving licences, and around 50% of men with driving licences, had access to a car or van. For cohorts born in the 1920s, the proportion of licenced females with car or van access rose from slightly under 30% to around 60%; the corresponding change for men in these cohorts was between around 55% and about 80%. For cohorts born in the 1930s the proportion of licenced females with car or van increased to around 80%, whereas for licenced males it increased to around 90%. Within region A, therefore, the proportion of female drivers with car or van access increased from around 20% to 80%, and for males from around 50% to 90%.

It is important to note that, within the age range 60 to 80 years, an age effect is not observed, i.e. the proportion of people with licences with car access does not diminish between ages 60 to 70 or 70 to 80. Within the UK, drivers aged 70 or older need to renew their driving licences every three years, as well as to state if they have developed any medical conditions which may affect their driving, but are not required to retake a driving test.[[3]](#footnote-3) Even though rates of impairment which may affect driving can be expected to increase with old age, there is no indication, at least up to age 80 years, that this substantively affects auto-mobility.

We now consider changes in the proportion of drivers with car or van access aged between around 30 and 55 years of age, how this proportion has changed from the early 1990s to 2008, and how this change has differs from males and females. This particular pattern of change is represented by the letters B and C in figure 1F, along with the arrow going left to right. We can see a notable increase in the proportion of licenced women in this age bracket with car or van access, from around 80% to around 90%. Most of this increase appears to occur fairly suddenly, around 2001-2002, rather than being a gradual change. For men in the same age-bracket there is no equivalent change, with rates between remaining around 90-95% throughout the period of observation.

Finally, we can look at how the proportion of people with licences with access to a car or van changes with age from around the age of 17 to 30 years, as indicated by the letters D and E in figure 1F, and the vertical arrow pointing upwards. We can see that, within this age range, there is very little difference between genders, and instead age effects dominate. At around 20 years of age, around 55% of those with driving licences also have access to a car or van. By the age of 25, this has increased to around 75-80%, and by the age of 30 to around 90-95% for men throughout the period 1993-2008; for women, rates increased to around 80% by age 30 up to around 2001, and to around 90% from around 2004 to 2008, due to the period-driven change represented by the vector from B to C.

The age-based pattern of increasing car or van access in young adulthood is important for understanding that rates of gender inequality in *realized* auto-mobility (‘drivers who drive’) only tends to emerge after the age of 30, and that up until this age, age tends to be a much stronger determinant than gender. Since the early 2000s, it is also apparent that rates *realized* auto-mobility from the age of 30 to 55 years tend to be very similar between the genders, although we saw some persistent though diminishing gender differences in rates of *potential* auto-mobility (proportions of sample with a driving licence) within Figures 1A-C.

## Drivers with access to a car or van, by highest educational qualification

Figure 1E shows how the proportion of registered drivers with access to a car or van varies by highest educational qualification as well as by gender, age and year. As with figure 1B, Figure 1E allows the mediating and moderating role of educational qualification on auto-mobility patterns to be better understood. As with Figure 1B, we can see, by comparing the shade of cells in the top left with the top right panels, that gender differences in this auto-mobility outcome (*realised* auto-mobility) are very low amongst those with a degree or higher qualification, with car or van access levels typically above 90% at all ages above around 30 years for both genders. There is also no apparent historic cohort pattern (region A in figure 1F) whereby *realised* auto-mobility increases over successive cohorts born from the 1910s to the 1940s; instead, rates of car or van ownership amongst both males and females with degrees from these cohorts tended to be close to 100%, though with fewer observations for females, leadings to a larger number of missing cells. If anything, amongst those with degrees and driving licences, rates of car or van ownership decreased slightly for cohorts born after World War 2, from around 95-100% for pre-War cohorts, to around 90-95% for cohorts born after 1945.

Both the subpopulations with lower and intermediate highest educational qualification (middle panel and low panel), differ from the ‘high’ qualification group in a number of ways. Firstly, the progressive increases in realized auto-mobility in the oldest cohorts with each successive cohort (region A, covering cohorts born from the 1910s to the mid 1940s), which are seen in the population overall, are clearly evident through the diagonal striation within this region. Comparing equivalent cohorts (for example looking at the very top left corners of each panel to compare the 1915 cohorts), we can see both that realized auto-mobility tended to be lower for females than for males, and for the low education compared with intermediate educational qualification group. For example, rates of realized auto-mobility amongst the oldest cohorts were around 20% for females with ‘low’ qualification, around 50% for males with ‘low’ qualifications, around 40% for females with intermediate qualifications, and around 70% for males with intermediate qualifications. For each of these groups, with the exception of females with low qualifications, rates of realized automobility reached around 90% or higher for those born after World War 2 (bottom of region A); for females with low qualifications levels reached levels of between 60 and 80% instead.

