Automated vehicles and future transport inequalities in the UK. Exploring the potential accessibility implications for older people

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

It is often argued that automated vehicles (AVs) will reduce the unmet accessibility needs of older people. However, these assumptions tend to overlook the potential barriers to AV uptake for older population groups and the fact that AVs may have broader effects on mobility behaviours and transport systems. Although these impacts cannot be predicted with certainty, early engagement with these questions may assure that older people's accessibility needs are considered in future transport policy.

The thesis focuses on two critical research gaps to untangle the future accessibility implications of AVs. First, it explores how transport policymakers perceive and plan to manage the effects of AVs on older people's accessibility. Second, it investigates older people's perceptions and acceptance of AVs.

The research draws from a content analysis of strategy and planning documents from transport authorities in England and interviews with transport policymakers and experts. Key findings are that while there is an emphasis on the potential of AVs for the UK ageing society, certain barriers to adoption of AVs are often overlooked. Moreover, the potential impacts of AVs on older people's accessibility as users of other modes (e.g. walking) are not considered. Transport authorities have mostly played a facilitating role in the development of AVs, but have not yet developed plans and policies to ensure that older people will benefit from the transition to AVs.

Through interviews with older citizens in Greater Manchester, the research identifies that some older people perceive that AVs would improve their current or future accessibility levels. Nevertheless, several factors may inhibit the ability and willingness of some older population groups to use AVs. Finally, the study explored older people's acceptance of different automated transport services. Although most interviewees appeared as willing to use at least some of the proposed services, some showed strong reluctance to use AVs.

Table of contents

List of Tables

List of Figures

List of Images

List of Abbreviations

AV	Automated vehicle
AVs	Automated vehicles
BCC	Bristol City Council
CAV	Connected and automated vehicle
CAVs	Connected and automated vehicles
CCC	Coventry City Council
DfT	Department for Transport
HE	Highways England
OCC	Oxfordshire County Council
MKC	Milton Keynes Council
TfGM	Transport for Greater Manchester
TfL	Transport for London
TfWM	Transport for West Midlands

1. Introduction

This research aims to advance knowledge relevant to the scholarship and policy debates around the equity impacts of automated vehicles (AVs), also called as autonomous, self-driving and driverless vehicles. Although the timelines of AV development remain unknown, AVs could have profound effects on mobility practices and the temporal and spatial organisation of human activities. These changes are likely to be experienced differently by different social groups.

This thesis is concerned with the accessibility implications of AVs for the older population in the UK (defined here as the heterogeneous population aged over 60). Accessibility refers to the ease or difficulty with which someone can reach destinations, goods, and activities to take part in society (Neutens et al., 2010; Pereira et al., 2016). The concept, here, encompasses access to AVs but also includes knock-on effects on other transport modes (e.g. public transport, walking, cycling) and the land-use system, which will all influence the ability of older people to access essential services and activities.

The research focuses on two factors that will potentially influence the accessibility impacts on older people in a transition to AVs. The first is the public sector's vision and policy response to AVs. The second is older people's perceptions and acceptance of AVs. The thesis employs a qualitative, multi-method research design. It draws from multiple data sources; first, a review of relevant literatures, second, an analysis of strategy and planning documents from a sample of public authorities operating at different government levels in England, third, interviews with a range of transport professionals working in AV experimentation and policy development across England, and fourth, interviews with citizens aged over 55 years across the city-region of Greater Manchester.

In the following sections, I briefly present the background and rationale of the research, followed by a description of the research objectives and questions guiding this study. Moreover, I outline the structure of the thesis.

1.1. Background of the research

Transport inequalities and transport-related social exclusion are now widely researched and documented issues (Lucas, 2012). Studies have demonstrated the uneven distribution of mobility and transport externalities across society in different geographical contexts. In the modern hyper-mobile

societies, lack of transport can lead to reduced accessibility, which, in its turn can prevent already disadvantaged individuals from taking up employment and education opportunities and reaching healthcare and social networks (e.g.Social Exclusion Unit, 2003; Abbott and Sapsford, 2005; Lucas et al., 2009; Kenyon, 2011). Over the last decades, researchers have aimed to untangle the causes and nature of these issues and propose solutions within and outside the transport sector (e.g. land use planning, healthcare provision and education policy) (e.g. Kenyon, 2011; Ahern and Hine, 2014). An important contribution of this body of research was that it advanced policymakers' recognition of how transport availability and accessibility levels can affect the social participation and health outcomes of individuals (Lucas, 2012).

Notwithstanding these advances in academic literature and policy priorities, transport inequalities remain a significant problem in the UK (Lucas et al., 2019). Older people are one of the population groups that frequently face significant mobility and accessibility challenges. Although the older population is quite heterogeneous, on average, the mobility patterns of older people are different from those of younger age groups. Older people are overall less mobile and more reliant on car lifts and public transport (Rosenbloom, 2004; Hjorthol et al., 2010; Lucas et al., 2016). Although much of this decline in mobility relates to transitions in life (e.g. retirement) and can be voluntary, older people can be obstructed in their out-of-home mobility due to an interaction of transport, land-use and health factors (Schwanen and Páez, 2010). In hyper-mobile car-centric societies, older individuals who cannot drive or access cars face barriers in their access to 'essential' and 'discretionary' destinations, with negative implications for their wellbeing and social inclusion (Musselwhite and Haddad, 2010b; Shergold and Parkhurst, 2012; Nordbakke and Schwanen, 2014).

Over the last decades, the UK population aged over 65 has increased rapidly, especially in rural and coastal areas where the largest proportions of older people are located (Office for National Statistics, 2018). In the UK, between 2016 and 2039 the population group aged over 65 years is set to grow by approximately 50% in all areas (urban and rural), while the group under 65 years is only expected to grow in urban areas by eight per cent (ibid). Similar trends are observed in other developed countries (ibid). Given the current accessibility problems experienced by this population group and the ageing rate, research on the future transport and accessibility experiences of older people is of critical importance.

In the future, changes within the transport domain are likely to shape inequalities. It is argued that automation in the transport domain, in combination with other recent advances in shared mobility and mobility-as-a-service (MaaS), will lead to a socio-technical transition, comparable to the emergence of the automobile (Docherty et al., 2018). Nevertheless, research on AVs over the last decade has predominantly focused on its technological limitations with initially limited engagement

with the social and distributional implications of the technology (Cavoli et al., 2017). Over the latest years, researchers have argued for increased attention to the social consequences of AVs to inform current and future policy decisions (Cohen et al., 2017; Milakis et al., 2017b; Bissell et al., 2018). Beyond the uncertainty around the timeframes and levels of technological progress in vehicle automation, many other questions remain to understand how AVs will impact on different groups and places.

Having discussed about the significance of research on AVs and future inequalities, in the next section, I discuss the rationale for the research topic and approach selected.

1.2. Rationale for the research: AVs and the accessibility of older population groups in the UK

Over the last decades, vehicles are becoming increasingly automated. Automation in this context refers to 'the use of electronic or mechanical devices to operate one or more functions of a vehicle without direct human input' (U.S. Department of Transportation, 2018). Automated features, such as cruise control and automated braking, are commonplace in modern vehicles. While the term AVs is used to describe vehicles with different automation levels and capabilities (SAE International, 2018; Cavoli et al., 2017), the recent academic and policy interest in AVs stems from technological advances that promise full automation of the driving task under specific environments or in any conditions. Although AV proliferation cannot be taken for granted, these technologies, in combination with other 'smart mobility' innovations could have profound effects on mobility behaviour, the land use system and society (Docherty et al., 2018).

Beyond private companies that are racing to gain a competitive advantage in the market of AVs, many governments have shown interest in AV development and experimentation. Although many governments recognise challenges in the governance of AVs, aspirations for economic and social benefits appear to drive policymakers' interest in AV developments (Taeihagh and Lim, 2018). The UK central government has placed considerable effort in accelerating the development of AVs, by creating networks and organisations devoted to AV activities, adapting regulations and standards, and investing in demonstrations and trials of highly AVs (Hopkins and Schwanen, 2018). The recently published 'Industrial Strategy' announced the government's aspiration to make the UK a 'global leader' in AV development (HM Government, 2017, p. 202).

It is often argued that fully AVs will improve the mobility of older people by addressing the barriers experienced due to driving cessation and the difficulty to access public transport (Alessandrini et al., 2015; Harper et al., 2016). Without diminishing the opportunities that AVs may offer for older people's

accessibility, these assumptions tend to neglect potential barriers to adoption of AVs, as also Fitt et al. (2019) and Kovacs et al. (2020) argue. Moreover, they overlook that AVs will affect wider mobility behaviour and the built environment. AVs will not only be a new mode of transport that may provide greater access to older people and those who do not hold a driving license. The effects of AVs on car dependence and the built environment are highly uncertain. These impacts, though, will also affect the ease to access services and opportunities by non-motorised transport for older people. Depending on how AVs are introduced in the transport systems, they could enable greater access, and improved quality of life or they could result in the exclusion of certain older population segments.

This research identified two key factors that are critical to understand the potential accessibility implications of AVs for older people. The first relates to the visions of public authorities and their abilities to govern the development and insertion of these new technologies in the public realm. The second relates to the limited engagement with older people to understand their perceptions of AVs and the extent to which these would improve their mobility and accessibility levels.

In line with the first factor, this research looks at governance and policy development in the domain of AVs. The social and equity impacts of AVs are complex, intertwined and highly uncertain. They are also dependent on the degree to which public authorities choose to manage the introduction of AVs and new mobility services in line with social justice, equality and inclusion values (Docherty et al., 2018). Although a well-managed introduction and development of AVs will not certainly lead to positive outcomes, a market-led approach is more likely to lead to technological exclusion and widened accessibility gaps for older population segments (Cohen and Cavoli, 2018). Multiple futures (from utopian to dystopian) that involve AVs can be imagined. Any assertions about the possibility of these futures should be made with a consideration of the policy context. This research aims to respond to a call for increased attention to the governance of AVs (Cavoli et al., 2017; Cohen et al., 2020), with a particular focus on what these will entail for the future older population.