A second way in which the two bottom rows of panels differ from the top row is that there tends to be more of a difference between females and males in realized auto-mobility rates, with these disparities greatest in the lowest educational group, and smaller in the intermediate educational group. A third observation to note is that the rapid rise in auto-mobility rates seen for females overall after around 2001, characterized by the vector B to C in figure 1F, is clearest to see in the panel for females with intermediate qualifications, though to some extent also evident for females with ‘low’ qualifications.

Finally, it is important to note that the increasing levels of realized auto-mobility seen between around the age of 20 and 30, as characterized by the vector D to E, is seen for all educational subgroups, and does not appear to differ strongly by gender.

# Discussion

## Summary of findings

Highest educational qualification is both an indicator of both the earnings potential of households that form as people form as they enter adulthood and the workplace, and also of the types of households they were part of as children. Though there have been large-scale structural changes in both the levels of qualification, and proportion of the UK population possessing degrees, over the many generations included in the BHPS sample, children from households where one or both parents had a degree are often likely to go to university themselves, and those from backgrounds where parents left school at an early age less likely to get a degree. Also, like gender, a highest educational qualification tends to remain fixed throughout most of adulthood. In earlier explorations of the data, we also looked at occupation and household earnings as a means of stratifying the overall population, and found highest educational qualification to be a more informative way of subdividing the population with regards to auto-mobility outcomes. This makes sense when we consider how average household earnings are likely to vary over the life course, with those going to university likely to earn less in early adulthood than those who leave full time education at an earlier age; occupation, similarly, is highly fluid over the life course, has become more so, and is arguably less hierarchical than highest qualification.

Interestingly, we found highest educational qualification to better explain, and more strongly moderate, both gender differences and differences in auto-mobility between the generations, than urban-rural classification. Whereas urban-rural classification to some extent characterizes the differential *need* of individuals to have their own form of transport, highest educational qualification, as a stable proxy for both future household and parental household earning potential and economic stratification, characterizes the differential *means* with which people can afford both to learn to drive, and then to own a car. The importance of age on differential *need* is clearly seen by looking at how the proportion of ‘drivers driving’ (Figure 1D) changes from the twenties to the thirties (as indicated in the arrow from label D to E in figure 1F), and this differential need does not appear to vary substantively between educational strata (Figure 1E).

Thinking about differential *means*, however, may go far to explaining both persistent and emerging differences between educational strata, and within each strata differences by gender. For example, we can expect that both the costs of learning to drive and owning a car will be more unaffordable for lower income households, with the former cost more likely to be borne (at least initially) by parents, and the latter costs by newly formed young adult households. Highest qualification, as we have suggested, can be a proxy for both parental and new household income, and the relatively constrained budgets of such households may explain both why the relatively low level of auto-mobility, its further decline, and also the large gender differences in auto-mobility within this educational strata. Like eyes per person, cars per household have diminishing marginal returns: the difference in geographic accessibility and opportunity for a household going from no cars to one car likely to be much greater than the additional opportunity made available from one car to two cars. In households that are only just able to afford one car, it is often the (male) main earner of the household who tends to be the car owner and driver.

## Limitations

The BHPS was superceded in 2008 by the UK Household Longitudinal Study (UKHLS), also known as Understanding Society. From the second wave onwards, original sample members from the BHPS were incorporated into the UKHLS, meaning the same households and individuals who first joined the BHPS in 1991 can be followed for a number of additional years. Unfortunately, many of the questions and classifications of responses are inconsistent between BHPS and UKHLS, meaning it has proved problematic to ‘extend’ the observations shown above beyond 2009 using the UKHLS. This is particularly the case when seeking consistent categorization of highest educational qualification, which we found to be a powerful means of distinguishing between sub-populations in terms of APC trends; the ISCED categorisations used in the BHPS were asked only in wave F of the UKHLS, and only as part of an immigrant and ethnic minority booster sample, with regards to qualifications obtained abroad.[[4]](#footnote-4) In principle, however, the period of observation can be extended to more recent years using UKHLS. This could be particularly informative as the UKHLS covers the period after the 2008 Global Financial Crisis and subsequent UK-wide recession; this recession is notable for its sluggish recovery, including a continued stagnation in wages and living conditions for much of UK society. We expect the trends towards decreasing mobility amongst those with lower educational qualifications to have worsened as a result of these changes, and so it should be a priority to explore this further.

The complex sampling and questionnaire design of the BHPS has both advantages and disadvantages, with the main advantage being that individuals can be tracked through time and so the effect of changes in individual circumstances on other outcomes estimated. A disadvantage is that, though the BHPS was initially drawn from a representative sample of the UK population, both selective attrition and the booster samples mean it can become somewhat less representative of the UK population over time.(Uhrig, 2008) Within the analyses presented here, the BHPS is presented ‘as is’, without attempts to explicitly follow the same individuals over time or to analyse the influence of specific changes in household or individual circumstance on mobility outcomes; however the BHPS has been used to allow these analyses to be explored in subsequent research.

## Causes of peak car: choice or constraint?

Many of the patterns discussed here have been identified in both the UK and elsewhere previously, though have not been presented using Lexis surfaces. Though it is now well established that we have likely passed Peak Car, the reasons for reducing auto-mobility, and the implications of such trends, are still being debated. A synthesis of extant research identified six broad categories of potential explanation for car use trends: life stage, affordability, location and transport, driving licence regulation, attitudes, and e-communication; it found somewhat stronger evidence for life stage explanations (such as having children later, and staying with parents and in full time education longer), and affordability explanations (such as rising costs of insurance, licencing, petrol, vehicles; against falling or stagnant household incomes) than other types, but with no clear single cause. (Delbosc and Currie, 2013) Analysis based on panel data in the USA also found lower incomes and delay in major life events (leaving parental homes later, having children later) largely explained lower car ownership amongst Millennials, and that after controlling for these factors Millennials were slightly more likely than expected to be car owners. (Klein and Smart, 2017)

Amongst these explanations, insurance costs may be a particularly strong factor in the UK, as they have risen particularly sharply in recent years. (Milligan, 2015; Noble, 2005) One UK-specific explanation for reduced car use amongst young is changes in taxation policy less favourable to users of company cars, and related to this falling trends in company car use. (Le Vine et al., 2013) Econometric modelling of Swedish car use trends found per capital GDP and fuel price alone may explain up to 80% of the decline since the 1980s. (Bastian and Börjesson, 2015) There is evidence that broader environmental concerns are not a substantial reason for not travelling by car, with no significant differences in environmental concerns identified between people using cars compared with other travel modes in a sample of commuters to a UK university. (Thomas and Walker, 2015) Qualitative research focusing on the relationship between auto-mobility and environmental concerns amongst younger adults (18-35) in New Zealand did not reach any definitive conclusions about this relationship. (Hopkins, 2016)

Regarding affordability as an explanation, vehicle registration taxes increased in the USA in the 1980s; these increases were found not to have decreased the proportion of people registering for new vehicles, but to substitution of newer and more expensive vehicles for older and cheaper priced vehicles, (Pritchard and DeBoer, 1995) suggesting both that cars were a somewhat inelastic commodity, and that there can be unintended consequences, in terms of moving to more polluting and fuel inefficient vehicles, to incentive structures intended to reduce car use. Similarly, in Japan it is estimated that falling population size and household size may both lead to increasing car ownership. (Yagi and Managi, 2016) It is also estimated that the average age of cars, like the average age of the population, is increasing in Japan, and that use of older cars (12 or more years old) is more sensitive to increase in fuel price than use of newer cars. (Yagi and Managi, 2016)

Regarding location as an explanation, important regional differences in car use trends have been observed. In England, car use trends from the 1970s, defined as miles driven per person per year, differ depending on whether people live in Greater London, other cities or conurbations, or elsewhere. Car use peaked in Greater London in the early 1990s and in other cities in the early 2000s; in less urban areas they have plateaued rather than fallen substantially since the early 2000s. (Headicar, 2013) The changing shares of the population living in these three urban groupings of place is therefore expected to influence the extent of future trends in car use. (Headicar, 2013) Like Greater London, car ownership in and around Paris, France, peaked in the 1990s. (Cornut and Madre, 2017) Regional lags in Peak Car have also been found in the USA, with peak car travel being reached in Washington State in 1992, another 10 states by 2000, and almost all states by 2011. (Garceau et al., 2015)