The second focal point of the empirical research in this thesis is the perceptions of the group in question, the older population. There has been some research in public attitudes towards AVs involving older people. However, there has been limited engagement with older people in the UK to understand if they envisage opportunities from AVs for their access to places, the barriers that may hinder adoption of AVs and broader concerns that could affect their out-of-home mobility (Musselwhite, 2019; Shergold, 2019a). Additionally, although AVs are expected to be introduced in different modes of transport (private, on-demand shared), the expectations and viewpoints of older people towards different modes and services remain under-explored. This research adopts a qualitative research approach to investigate how older people perceive AVs will affect their mobility and accessibility levels. Exploring how older adults envisage the transition to automation can allow

researchers and policymakers to build knowledge about the future, drawing from citizens' experiences and aspirations. A key motivation for the empirical research within this thesis is to enhance knowledge and understanding of the potential accessibility implications of AVs and ensure that the voices and concerns of older citizens are included in policy debates.

1.3. Aim of the research and research questions

The overarching aim of this research is to investigate the potential accessibility impacts of AVs for the older population groups in the UK.

Based on this overarching aim and the gaps identified in the literature, five research questions were devised:

1. *How do transport authorities and key transport professionals perceive the impacts of AVs on the accessibility of older people and other socially/ transport disadvantaged groups?*

The rationale underpinning this and the following research question (question 2) is that there is a gap in our understanding of how key UK actors in the governance of AVs anticipate that the deployment of the technology will impact on accessibility inequalities, and specifically, on older population groups. The literature review showed that the accessibility impacts of AVs for older people are highly uncertain. The outlooks that policymakers construct for the future can influence their policy and planning responses (Lyons and Davidson, 2016; Cohen and Jones, 2020). Critical engagement with the uncertain outcomes of AVs for the accessibility of older people may allow public authorities to reflect if and how AVs can be deployed to meet the needs of this group.

The perceptions of these actors are compared with the outputs of the literature review around the plausible implications of AVs for older people. Although the focus is always on the older population, the research has investigated perceptions surrounding the impacts on low-income groups and disabled people. This was selected on the understanding that disabled and low-income individuals may be disadvantaged sub-segments of the heterogeneous older population.

2. *What is the emerging policy response towards AVs, and how is this likely to affect the accessibility of older people and other socially/ transport disadvantaged groups?*

It is argued that a market-led approach in the governance of AVs is more likely to lead to exacerbated accessibility inequalities (Cohen and Cavoli, 2018; Papa and Ferreira, 2018). The literature review on the accessibility implications of AVs on older people showed how the direction and scale of impacts are dependent on policies and regulations. The research aimed to identify if authorities have linked

plans for AVs with broader strategic goals (e.g. reduced accessibility inequalities, improved accessibility for older people) and if they have identified specific policies or regulations to steer the development of AVs in line with the needs of these groups.

3. *Do older people perceive benefits for their mobility and accessibility from AVs, and if so, what are these?*

This and the following questions stem from the gaps in research exploring older people's perceptions and acceptance of AVs. The specific question seeks to understand if older people anticipate opportunities for their accessibility from AVs. Researchers often argue that AVs will allow those who cease driving or cannot access public transport to increase their mobility and accessibility levels (Alessandrini et al., 2015; Harper et al., 2016). Nevertheless, how older people themselves think about the use of AVs and their future opportunities for mobility and access remain underexplored.

4. *What are the barriers possibly inhibiting older people's adoption of AVs from their perspectives?*

The question sought to explore how older people perceive potential barriers to the adoption of AVs. The qualitative approach taken was thought as appropriate to identify barriers as imagined by older people themselves. The literature suggests several barriers to adoption, for instance, safety concerns (Nielsen and Haustein, 2018) and low experience with digital technologies (Lee, C. et al., 2017).

5. *What is their willingness to adopt different types of automated vehicles & services, and what are the factors (benefits, barriers) appearing to influence this?*

Although much research on public acceptance focuses on automated private cars, AVs could appear in several forms. To date, little is known about older people's opinions of alternative automated vehicles and services. This research attempted to fill some gaps in this area by developing hypothetical scenarios of services and investigating their potential acceptance by older people.

The thesis employs a qualitative mixed-method research strategy. In addition to the literature review (chapters 2 and 3) and the document analysis (chapter 5), it draws from interviews with transport professionals (chapter 6) and individuals aged over 55 years (chapters 7 and 8).

1.4. Outline of the thesis

Following this introduction, **Chapter 2** presents a review of the literature concerning the accessibility needs and barriers experienced by older people. The chapter allows us to draw key conclusions about the current state of factors inhibiting access for older people. Its outcomes are used in conjunction

with these of chapter 3 to develop the initial conceptual framework. The review draws from evidence through the National Travel Survey, peer-reviewed and grey literature focused on the UK context and other middle-, high-income countries. Finally, the chapter demonstrates that older people are a rather heterogeneous population group in terms of resources, needs and barriers.

Chapter 3 synthesises the literature around the accessibility impacts of AVs with the factors affecting older people's accessibility (as identified in chapter 2). It leads to the creation of an conceptual framework demonstrating the potential influences of public authorities and the accessibility experiences of older people in a transition to automation.

Chapter 4 presents the methodology and methods used in this thesis. It begins with the description of the initial sampling approach to purposively select twelve transport authorities in the UK and discusses how and why the research has focused on different levels of transport authorities across England. It also provides details about the process of interviews with, first, policy actors and experts and second, citizens aged over 55 years. Moreover, the chapter described the analytical approach used in the context of document analysis and the interviews.

Chapter 5 is the first chapter of findings, presenting the in-depth document analysis. It illustrates how a sample of twelve public authorities frame the implications of AVs within their recent strategy and planning documents. It examines whether and how the accessibility impacts of AVs for the older population and other social groups are analysed. It compares the findings of the documents with the range and direction of plausible impacts on older people, as demonstrated in chapter 3 through the literature review. Additionally, it discusses the themes of policy responses emerging from the content analysis of the documents that were examined.

Chapter 6 presents the findings from fifteen interviews with relevant policy officials, planners and experts within the field of AV policy development and planning at the national and local level. The interviews addressed the first two research question with a similar analytical approach as that followed in the document analysis.

Chapters 7 and 8 present the findings from the interviews with adults aged over 55 years in Greater Manchester. **Chapter 7** describes overarching themes related to the awareness around AVs, perceived mobility and accessibility opportunities from AVs, and barriers inhibiting adoption of AVs. **Chapter 8** presents and discusses the findings from the interviews with older adults pertaining to different use cases of AVs, as presented with the use of scenarios in the interviews.

Finally, **Chapter 9** draws the conclusions of this thesis. It summarises how the research questions were answered, the key contributions of the thesis and the limitations of the research. I use the concluding remarks to develop policy recommendations and future research directions.

2. The accessibility barriers of older population groups

2.1. Introduction

In this chapter, I present a critical review of the literature to identify the key factors that influence or impede the accessibility of older people. The review outlined in this chapter illustrates the heterogeneity within older population groups in terms of mobility and accessibility patterns. It is the first step to construct a conceptual framework that explains how AVs may impact on the accessibility levels of older population groups. The factors or barriers identified in this chapter are linked to the accessibility impacts of AVs (chapter 3) to identify key gaps in knowledge and develop the conceptual framework.

I derived the materials for this critical review primarily from peer-reviewed journals and non-academic reports (grey literature). I focused the search strategy for relevant literature pieces on published material mostly from the period 2000 to 2020. I used Scopus, Science Direct and Google scholar databases to carry out the review. Beyond targeted searches in these databases (e.g. using terms such as Older people AND accessibility), I used forward and backward snowballing (Van Wee and Banister, 2015) from relevant studies. Whilst the focus of the literature review concerns the UK, studies from other developed countries were also reviewed. Finally, I have drawn from the publicly available National Travel Survey statistics for England to discuss key issues related to older people's mobility patterns.

Before presenting the factors that influence the accessibility of older people, I begin this chapter by discussing how the mobility of older people (on average) differs from other age groups, drawing from peer-reviewed studies and the publicly available National Travel Survey statistics for England. Following that, I present the various factors that affect the mobility and accessibility of older people. These point to the differences observed within the older population groups. The factors are categorised under four themes:

1. Access to transport and barriers related to specific transport modes;
2. Built environment – Rural and urban settings and location of services and activities
3. Health;
4. Socioeconomic characteristics and individual resources.

2.2. Current differences in travel behaviour across age groups

Several studies across and beyond Europe (e.g. US, Canada, Australia) show that older people (on average) differ in travel behaviour and activity participation from younger adult groups (Haustein and Siren, 2015). Overall older people tend to be less mobile; they make fewer journeys, travel over shorter distances and use cars less frequently than younger age groups (Rosenbloom, 2004; Hjorthol et al., 2010; Lucas et al., 2016). The differences do not stem from age as such. They relate to events that commonly take place at older ages, for instance, changes in the employment status and retirement, in the household status (e.g. living in single-person households) and a degree of physiological decline which also affects the capacity to use different modes of transport (e.g. holding a driving license) (Stjernborg et al., 2014; Hjorthol et al., 2010).

Changes in how these events are experienced by older people may take place in the future. These can be triggered both by transport (e.g. in-vehicle technologies in cars and AVs) and non-transport factors. In the UK, during the last decade, the number of employees aged over 50 has increased (more significant in the group aged over 65), although high unemployment levels and inequalities in job opportunities exist (Centre for Ageing Better, 2019). Changes in non-transport, assistive technologies can also affect the housing choices of older people, which may, in turn, influence the mobility patterns of older people (Shergold et al., 2015). Virtual mobility may become a more prevalent way to access services and opportunities for all age groups in the future. For older people, online activities, such as online shopping, telecare and the use of social media may substitute some journeys, although there may always be health and social factors limiting virtual mobility and substitution of travel (Parkhurst et al., 2013).

Indicatively for England, looking at the recent National Travel Survey statistics, it is evident that mobility levels peak at the age of 40 to 49. The number of trips falls after the age of 50, with a more significant decline after the age of 70 years old (figure 2.1). As expected, commuting trips decline as people reach their 50s, while there is an increase in shopping and other trips (e.g. just walking), visiting friends at a private home, other escort trips (specifically for the group 60 to 69), entertainment and other activities. Similar trends are observed in distances travelled, while the drop in mobility after the age of 70 is even more notable (figure 2.2).