There are some compelling theories for why ICT use may have been partially responsible for declining car use, and why this decline occurred largely within younger cohorts. In the USA, nearly 90% of shopping trips are made by car, (Popovich and Handy, 2015) and so increasing use of online shopping amongst young adults may be one reason for declining car use overall. With ever improving ICT, teleworking has ever more potential to reduce the need for physical travel long distances for work purposes, but remote working remains marginalized in Ireland. (Hynes, 2014) ICTs may both reduce the need for motor travel, and also allow for better organization and utilization of private vehicle stock through apps and information sharing platforms like Uber, enabling what’s sometimes referred to as ‘collaborative consumption’. (Hamari et al., 2016) Despite this, when compared with other factors, ICTs do not appear a predominant explanation for the decline, with economic constraint and deferred life events appearing more powerful explanatory factors.(Delbosc and Currie, 2013)

It may be helpful to think about the various categories of explanation for declining auto-mobility amongst younger cohorts as having either a broadly optimistic choice-based or a broadly pessimistic constraint-based interpretation and implications for future mobilities and inequalities. By looking at highest educational qualifications, and seeing that mobility rates have declined the least for the most educated and the most for the least educated, we are inclined more towards a constraint-based interpretation, in which auto-mobility has become increasingly unaffordable for substantial sections of society, instead of a predominantly choice-based interpretation in which fewer people either need or want to drive cars. This is underlined by the observation that universities tend to be in cities with relatively high density and effective transport links, and so the highest educational subgroup may often have particular low needs to drive, despite having very high rates of driving licence ownership. We suggest it is also supported by noting that inequalities in driving licences and car access by gender tend to be greatest amongst lower educational groups, which might be expected in households only just able to afford a single car and driver.

Despite our pessimistic interpretation of the data and extant literature, suggesting getting priced out rather than opting out of car ownership is behind much of the trends, we remain hopeful and optimistic about the potential for technological change to lead to a more equitable and effective use of cars, alongside other transport modes, in the coming decades. Car sharing schemes are one of the earliest means by which the car can be used more efficiently as an asset, and the potential for accelerating car sharing behaviours through ICTs is as yet unrealised. . In 1999 around 38,000 people were registered in car sharing schemes in European cities. (Prettenthaler and Steininger, 1999) Increasing car sharing scheme adoption could potentially save around 84,000 tonnes of CO2 being emitted in Dublin per year, and over 200,000 tonnes of CO2 emission per year in Ireland as a whole. (Rabbitt and Ghosh, 2016) Car sharing could encourage other transport modes, including active travel, and so has potential health benefits, as well as allowing an expensive and rapidly depreciating asset to be used more efficiently. (Kent, 2014) Car-sharing schemes have been shown to be more attractive to people who are already multi-model in their travel behaviour, rather than mono-modal car users. Given that most, but not all, car trips by elderly people in the USA are of relatively short distance (8km or shorter), electric vehicles may be attractive within a car-sharing fleet for older drivers as long as non-electric vehicles are also available in the fleet for longer trips. (Shaheen et al., 2016)

Car sharing schemes long predate autonomous vehicles as a viable means of shifting car use towards being a shared commodity. At least one car manufacturer has entered the car-sharing market, with a marketing strategy focused on ‘selling mobility instead of cars’.(Firnkorn and Müller, 2012) The price of ride-sharing could be reduced, and so the attractiveness of ride-sharing more attractive, if the dominant platform operators (such as zimride, blablacar, and carpooling.com) who provide the information infrastructure to enable such schemes, were to improve their algorithms to better accommodate ‘multi-hop’ ride sharing. (Teubner and Flath, 2015) Higher densities of both asset providers (car users) and asset providers (passengers) can also be expected to reduce prices and waiting times for this emerging travel mode, and so make them more economical and attractive in comparison to fully private car use. (Efthymiou et al., 2013)

Automated vehicles, like car sharing schemes, offer not just the possibility for replacing or blurring the public/private distinction in car ownership, but for augmenting train and coach use as well. (Yap et al., 2016) Autonomous car use and technology is still in its infancy, but offers the potential for cars to become more of an efficiently used shared asset rather than a private asset parked, and so not used, for most of the day. (Thomopoulos and Givoni, 2015)