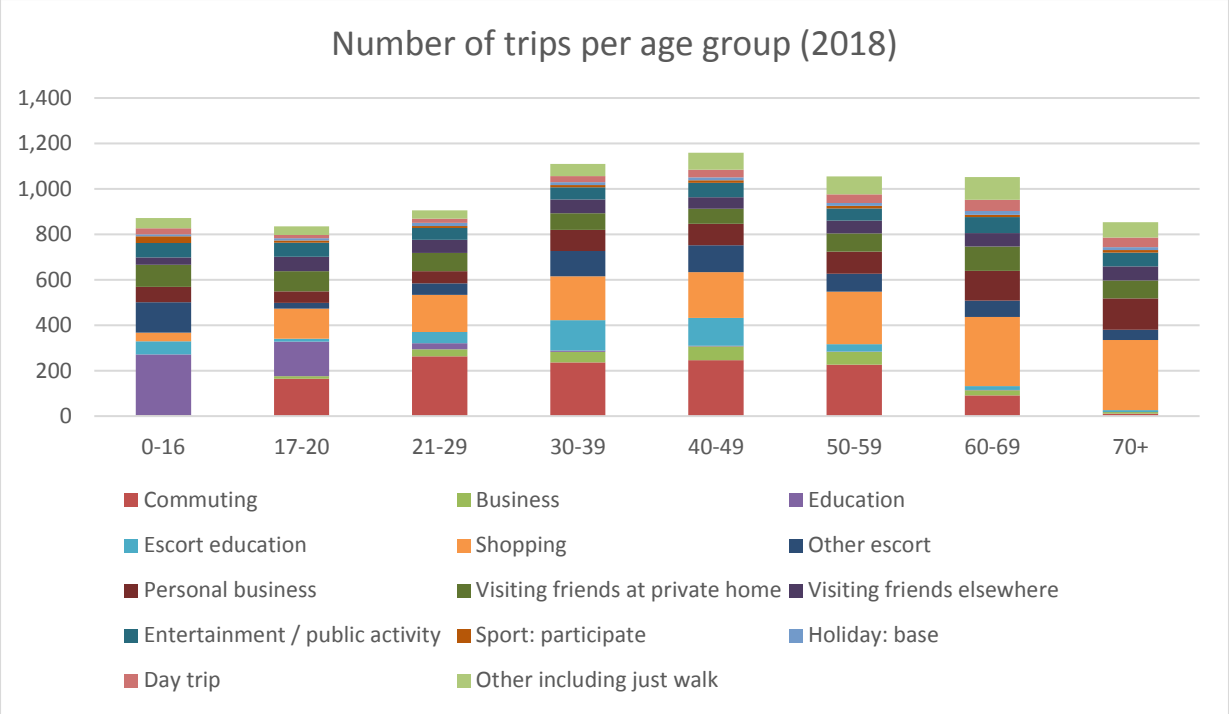

Figure 2.1: Average trip rates by age group. Own elaboration from Table NTS0611 (DfT, 2019c)

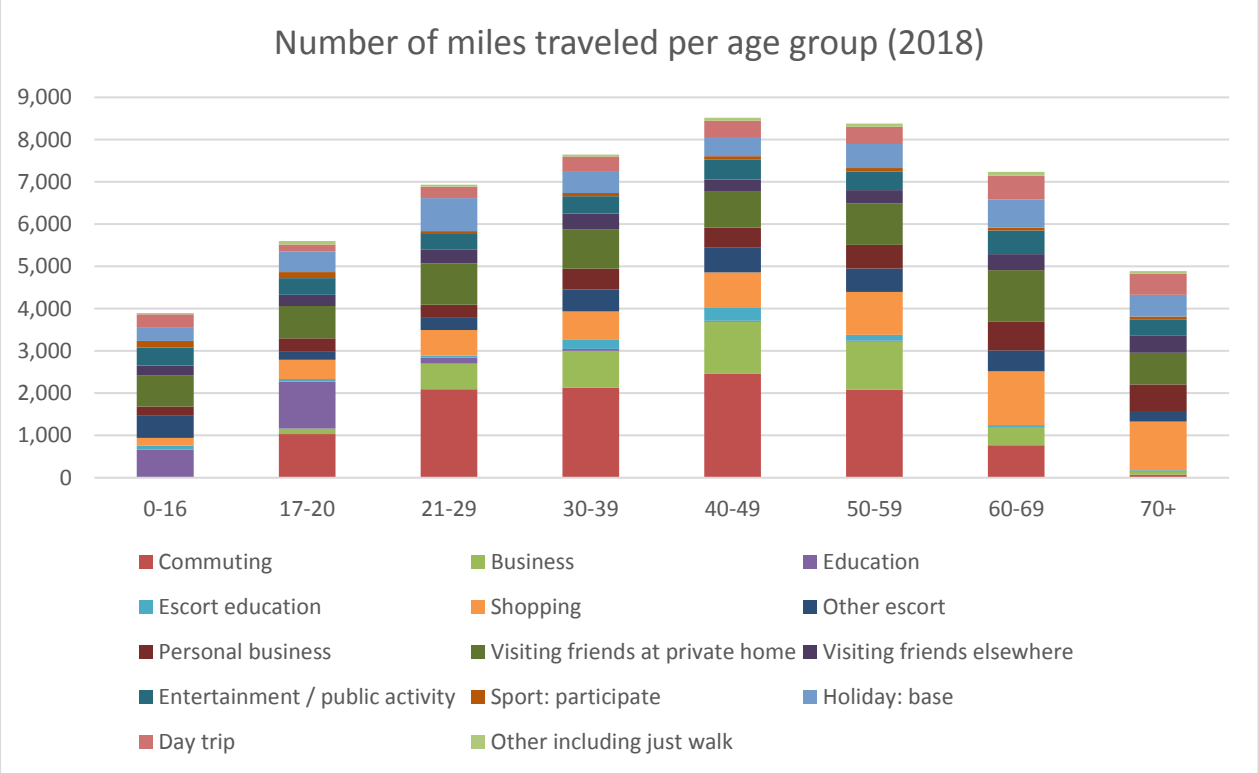

Figure 2.2: Average distance travelled by age group. Own elaboration from Table NTS0612 (DfT, 2019d)

Figure 2.3 shows the percentage of trips made by different modes across ages. Car use (either as driver or passenger) peaks at the age group 50 to 59. After this age, car driving trips decline, particularly after the age of 70 due to driving cessation. After the age of 60, and particularly after 70, people tend to make a larger proportion of their trips as car passengers, by bus and taxi. The proportion of walking trips also increases slightly across older age, although walking distances decline (Shergold et al., 2016). The car, therefore, remains an important mode of transport for older people.

The lower levels of mobility of older people are partly related to reduced needs and preferences for out-of-home mobility (Nordbakke, 2019). Nevertheless, low actualised mobility also stems from the interaction of contextual (e.g. transport and location of services) and individual barriers as the next section discusses.

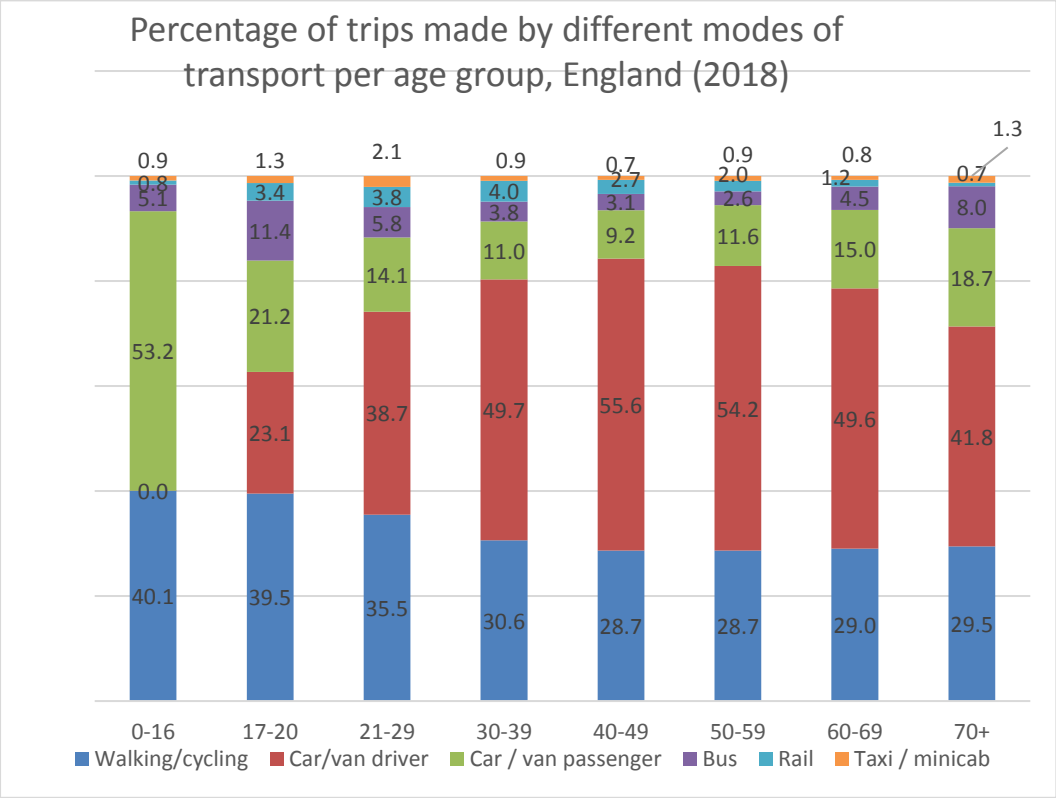

Figure 2.3: Percentage of trips made by different modes of transport per age group. Own elaboration from Table NTS06001 (DfT, 2019f)

2.3. Factors influencing the accessibility of older people

Relevant studies recognise several factors that relate to the mobility, accessibility and activity participation levels of older people. These relate mostly to three components of accessibility; the transport, land-use and individual components (Geurs and van Wee, 2004), while the factors

sometimes relate to more than one component. For instance, access to a car falls into the individual component, while access to public transport and other door-to-door services can be placed both under the category of transport and land-use (as it discusses both supply of public transport and residential location). The review of the relevant factors and categorisations proposed by others (e.g. Nordbakke and Schwanen, 2014; Haustein and Siren, 2015; Luiu et al., 2017) led to the following classification of factors influencing the accessibility levels of older population:

1. Access to transport and barriers related to specific transport modes;
2. Land-use system – Rural and urban settings and location of services and activities
3. Health;
4. Socioeconomic characteristics and individual resources.

2.3.1. Access to transport and barriers related to specific transport modes

2.3.1.1. Access to cars and holding a driving license

Access to cars and a driving license among older people also relates to age, health factors, socioeconomic and personal characteristics (i.e. income, gender). The levels of access to cars and car journeys across older ages have been increasing during the last decades in the UK and other developed countries, reflecting the increasing dependence of previous generations on cars (Alsnih and Hensher, 2003; Hjorthol et al., 2010). In the future, in the UK, older women may have slightly higher access to driving licenses matching the levels of older men (Stokes, 2013). In any case, a significant proportion of the older population is likely to continue not having access to a driving license or personal cars, without substantial changes in how cars are driven and accessed.

Car availability is a significant factor in contemporary travel behaviour. The National Travel Survey statistics (dataset covering period 2002 - 2019) show that in England people in households with cars make more trips and travel much further than those without cars, with main drivers being the most mobile (DfT, 2019e). Although a significant proportion of older people does not hold a driving license, older people as a whole are quite heavily reliant on car lifts to travel around and access opportunities (Mattioli, 2014). Several studies to date suggest that access to a car and holding a driving license play a critical role in the mobility and accessibility levels of older people. Older people prefer the car because it allows them to travel anywhere and anytime they want to (Davey, 2006; Musselwhite and Haddad, 2010b).

Holding a driving license is associated with higher trip frequency and activity participation (Luiu et al., 2018b; Siren and Hakamies-Blomqvist, 2004). In addition, the driving license status appears to determine the level of unmet accessibility needs; these are activities older adults would like to undertake more often if they could (Siren and Hakamies-Blomqvist, 2004; Nordbakke and Schwanen, 2014; Haustein and Siren, 2014; Kim, S., 2011).

Access to a driving license is often lost at older age due to health and other reasons. Studies focusing on driving cessation have shown that this event is associated with a decline in the trip frequency and the activities a person undertakes (Marottoli et al., 2000; Rosenbloom, 2001; Shope et al., 2019) as well as with an increase in depressive syndrome (Chihuri et al., 2016), and a reduction in quality of life (Musselwhite and Haddad, 2010b). Siren et al. (2015) did not find clear differences in activity participation levels among two groups of drivers and ex-drivers, although ex-drivers appear to have significantly more unmet participation needs, particularly leisure needs. The study of Haustein and Siren (2014) led to similar conclusions about the negative implications of driving cessation, particularly for leisure activities. Musselwhite and Haddad (2010a) argue that the satisfaction of accessibility needs is not the main problem after driving cessation, although car allows meeting access needs with convenience. However, individuals that go through this process do not sufficiently meet their emotional and aesthetic mobility needs. For instance, trips for their own sake or trips to beauty spots becomes difficult for people who cease driving (ibid).

Previous studies have argued that the positive impact of driving license status on the activity participation of older people stems from the better health condition of drivers (Scheiner, 2006). Health issues (for instance, vision problems) can lead to driving cessation (Rosenbloom, 2001; Shope et al., 2019). Moreover, older drivers tend to have better health condition than ex-drivers and non-drivers (Haustein and Siren, 2014; Siren and Haustein, 2014). However, other studies controlling for health variables have found that the impact of driving license pertains (Marottoli et al., 2000; Siren and Hakamies-Blomqvist, 2004; Nordbakke and Schwanen, 2014). Furthermore, the car can take the role of an assistive tool for the mobility of older adults who experience age-related health issues (Siren and Hakamies-Blomqvist, 2004). Haustein and Siren (2014) showed that unmet leisure needs were affected by the driving license ownership when health variables were controlled for, both for individuals who had never driven and for those who used to drive. In contrast, for shopping needs, the lack of license played a role only for those who never used to drive (ibid). The authors suggest that shopping needs may be taken into consideration in the decision to cease driving, whereas leisure needs are not (ibid).

Recent studies have added to our understanding of the importance of driving and access to a car, partly supporting or challenging the evidence on the significance of cars for older people. Shergold

(2019b) when looking at the impact of car access on the discretionary activity participation of older adults in rural areas of Southwest England and Wales, found that it plays a significant positive role in taking part in formal leisure activities. However, the opposite holds for informal activities, i.e. visiting friends and family. He argues that older adults who cannot get access to a car have developed social networks in proximity or moved closer to their families and friends. Also, Nordbakke (2013) suggests that the car is essential when it comes to activities, such as carrying heavy items, or evening trips. However, their study shows how older women's out-of-home mobility and access needs are shaped in response to past experience with other transport modes, good public transport services and temporally and spatially accessible activities in their local environment.

Recent research has also attempted to understand differences in the experiences of driving cessation to support older people in this process. The need to cater for public transport and community transport services, interventions in the public realm to improve the walking opportunities, providing support with planning for post-car life, such as travel training, or ensuring informal support from their social networks and institutions are discussed in the relevant literature (Ahern and Hine, 2012; Musselwhite and Haddad, 2010b; Murray and Musselwhite, 2019).

Therefore, current evidence suggests that lack of driving license and access to cars restricts the mobility and access to certain destinations for older people. Nevertheless, the extent to which lack of these resources impairs the ability of older people to access places depends on the location of activities and the availability of transport alternatives.

2.3.1.2. Access to public transport and other door-to-door transport services

The reliance of older people on cars and the inaccessibility to activities for those who cannot access private cars partly stem from the lack of adequate alternatives to private cars. Although public transport plays an important role in the mobility of older people, several barriers to using public transport are reported in the literature.

The concessionary bus fare policy offers free off-peak travel to retired individuals and disabled people in Great Britain (DfT, 2017a). Therefore, the cost of public transport is not reported as a barrier in the UK within the studies examined. Nevertheless, public transport is often a non-viable option for older people; it requires complex transfers, it does not serve off-peak times and destinations where older people may want to go, particularly the ones that relate to 'discretionary' activities (Davey, 2006; Musselwhite and Haddad, 2010b; Schwanen et al., 2012; Zeitler and Buys, 2014; Ryan and Wretstrand, 2019). The distances from and to bus stops are also another barrier for older people, particularly for

individuals with mobility difficulties and those aged over 80 (Zeitler and Buys, 2014; Nordbakke and Schwanen, 2014; Shergold and Parkhurst, 2012). The suburban and rural older population can be disproportionately affected by inadequate public transport (Ahern and Hine, 2012). In England, outside of London, bus services are increasingly being concentrated in urban centres due to a combination of bus deregulation and economic austerity measures (Campaign for Better Transport, 2018; DfT, 2018a). The difficulty of local authorities to support subsidised buses particularly in rural areas, small towns and urban peripheries has led to significant gaps in public transport provision and accessibility in these areas (Lucas et al., 2019). It is characteristic that the use of concessionary bus passes declines as the area type becomes less populated (DfT, 2017a). This decline in the use of free public transport by pensioners possibly relates to the lack of frequent and convenient bus services in areas outside of London and large metropolitan areas.

Other barriers relate to the inaccessibility of public transport stops and stations, the behaviour of drivers and the fear of falling inside the vehicle (Broome et al., 2010). Personal security concerns are also an issue for older people, inhibiting them from using public transport, especially during night time (Musselwhite, 2017c).

Flexible transport options such as community transport supported by the volunteering sector or 'dial-a-ride' services provided by local authorities can reduce some of these barriers for those who cannot use conventional public transport or areas with low population density and travel demand. Nevertheless, issues of service availability (temporal and geographical), unreliability, information and attitudinal barriers mean that these have not scaled up to satisfy mobility and accessibility needs of older people (Shergold and Parkhurst, 2012; Ahern and Hine, 2012; Luiu et al., 2018a). Taxis can be the only transport option, for instance, to get to medical appointments for those who cannot access a car or get lifts from others (Shergold and Parkhurst, 2012; Ahern and Hine, 2012). However, older people often perceive them as expensive transport modes (Schwanen et al., 2012; Nordbakke, 2013).

2.3.1.3. Walking and cycling

Cycling in the UK currently represents a low proportion of journeys, and cycling participation of older people is lower than that of younger age groups (DfT, 2017b). Barriers to cycling for older people relate to the cultural context and the lack of suitable infrastructure in car-dominated environments (Goodman and Aldred, 2018). In countries with higher cycling rates, cycling enables access to services and opportunities for a larger proportion of older people, although functional impairments and fear of accidents can lead to driving cessation (Ryan et al., 2016).

Walking is the second more frequently used mode of transport for older adults. For older adults who can walk, walking can play an essential role in their access to local amenities when these are in close distance to their housing locations (Shergold and Parkhurst, 2012). It is valued for its social interaction elements (Musselwhite and Haddad, 2010b) and the sense of independence from others, even when mobility aid technologies are used (Schwanen et al., 2012). However, walking in later life can be challenging for older adults who experience mobility and other health issues, as further explained in the section of health. Given the physiological decline experienced at an older age but also the dispersed pattern of land-use development, walking cannot fully meet accessibility needs.

The built and street environment appear to affect walking and the extent to which it can satisfy access to places. Lack of suitable pavements, uneven surfaces, pedestrian crossings, severance and the existence of heavy traffic and poor lighting can obstruct older people from walking (Musselwhite and Haddad, 2010b; Shergold and Parkhurst, 2012; Metz, 2010; Broome et al., 2010; van Schalkwyk and Mindell, 2018). Lack of benches and public toilets can also be a barrier to medium-, longer-distance journeys by walking and the use of public transport (Nordbakke, 2013; Holley-Moore and Creighton, 2015). Older people, on average, walk slower than the standard speed that is used to determine pedestrian road crossing times (1.2 m/s) in various high-income countries, including the UK (Asher et al., 2012; Musselwhite, 2014).

Finally, older people face temporal barriers to walking (either to their destinations or public transport stops and stations) (Nordbakke, 2013). Those at oldest ages are more fearful about walking after dark, possibly because of fears about criminal activity, poor lighting and fear of falling (Office for National Statistics, 2018).

2.3.2. Land-use system – Rural and urban settings and location of services and activities

The studies that explore the influence of the built environment on older people's accessibility focus mainly on the distinction between urbanity and rurality. There has been conflicting evidence about the impact of population density as understood though these simplifications (i.e. urban and rural categories), but this is possibly related to the difficulty to make international comparisons with these categories (Luiu et al., 2017). Moreover, they are rather aggregate indicators of proximity to services, and they do not provide any further details about the location of activities older people want to reach.