Much simpler technologies, combined with better infrastructure, offer hope for healthier ageing through active travel. Although even within the famously cycle-friendly Netherlands younger people tend to cycle more than older people, rates of cycling are increasing amongst the elderly, including ‘Baby Boomers’ found resistant to modal change in the UK; this has partly been attributed to the availability of e-bikes as well as cycle infrastructure, suggesting the potential for technological innovations to increase active travel at older ages.(Harms et al., 2014)

## Associations and effects of car use

Large scale adoption of more sustainable, active travel modes can lead to large scale improvements in public health; if some but not most people switch to active travel modes, however, cyclists and walkers experience higher risks of harm from air pollution and traffic accidents due to the car-using majority. (de Nazelle et al., 2011) A cost-utility analysis of cycling in the USA has, however, estimated that the health benefits of cycling are still likely to outweigh the additional health risks of these factors. (Edwards and Mason, 2014) Health economic modelling suggests that reducing car use and increasing walking and cycling could lead to substantive increases in disability adjusted life years (DALYs) in UK populations, by reducing exposure to harm from air pollution, road traffic injuries, and low physical activity. (Woodcock et al., 2013) Similar research based on a cross sectional survey in Melbourne, Australia, has also estimated potential health benefits of increasing active in DALYs, and noted that people living closer to urban centres are more likely to have adequate levels of physical activity. (Beavis and Moodie, 2014) A similar exercise to estimate the health impacts (in DALYs) of road transport in New Zealand found lower levels of harm to health from air pollution and noise than in many other countries, but that heavy good vehicles were responsible for a disproportionately large share of attributable deaths. (Briggs et al., 2015) A similar health impact assessment in the Belgian city of Flanders, which has both high air pollution but also high rates of cycling, also estimated that a modal shift from car use to active travel would confer greater health benefits than harms. (Buekers et al., 2015) A large scale EU-funded project to explore these issues throughout Europe is currently in progress. (Gerike et al., 2016) A paper published in the Lancet in 2016 identified eight city planning initiatives considered likely to improve public health by encouraging switching to active travel. (Giles-Corti et al., 2016)

Social disadvantage can therefore lead to reduced auto-mobility, as well as having other mixed effects on health and wellbeing, and socioeconomic outcomes, through both mobility-related and other pathways. Reduced auto-mobility can be a result of disability and impairment, which can adversely affect the ease of learning to drive, of driving, and the ease of using other transport modes, and so further compound socioeconomic disadvantage relating to disability and impairment.(Durkin et al., 2016; Pyer and Tucker, 2017) Conversely, socioeconomic disadvantage itself can lead to some forms of increased active travel, and some of its associated health benefits of less sedentary behaviour. In England and Wales, poorer socioeconomic groups tend to walk, but not cycle, more than richer socioeconomic groups. (Goodman, 2013) Time use studies in the UK in 2005 have shown that young people, those without access to a car or van, the unemployed, and those from less affluent backgrounds, were all more likely to engage in active travel and meet recommended physical activity targets than the general population.(Adams, 2010) When active travel options are not possible, lack of car access increases reliance on public transport, and so increasing public transport costs, which in Australia were found to be less cost-effective than private transport, can compound other forms of socioeconomic household disadvantage. (Li et al., 2015) In the UK, there was some hope in the early 1990s that privatisation of British Rail’s assets would lead to an improvement in quality of service and so increasing attractiveness of rail as an alternative travel mode to car use. (Harman, 1993) Though passenger numbers increased, quality did not and ticket costs increased. The attractiveness of travel by rail can be increased somewhat by providing additional transport, such as electric station cars, from train stations to final destinations, but unless end-to-end public transport solutions are widely available cars may well remain much more attractive and convenient means of conveyance. (Cervero, 1997)

Preferences for cycling and other forms of active travel can be influenced by substantial changes in life circumstances or environments.(Chatterjee et al., 2012) It is estimated that, amongst commuters to a UK university who use the bus as their dominant travel mode, around two fifths of trips could be substituted for active travel. (Bösehans and Walker, 2016) Amongst Cyprian teenagers, provision of cycle infrastructure can increase preferences to cycle, with increased cycling and walking preferences then leading to greater multi-mobility and less car reliance more generally. (Kamargianni and Polydoropoulou, 2013)

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