Some studies outside the UK have found no effect of urban/rural context on activity participation or unmet activity needs (not necessarily as a result of poor accessibility) (e.g. Nordbakke and Schwanen, 2014; Scheiner, 2006), while others have shown a significant effect (Kim, S., 2011). In contrast, it is

also shown that older adults in high-density areas make more trips and travel shorter distances, although they are not necessarily less car reliant (Figueroa et al., 2014).

For England, the current evidence suggests that older adults in rural areas experience more challenges in terms of accessibility and social exclusion when neighbourhood deprivation differences and individual characteristics are controlled for (Prattley et al., 2020). This seems to be related to the lower availability of services and amenities and the lack of adequate public transport supply in areas outside urban cores and particularly in rural areas with low population density (Lucas et al., 2019; Shergold and Parkhurst, 2012). Although long distances to services and amenities are not only an issue for rural populations (see, for instance, Lucas et al. (2019) for a detailed account of spatial accessibility to hospitals across England), inaccessibility can become an issue for those who do not have access to a car in these areas. Rural residents in the UK are more car-dependent (Holley-Moore and Creighton, 2015; DfT, 2019b) and may, therefore, be better able to access services as long as they can use a car. Shergold and Parkhurst (2012) found that access to a car and to a lesser extent the degree of rurality explained accessibility and self-reported exclusion problems in a study of rural older populations in South of England and Wales. They also showed that the accessibility barriers related mostly to necessary services (e.g. hospitals) and cultural activities (e.g. cinemas), while access to some community leisure activities was good, preventing older people from feeling excluded.

Beyond the degree of urbanity/ rurality, what appears to be critical is the extent to which older adults – who do not have access to private cars – live in proximity to their social networks and services. Nordbakke (2013) through her focus group study showed how the mobility of older women is influenced by the distance to the activity, the extent to which direct public transport connections exist and the topographical location of the activity. Perceived proximity to goods and services was shown to reduce the levels of unmet activity participation needs, regardless the place of living (inner city or outer suburb) in a metropolitan area of England (Luiu et al., 2018b).

2.3.3. Health factors

The health condition of older adults appears as one of the most significant factors for their out-of-home mobility and accessibility. Health affects the ability and need to use different transportation modes as well as the activity participation of older people. Moreover, health inequalities are evident within this group, with older old and lower-income groups more likely to experience health issues than their counterparts (Centre for Ageing Better, 2019). People at their 65 (data from 2016 and 2018) are expected to live a significant part of their later lives with a disability (men under half and women more

than a half of years) (Office for National Statistics, 2019). Moreover, in England, the proportions of men and women who need help with activities (e.g. dressing, bathing or showering, eating, getting out of bed, and using the toilet) increase from 15% of people aged 65-69 to 36% of men and almost half (49%) of women aged 80 and over (Centre for Ageing Better, 2018).

Older people often make decisions about the location of their houses and the activities they participate in response to their declining physical and mental health (Nordbakke, 2013). Poor health has been associated to lower diversity in the activities older people take part in (Scheiner, 2006) and a higher level of unmet activity needs (Haustein and Siren, 2014; Nordbakke and Schwanen, 2014; Luiu et al., 2018b).

Better health entails the ability to choose among a higher number of transport modes (Ryan, 2020). Medical conditions, visual or cognitive issues, can affect the ability, self-confidence and rights of older people to drive (Rosenbloom, 2001; Musselwhite and Shergold, 2013). Older people with age-related functional impairments may choose to self-regulate their driving activity (e.g. avoiding driving at night or alone, heavy traffic, adverse weather conditions, long distances) (Adler and Rottunda, 2006; Kostyniuk and Molnar, 2008). However, a decline in physical condition can also lead to higher dependence on cars to meet mobility needs, for instance, the car allows to carry heavy shopping with some convenience (Schwanen et al., 2012). Health also deters the ability to use public transport. Difficulties arise during the process of boarding on and off the vehicle, standing and feeling a risk of falling inside the vehicle, and due to the difficulty to walk to the closest public transport stop (Musselwhite, 2017c; Luiu et al., 2018a). Finally, sensory (e.g. the risk of falling, reduced perception of the road environment and detection of approaching vehicles), cognitive (e.g. difficulties with multi-tasking processes required when walking/crossing the road) and physical impairments (i.e. loss of muscle, endurance, pain in joints) pose difficulties for older pedestrians (Tournier et al., 2016).

2.3.4. Socioeconomic and individual characteristics

2.3.4.1. Age

The effect of age on mobility and accessibility is not direct. Age, though, relates to changes in the health condition, the ability to access different transport modes and other transitions in life. Increasing age is associated with reduced transport options due to a combination of health issues that affect the use of cars, public transport and life transitions (Scheiner, 2006; Holley-Moore and Creighton, 2015).

In England, individuals over 80 are overrepresented in the group that find it most difficult to access healthcare destinations, while they are also more in need of healthcare services (Holley-Moore and Creighton, 2015). A recent analysis of data from the English Longitudinal Study of Ageing shows that people aged over 80 in England experience more difficulties in accessing services and amenities and general social exclusion, irrespective of other factors, e.g. health (Prattley et al., 2020). This possibly suggests non-health-related accessibility barriers, for instance, due to changes in the social environment of the person.

2.3.4.2. Income

Currently, there is a substantial proportion of older people over 65 years old (16% or 1.9 million people) that live in relative poverty and a further 1.1 million in severe poverty (incomes lower than 50% median income) (Centre for Ageing Better, 2019). Single women, ethnic minorities and those over 80 years old are overrepresented within the groups of relative poverty (ibid). Low income older adults belong more frequently in the group of people that had never had a driving license in their lifetime (Haustein and Siren, 2014). Low income is associated with lower car ownership and mobility across all age groups (Stokes and Lucas, 2011; Lucas et al., 2019). Therefore, lower-income people are more likely to be dependent on public transport and walking to access services and activities.

In the UK, low income older adults tend to have the poorest access to healthcare services (Holley-Moore and Creighton, 2015), possibly because they have lower access to cars and difficulty to use taxis. Studies from other countries have also found an association between low income and poor access to activities of importance (Kim, S., 2011; Ryan et al., 2019). Beyond the cost of the journey, lower-income older people travel less to take part in leisure activities, possibly because they cannot afford their cost (Nordbakke, 2019).

For lower-income car drivers, the cost of motoring affects their decision to keep driving at an older age and their overall financial situation. Financial concerns currently appear to play a role in decisions about giving up on driving (Adler and Rottunda, 2006; Ahern and Hine, 2012; Rosenbloom and Winsten-Bartlett; Rosenbloom, 2001). Low-income individuals at car-dependent environments (e.g. rural areas) often need to spend a significant proportion of their income for motoring costs or taxis, which leads to suppressed mobility (Shergold and Parkhurst, 2012).

2.3.4.3. Gender

Across all age groups, women's travel patterns differ from those of men. Women are more likely to live in carless households (although differences are declining) and to make more trips, while they travel for shorter distances overall (DfT, 2019e; Lucas et al., 2019). Car license holding has increased among older people in general over the last decades, and the increase was particularly pronounced for older women in the UK (Shergold et al., 2016). Similar findings are reported for other countries, for instance, Scandinavian countries (Hjorthol et al., 2010) Nevertheless, the gender gap still persists with 54% of women and 83% of men aged over 70 holding a car driving license in 2018 (DfT, 2019g).

Older women tend to travel more by car as passengers, by public transport and by walking comparing to their counterparts (Li, H. et al., 2012). They tend to depend more on others, usually their spouse, for their mobility and accessibility needs (Siren and Hakamies-Blomqvist, 2006). For these reasons, their mobility and access to opportunities can also be impaired as a result of the loss of a spouse (Ahern and Hine, 2012). Older female drivers have been found as more likely to self-regulate their driving activity and to give up on driving, even when they are still capable of driving (Adler and Rottunda, 2006; Siren and Haustein, 2015). This may partly relate to different emotional values and social norms attached to driving among older men and women (Musselwhite and Haddad, 2010a).

Given that older women differ in the use of transport modes, they are often found with higher unmet activity participation needs than men (Hjorthol, 2012; Kim, S., 2011; Luiu et al., 2018b). Most studies that investigate unmet activity participation needs do not find a significant effect of gender (when controlling for other factors), although gender effects are reflected in the driving license status which is a common predictor of unmet needs (Luiu et al., 2018b). Exceptions to this are the studies of Hjorthol (2012) and (Scheiner, 2006) who have found being female positively associated with unmet activity needs, even when other background variables are controlled for.

2.3.4.4. Social network and household composition

The size of the social network of older people appears to affect their level of out-of-home mobility and activity participation (Scheiner, 2006). Older people mention the lack of social connections as a reason for not being able to take part in activities, beyond accessibility factors (Nordbakke and Schwanen, 2014). For people without other transport options (e.g. the ability to drive), lifts from their families and the wider community play a critical role in the extent to which they are able to meet their accessibility needs (Ahern and Hine, 2012; Ryan et al., 2019). Musselwhite and Haddad (2010b) show

how ex-drivers can only access leisure destinations and the countryside through lifts by their friends and family, given that public transport does not commonly serve these destinations. However, older people often hesitate to ask for lifts for non-essential travel needs (ibid). Relying on car lifts from others can challenge the sense of independence of older individuals in western societies (Nordbakke and Schwanen, 2014).

The evidence around the living status of older adults and their mobility points to different directions. Some studies suggest that older people who live alone tend to engage more in out-of-home activities and be more satisfied with their activity levels (Scheiner, 2006; Nordbakke and Schwanen, 2014). This can be explained from the fact that they have a higher motivation to get out for social contact or have less caregiving responsibilities (Scheiner, 2006). Also, it is argued that single older people who have lived alone for longer are often more multi-modal and used to alternative transport modes, which possibly allows them to remain mobile when they lose access to one mode (e.g. due to driving cessation) (Nordbakke, 2013; Ryan et al., 2019). However, looking at leisure activities, specifically, Haustein and Siren (2014), in their Danish study, found that living with a partner reduces the expressed unmet participation needs. The researchers attribute this to the possibility to get car lifts from spouses and satisfying more social needs at home.

The transition from living with a spouse to living alone also seems to have varying effects on the mobility and accessibility of older people. For some, particularly women who are reliant on car lifts from their spouses, their accessibility can be impaired as a result of the loss of their spouse (Ahern and Hine, 2012). However, this depends on the context and the availability of non-car transport options. Good walking infrastructure and specialised door-to-door transport services appear to mediate the effect of transitioning to a single-person household in mobility (Stjernborg et al., 2014).

2.4. Conclusion – factors affecting the accessibility of older people

The literature review demonstrated how individual and contextual factors interact to shape the accessibility of older population groups. Table 2.1 presents a summary of the identified factors that seem to influence the accessibility of older people. Some of the factors appear to have indirect effects on the accessibility levels. For instance, being an older woman seems to lead to poorer accessibility levels due to lower rates of driving license holding. In its turn, car access plays a critical role in accessibility levels, in current car-dependent environments. However, having access to a driving license and owning a car are not the only factors that shape the accessibility of older people. Other individual (e.g. health or income) and contextual factors (e.g. provision of public transport, proximity

to activities, the walkability of an area) also affect the extent to which older people can use transport modes to access activities of value. It seems, therefore, critical to consider the interplay of these factors with AVs and new mobility services.

Table 2.1: Overview of factors affecting the accessibility of older people

Category	Factor	Key issues
Transport	*Access to cars and holding a driving license*	• Lack of access to driving license and cars can be problematic when there are no other transport alternatives; • The car can play a compensatory role for individuals with mobility issues; • Barriers related to health, income, age, gender (being female)
	Access to public transport and other door-to-door transport services	• Public transport can facilitate accessibility; • Barriers related to the geographical, temporal availability of public and community transport, distance to/ and from stops and stations, safety and security aspects, health, cost (taxis) and social norms (community transport)
	Walking and cycling	• Walking provides access to local amenities; • Barriers related to the built environment, infrastructures (e.g. traffic dominance, safety) and location of activities (distances), personal security and health factors
Land-use system - Rural and urban settings and location of services and activities		• Proximity to services facilitates accessibility; • Barriers appear in rural areas (for some activities and those without car access, as a result of public transport and lack of services)
Health		• Poor health leads to reduced activity participation, inhibits access to transport modes (e.g. driving, walking) and, as a result, accessibility
Socioeconomic characteristics and individual resources	*Age*	• Individuals aged over 80 face more barriers to accessibility; • Barriers partly related to declining health and ability to use different modes and life transitions
	Income	• Lower-income groups are found in some studies to report poor accessibility and activity participation; • Barriers related to lower car access, lack of affordability of activities and motoring costs
	Gender	• Older women are found in some studies to report poor accessibility more frequently than older men;

Category	Factor	Key issues
		• Barriers seem to stem from lower access to driving license, life transitions after the loss of spouse and access to lifts
	Social network and household composition	• The social network can facilitate access through car lifts and influence needs for mobility; • Barriers related to non-essential journeys; • Debate around the role of household composition

3. The impacts of automated vehicles on the accessibility of older people

3.1. Introduction

Having identified the key factors influencing the accessibility of older people in chapter 2, in this chapter, I present a synthesis of these factors with a literature review of studies dealing with the accessibility implications of AVs. The review allows, first, to illustrate the key phenomena that will shape the accessibility of older people in the future. Moreover, it shows that the direction and the scale of accessibility impacts are dependent on how AVs are governed.

In this chapter, I provide more detailed definitions of AVs and other innovations (in the domain of shared mobility and Mobility-as-a-Service). These 'smart mobility' technologies will influence how older people experience the transition to automation. Following these, I examine the accessibility implications of AVs for older people through a synthesis of studies on the accessibility impacts and public acceptance of AVs, informed by the outputs of chapter 2. Additionally, I discuss the governance implications of AVs and how policies may affect their accessibility impacts. I conclude with the development of a conceptual framework that demonstrates how AVs may influence the accessibility levels of older people.

3.2. The development of AVs: common definitions and timelines

The research explores the implications of AVs for older people, as commonly defined by levels 4 and 5 (SAE International, 2018). Nevertheless, I recognise that this taxonomy is simplistic and can often be misleading about what has been and what can be achieved in terms of self-driving capability (Parkhurst and Lyons, 2018; Stayton and Stilgoe, 2020).

In automation level 1 and 2, the human driver performs fully or partly the dynamic driving task, with driver assistance systems executing steering, acceleration/deceleration functions (SAE International, 2018). In levels 3 and 4, an automated driving system performs all or parts of the dynamic driving task in specific environments. In level 3, the human driver is expected to intervene when there is a request to do so, while in level 4, the human driver is not expected to intervene following a request. Level 3 AVs are often described as conditionally automated (Milakis et al., 2017a; CCAV, 2019). Level 4 AVs are expected to be able to drive in specific operational design domains, specific road environments, environmental, geographical conditions (ibid). These are also often described as AVs that will operate

in digitally geofenced areas (areas that are well covered by digital mapping), for instance on parts of a motorway or in an enclosed University campus. In level 5 – what is known as full automation - the automated driving system performs full-time the dynamic driving task in all operating conditions (environmental, geographical, temporal, traffic or road environment characteristics) (ibid).

The timelines and levels of market development of AVs remain unknown. For instance, Litman (2017) predicts that in the US level 5 AVs will be available in the market, but only affordable by high-income individuals in 2020s to 2030s, and approachable by lower-income groups in 2040s to 2050s. Milakis et al. (2017a) identify several driving forces that are likely to determine the pathways for AVs with the ones evaluated as more uncertain and important being policy (supportive or restrictive towards AVs) and technological development of conditionally (level 3 according to SAE taxonomy) and fully AVs (levels 4 and 5 according to SAE taxonomy). The timeframe for market introduction is estimated for conditionally and fully AVs between 2018 and 2028 and 2025 and 2045, respectively. For the UK, it is argued that level 4 and 5 AVs could be widespread by 2040, initially in geofenced, enclosed areas (Government Office for Science, 2019).

The extent to which level 5 automation as described in the SAE taxonomy can be achieved is debatable. AV manufacturers who often use ambitious timelines for the development of fully AVs are reported to change their claims to more conservative timelines (Shaheen et al., 2018). Technology developers have an interest in overstating the level of technological maturity and pace of progress to persuade the public and governments for continued investment and favourable regulations that enable licensing of AVs in any form they are available (Stilgoe, 2018). Beyond the debate of timelines to achieve level 4 or 5 of automation, others point to the progress required to reach a full level of automation to be used in any operational environment, the extent to which this will be possible, and the magnitude of changes AVs will impose on existing road infrastructures, laws and public behaviours (Stilgoe, 2017). From this point of view, level 5 AVs may be utopian and what is important is to define the specific conditions that allow for a vehicle to be used in self-driving mode (Stayton and Stilgoe, 2020). These include any information about the surrounding environments, the road and digital infrastructure, and the extent to which the road space is shared with human-driven cars, pedestrians, cyclists, and associated behaviours of road users (ibid).

Automated technology is often discussed in conjunction with connectedness, as in connected and automated vehicles (CAVs). Connected vehicles are able to communicate with each other (vehicle to vehicle communications) and/or with the infrastructure (vehicle to infrastructure communication). Connectedness is estimated to be essential for traffic flow and congestion benefits assumed from the introduction of AVs (Fagnant and Kockelman, 2015). The electrification of the vehicle fleet is also another transport trend much discussed with regard to the operational costs of AVs and their impacts

on air pollution and energy consumption. Although there is a widespread assumption that all AVs will be electric, electrification and automation can occur independently of each other, whereas AVs are highly likely to require a degree of connectedness with other vehicles or the surrounding infrastructure (Cohen and Jones, 2020).

For this thesis, the term AVs is used to describe self-driving capability (either Level 4 or Level 5 AVs (SAE International, 2018)).

3.3. Shared vehicles and journeys and Mobility-as-a-Service

In recent years new ways of accessing transport beyond the dominant private car ownership models have emerged. It is commonly argued that the development of AVs will coincide with and further facilitate a shift away from private car ownership to increasing on-demand use of shared mobility services and multimodality. In terms of market interests and developments, there may be competing forces among private companies that will influence how AVs are accessed and used. Some companies (mainly traditional automobile manufacturers) may have a strong interest in a future where automated car ownership prevails. In contrast, 'disruptive' mobility operators may be more interested in growing the market of shared mobility services (Legacy et al., 2018). The models of access that may emerge given the current trends and market interests (private or shared vehicles and journeys) appear as critical factors to understand long-term impacts of AVs, including the accessibility of different groups and places (Milakis et al., 2017b).

The term shared mobility refers to different types of personal vehicle sharing (e.g. car, scooter and bike-sharing); services that include the sharing of a ride, carpooling, on-demand for-hire ride services (e.g. ride-hailing, micro-transit) or the sharing of a delivery/cargo ride (Shaheen and Chan, 2016; Jin et al., 2018). All of these technologies allow occasional access to transport for their users. An important distinction for this thesis can be between shared vehicles (vehicles that are available to multiple travellers, such as bike-share, car clubs and ride-hailing) and shared journeys (this involves multi-occupancy journeys with travellers that may or may not know each other, such as car-sharing, ride-sharing, or demand-responsive buses) (Marsden et al., 2019).

Over the last years, the widespread adoption of the Internet, smartphones and open data policies enabled the development of new types of shared mobility services. App-based shared mobility services have emerged in several cities worldwide, operated by private transportation and technological companies, commonly referred to as '*Transportation Network Companies'* (TNCs) (Jin et al., 2018). The distinctive characteristic from previous forms of shared mobility is that these match

passenger demand and vehicle supply on real-time with the use of mobile phone applications. Uber, Lyft, Chariot, Didi and Ola are some of the most well-known companies that operate in numerous cities globally (ibid). The services they offer include ride-hailing, ride-sharing, demand-responsive buses and dockless bike-sharing. Ride-hailing (app-based taxi services), in which the company connects a private driver to the passenger through mobile devices and applications is one of the fastest-growing shared mobility services (Jin et al., 2018; Shaheen et al., 2018).

Another emerging transport innovation potentially leading to changes in how transport is accessed is Mobility-as-a-Service. Although there is no universally accepted definition for MaaS, the term is commonly used to describe a range of platforms, applications and underlying business models that enable the integration of several transport modes, providing information, booking and payment services (Mulley, 2017; Smith et al., 2018). Travel planning applications are already mainstream in many parts of the UK. Currently, cities and industries are experimenting with more advanced forms of MaaS to facilitate seamless, door-to-door mobility through different transport modes and services, anticipating a shift away from private car ownership and more multi-modal mobility practices (Transport Committee, 2018). The distinctive characteristic of the MaaS concept is that mobility services can be developed as service packages offered to customers – travellers, like the ones offered in the communications sector (Pangbourne et al., 2018).

There is a common assumption that the trends towards increased automation, a shift from personal car use to on-demand access of different transport modes and multi-modal practices, could coincide and lead to a transition to 'Smart Mobility' (Docherty et al., 2018). New operational and business models for transport access would have implications for the accessibility of older people, as well as in general accessibility inequalities.

In this thesis, I use the terms on-demand or shared AVs to refer to any type of AVs that will be asynchronously (e.g. on-demand shared cars, taxis, ride-hailing), or synchronously shared (e.g. any form of on-demand public transport, shuttles, or ride-sharing). The most critical distinction is between synchronous and asynchronous sharing modes, as these models will have different impacts on traffic networks and people (e.g. motorised travel demand). In this chapter, I frequently use the term ride-sharing to refer to synchronously shared AVs (used simultaneously by different individuals for at least a part of the journey). The people that share a journey can either know each other (e.g. car-sharing) or not (e.g. the progression of services like UberPool). Finally, I also use the term 'use cases' and 'models of access' to denote the various types of vehicles, operational and business models of AV services that can appear in the future.

3.4. The accessibility implications of AVs

A common claim for AVs is that they will improve the mobility and accessibility of older people by addressing the barriers imposed due to driving cessation and the difficulty to access public transport (Alessandrini et al., 2015; Harper et al., 2016). These techno-optimistic claims are frequently made without considering the factors that influence the mobility and accessibility of older people. Moreover, the willingness of older people to use AVs is often overlooked in these assumptions.

Few recent publications have engaged with wider implications of AVs (e.g. impacts on travel demand and travel behaviours, the built environment) in combination with the factors inhibiting mobility and accessibility for older people (Fitt et al., 2019; Kovacs et al., 2020). These posit that the accessibility, social inclusion and wellbeing impacts on older people are complex, highly uncertain to be predicted by modelling exercises, and dependent on the policy and regulatory responses.

To explore the accessibility impacts of AVs on older people, I used the four components accessibility model, as operationalised by Geurs and van Wee (2004). I synthesised this part of the literature review with the findings from chapter 2. This allowed considering the specific factors that affect the accessibility of the heterogeneous older population (e.g. health, age, gender, the built environment, the urban/rural context, the availability of public/community transport). Kovacs et al. (2020) recently approached the implications for the mobility of older people with a similar methodology, discussing the influence of AVs on the factors that inhibit their mobility (health, environmental, economic, social).

AVs could impact on the four different dimensions of accessibility (Cohen and Cavoli, 2018; Papa and Ferreira, 2018; Milakis et al., 2018), as defined by Geurs and van Wee (2004):

a) The land-use component. It includes, first, the availability and, second, demand for activities and opportunities (e.g. jobs, shops and health and housing locations) and the relationship among these two.

b) The transport component. It describes the *'disutility'* caused by factors such as time, any costs associated with the travel and the effort required to undertake the trip (e.g. perceived safety, security). The disutility is created by passenger demand and the supply of transport.

c) The temporal component. It refers to the time that individuals have available to take part in various activities and the time that activities across the day or days when activities are available (e.g. shopping destinations or work).

d) The individual component. It encompasses personal characteristics, needs, abilities and opportunities. These influence access to transport and opportunities.

The four components model has already been used to explore the accessibility impacts of AVs (Cohen and Cavoli, 2018; Papa and Ferreira, 2018; Milakis et al., 2018). My review began with an open-ended, less systematic approach where I read and kept notes of papers on AVs and the relevant components of accessibility (for instance, papers on how AVs will influence the built environment, like (Zakharenko, 2016) or AVs and older people's mobility (Shergold et al., 2016). As my thesis progressed, the research on AVs began shifting to an extent from very technical-focused to engaging with the social and distributional effects of AVs (Cavoli et al., 2017). I used publications that employed the four components model to examine the potential accessibility impacts of AVs (and to an extent inequalities) to supplement my review (Cohen and Cavoli, 2018; Papa and Ferreira, 2018; Milakis et al., 2018). I further used forward and backward snowballing and targeted searches on Scopus and Google scholar with Boolean operators (AND, OR) (Van Wee and Banister, 2015) to make sure the most relevant publications are included.

3.4.1. Temporal component

AVs could allow some travellers that experience time pressure to use their time on-board for productive or relaxing activities, saving them time from daily activities that take place in other environments, e.g. job locations (Pudāne et al., 2019). Also, fully AVs could be used to do activities themselves, for instance, shopping deliveries or to transport children to and from school (Milakis et al., 2018). From this perspective, AVs could help reduce the temporal constraints of their users that inhibit them from taking part in activities as they wish to do.

On the other hand, having the option to be productive while on-board may lead to a change of expectations (for instance, working while commuting being normalised and not affecting total hours dedicated to work) and marginal impacts in terms of time constraints (Pudāne et al., 2019). The extent to which AV users will want to use their journey time for productive activities is disputed, as many may choose to engage with relaxing activities (Cyganski et al., 2015). Motion sickness could be a barrier for many people given the vehicle design and speeds that may be considered desirable from a traffic flow perspective, while ride-sharing models may not provide suitable environments for on-board activity participation (Singleton, 2018). Temporal barriers are not of direct relevance to the older population group.

Time constraints can be a barrier to engage in out-of-home activities for some older people (Nordbakke and Schwanen, 2014; Luiu et al., 2018b). However, these are likely to be experienced by active and highly mobile older adults or by those who have caring responsibilities at home.

Nevertheless, the indirect effects of the abovementioned impacts on wider travel behaviour, mode shifts and location of activities could play a role for older people's accessibility, as discussed in the section of the land-use component.

3.4.2. Transport component

3.4.2.1. Journey times

Focusing on journey times as a measure of accessibility does not necessarily reflect the barriers or needs of older people per se (Shergold and Parkhurst, 2012). The emphasis on journey times in transport planning and appraisal has traditionally catered for the needs of hypermobile groups (Martens, 2011). Although improvements in network efficiency are possible in a scenario of level 4/5 AVs and high levels of market penetration, increased travel demand may lead to worsened congestion and increased journey times. Studies show that CAVs will be able to make more efficient use of the road space as they will require shorter gaps between vehicles and optimized routing decisions (Fagnant and Kockelman, 2015). Connectedness is a key precondition to achieve these network efficiency benefits (Cohen and Cavoli, 2018). Nevertheless, if travel demand increases as a result of new groups being able to access motorised transport and improved road capacity, the result could be a marginal change or negative impact on journey time and reliability (Anderson, K. et al., 2014; Milakis et al., 2017b).

3.4.2.2. Cost of AVs

The issue of cost interacts with the individual component (i.e. lower-income older people). There is much uncertainty around the cost of AVs and the extent to which this will be affordable to different income groups (Cohen et al., 2017). In the US, it is argued that AVs for private ownership will be widely available by as early as 2030, but they will be largely unavailable to poorer households at this time (Litman, 2017). Mass deployment of AVs could reduce the cost of owning such a vehicle, but in any case, this is not expected to be as low as the cost of a conventional vehicle (Fagnant and Kockelman, 2015). Even if the cost is reduced over time as argued and usually seen with new technologies, it can be hypothesised that some lower-income groups will still not be able to afford them, as in current conditions (Mattioli et al., 2018b; Lucas et al., 2019). In addition, it is predicted that only the highest income groups can be benefitted in terms of reduced total cost from automated car ownership,

whereas low- and middle-income groups will bear increases in total cost of ownership (Wadud, 2017). This is driven by the higher value of time, and the longer distances travelled for higher-income households comparing to their counterparts (ibid).

However, there may be a reduction in the operational cost and fares of buses and on-demand shared vehicles (cars, taxis) (Bösch et al., 2018; Wadud, 2017; Tirachini and Antoniou, 2020), or community transport (Kovacs et al., 2020). Wadud (2017) estimated that the taxi sector would experience the highest reduction in total costs from the introduction of AVs, possibly explaining why TNCs are so invested in this technological development. Particularly in high-income countries with high transportation and labour costs such as the UK, it is estimated that the introduction of electric AVs will lead to a reduction in the production costs of different modes, from buses and on-demand shared vehicles (ride-hailing and ride-sharing) (Becker, H. et al., 2020). The relative cost differences among the various modes may decrease, while sharing a vehicle may become more affordable comparing to owning a private car (ibid). These estimated costs refer to production costs calculated based on current policies and tax frameworks, which could be different in the future. Additionally, they do not fully reflect the implications for passenger costs which would be influenced by subsidies, dynamic pricing structures commonly used by TNCs, demand, and competition among different modes and operators (Becker, H. et al., 2020). Cost can become a larger barrier to mobility for low-income people in cities with inadequate public transport provision, given the surge pricing mechanisms employed by TNCs, like Uber (Atkinson-Palombo et al., 2019).

The affordability of private and other forms of automated transport is critical for the mobility and accessibility impacts on lower-income groups across all ages. Policies such as mobility credits for lower-income groups have been proposed as a solution to ensure that the cost is not a barrier to on-demand access of AVs (Cohen and Cavoli, 2018). There is a possibility that lower prices in on-demand shared AVs in combination with increased mobility and empty vehicle running will lead to higher motorised travel demand (Wadud et al., 2016). This might require the implementation of economic policies (e.g. road pricing), which would also affect the affordability of different modes (Becker, H. et al., 2020). Integrated pricing and planning of the various forms of non-private transport could be a useful tool for the public sector to improve affordability while controlling for increased travel demand (ibid). In the UK, currently, concessionary bus fares are offered to all individuals over the age of 60 for off-peak travel. It is uncertain if and how this policy would be altered (and if there would be political and public support to do so) in a scenario where on-demand access to motorised transport (automated or not) becomes widespread.

3.4.2.3. New mobility services and availability of non-private forms of transport across places

Other changes that could impact on the transport component relate to the emergence of new mobility services and the availability of non-private transport across places. On-demand shared AVs in various forms could complement conventional public transport services and provide more convenient transport options (UITP, 2017). Individuals who do not own or have access to a private car would be able to use a range of services on-demand to access opportunities. Shared AVs could potentially reduce enforced car ownership and car-related economic stress (Mattioli et al., 2018a) as well as the social isolation of rural communities or other areas that are poorly served by public transport (Cheyne and Imran, 2016). For older people with mobility difficulties, the use of these services would not require walking long distances to public transport stops and stations (Zeitler and Buys, 2014; Nordbakke and Schwanen, 2014; Shergold and Parkhurst, 2012).

Although on-demand shared AVs could reduce temporal and geographical barriers associated to fixed-route and timetable public transport, service gaps and inequalities in provision and accessibility could remain or even exacerbate in a transition to AVs and new mobility services. Shared mobility services and MaaS applications may be primarily targeted to large urban areas, excluding peri-urban and rural areas (Government Office for Science, 2019). This is currently observed in the case of shared mobility services, such as car clubs and bike-sharing schemes. Central locations or areas adjacent to employment centres may be prioritised on the grounds of commercial profit (Clark and Curl, 2016; Dowling and Kent, 2015). Without any intervention, private companies may choose not to serve deprived communities, as currently found with Uber in some US cities (Jin et al., 2019). It is also uncertain whether the lack of supporting infrastructures will inhibit the deployment of AVs in rural areas (Government Office for Science, 2019).

3.4.2.4. Complementarity/ competition with conventional public transport

Another important issue is how AVs in different forms may influence the mode share and, as a consequence, the availability of conventional public transport in different areas. This, in turn, could influence the levels of financial support available for conventional public or community transport (Kovacs et al., 2020). If private AV models prevail (and they are affordable to buy and accessible to diverse groups of users), there could be a decline in public transport, as more groups have access to cars (Harper et al., 2016). Additionally, a reduction in the value of time and the operational costs in the case of private AVs could also lead to a shift away from public transport (Soteropoulos et al., 2018).

It is uncertain how on-demand shared AVs would affect mass transit ridership, its viability and level of service. The recent emergence of TNCs and ride-hailing has already ignited a debate about their impacts on buses and mass transit ridership (Shaheen et al., 2018; Marsden et al., 2019). Some studies argue there is a supplementary role for ride-hailing, which supports public transport use on the grounds that these services can cater for off-peak demand (e.g. weekends, late at night, or in places with inadequate public transport coverage (American Public Transportation Association, 2016; Jin et al., 2019). On the other hand, a mode shift effect from public transport to ride-hailing has also been observed, particularly in high-density areas where there is already good public transit coverage (Circella and Alemi, 2018; Clewlow and Mishra, 2017; Jin et al., 2019; Rayle et al., 2016). A recent survey in England found that ride-hailing, predominately Uber, was the most popular shared mobility mode, used by the 28 per cent of respondents, of which 36 per cent stated they would have used bus or train otherwise (DfT, 2019h).

MaaS platforms could also affect the extent to which shared AVs complement or compete with high-capacity public transport (Pangbourne et al., 2020). The limited experience from Finland and Whim, a MaaS application platform shows that users reduced the car use and increased their public transport but also taxi use (London Assembly, 2018). Conventional public transport services may not always be included in MaaS applications (Pangbourne et al., 2018). Depending on the service packages, the pricing and mechanisms used to nudge people towards particular travel choices (Lyons et al., 2019), ride-hailing can be more or less competitive to buses and other public transport systems.

Modelling studies have indicated that on-demand shared AVs could lead to a shift away from public transport (and active travel), particularly if a substantial reduction in the costs is assumed (for instance, comparing to conventional taxis) and the value of time (Soteropoulos et al., 2018).

In response to these opportunities and risks for the availability of collective forms of transport and spatial equity, different interventions from public authorities are suggested as possible. Policies could aim to improve the current provision of mass transit and encourage or regulate the location and timing of on-demand shared AV services in a way that complements public transport (Cohen and Cavoli, 2018; Papa and Ferreira, 2018). The ownership models and regulations for any non-private forms of transport would also play a critical role in how the various services are integrated and the efficiency and spatial equity outcomes (Curtis et al., 2019; Docherty et al., 2018).

3.4.2.5. Road safety and security

Advocates of AVs argue that they will significantly reduce road crashes. AVs will eliminate human error that accounts for the majority of road accidents (Litman, 2017). Moreover, AVs could be designed and regulated so that they protect and prioritise the movement of pedestrians and cyclists (Millard-Ball, 2016). In this way, they could improve the perceived and actual safety of vulnerable road users and therefore the ability to reach destinations by active modes of transport. However, as Millard-Ball (2016) argues, this would make AVs slower and possibly less attractive to consumers. Regulations might be imposed to control the unhindered movement of pedestrians and cyclists that would take advantage of the risk-averse AVs to move faster (ibid).

Beyond the challenges around the interaction among AVs and other road users (i.e. pedestrians, cyclists, conventional car drivers), AVs entail new risks, including hardware and software failures and cyber-security threats (Anderson, J. et al., 2016; Cavoli et al., 2017). In a rather 'dystopian' scenario, Papa and Ferreira (2018) imagine a future in which AV manufacturers will produce vehicles with more or less aggressive driving styles. AVs with greater safety capabilities may be available for people who are able and willing to pay for expensive insurance coverage, leading to safety inequalities in terms of income (ibid).

The effects of AVs on road safety and security are likely to be important for the accessibility of older people in two ways; first, perception of safety is likely to affect the acceptability of older people towards AVs (Nielsen and Haustein, 2018) and, second, they could impact on their ability and willingness to walk (Rahman et al., 2019). The outcomes are likely to be dependent on regulations about the safety features of AVs and the extent to which these prioritise the safety of vulnerable road users (Papa and Ferreira, 2018).

3.4.2.6. Severance and road space allocation to walking and cycling

Transports severance stems from barriers to (non-motorised) mobility imposed by the existence of transport infrastructures or traffic (Jones and Lucas, 2012). It can have both physical (i.e. the shape of transport infrastructure, the dominance of traffic) and psychological elements (i.e. avoiding areas because of security concerns, feeling fearful of crossing a road due to traffic) (ibid). In the case of older adults, the dominance of traffic and the lack of frequent crossing intersections can be a psychological barrier to walking (Musselwhite and Haddad, 2010b).

It is argued that a shift from private car mobility to on-demand use of AVs could release significant road space that is currently used for on-street and off-street parking (Alessandrini et al., 2015; Duarte and Ratti, 2018). The freed-up street space could be used to make city centres and towns more liveable spaces and to improve the road environment for pedestrians and cyclists (ibid). The use of on-demand shared AVs would result in a reduction in the number of cars (or vehicles more generally) being used and parked on the roads. For instance, in a simulation study for Lisbon, Portugal, a reduction of parking spaces (between 84% and 94%) was calculated in scenarios that assumed a shift from conventional cars to automated taxis (ride-hailing) and ride-sharing, respectively (International Transport Forum, 2017).

In contrast to on-demand shared AVs, private AVs would have limited effect on the demand for parking land, although they could alter the spatial distribution of parking spaces (Soteropoulos et al., 2018; Zhang and Wang, 2020). Private AVs would not lead to an equally significant reduction in the total number of vehicles required (Zhang et al., 2018). Therefore, shared mobility and, to a lesser extent, automation could support the reallocation of road space from parking space to pedestrians and cyclists.

On the other hand, even if AVs are used in on-demand models, an increase in traffic would eradicate these benefits. Travel demand could increase as a result of empty vehicle driving (Zhang and Guhathakurta, 2017) or a shift from buses to on-demand shared AVs (even in scenarios of 100% automated ride-sharing) (International Transport Forum, 2017). Additionally, the mobility of pedestrians and cyclists could be hampered by the increased number of pick-up/drop-off areas (Zhang and Wang, 2020) and platoons of vehicles driving close to each other (Fraedrich et al., 2018). The spatial and social distribution of parking demand could also be unequal (both in private and on-demand AV scenarios). Parking demand and traffic may move away from urban centres (Zakharenko, 2016) and possibly to lower-income areas where land is cheaper (Zhang and Guhathakurta, 2017).

To avoid risks for increased traffic dominance and severance, policies that support on-demand use rather than ownership in combination with slower speeds and other measures supporting active travel and public transport are likely to be required (Cohen and Cavoli, 2018). Targeted policies to take advantage of the opportunities from reduced parking requirements to improve the environment for walking and cycling could also be implemented (Papa and Ferreira, 2018). Other policies and regulations are also suggested to avoid increased motorised demand, such as road pricing and restriction of access in urban areas where they may compete with active modes of transport (Singleton et al., 2020). For older people with mobility difficulties, age-friendly design practices might need to be considered to encourage walking and cycling (e.g. provision of benches and public toilets, reduced traffic speeds and road crossings adapted to pedestrian speeds) (Holley-Moore and Creighton, 2015).

3.4.3. Land-use component

The relevant question here is how AVs are likely to impact on the built environment and the location of activities. Compact cities with mixed land-uses entail shorter distances to reach destinations that favour walking, cycling and public transport (Newman and Kenworthy, 1996). On the other hand, low density and highly segregated locations of activities mean that longer distances need to be covered and are simultaneously a result of and a contributing factor to higher car use. Therefore, changes in the built environment and land use development will shape travel behaviours and socio-spatial inequalities in mobility and accessibility. Dispersed urban development has implications for the funding and provision of public transport due to the need to serve larger areas with lower demand. Changes in the density of cities will have consequences for those who depend on walking, cycling and public transport to meet their travel needs and the time they need to travel to reach the destinations they want (Cohen and Cavoli, 2018).

The deployment of AVs could lead to two opposing effects in location choices; greater densification of urban cores and urban sprawling (Milakis et al., 2018). On-board relaxation or engagement with productive activities could alter the organisation of daily schedules and open up the time and spatial horizons for some AV users who find automated driving pleasant and convenient (Pudāne et al., 2019). This, in its turn, may lead to further dispersal of housing and job locations. AVs (particularly in private modes) could increase the accessibility of exurban and rural areas, leading to further sprawling (Meyer et al., 2017; Soteropoulos et al., 2018). It is also argued that reduced parking demands in urban cores would entail increased economic activity and land value, pushing residents outside of these areas (Zakharenko, 2016).

On the other hand, it is argued that a shift to shared automated mobility might attract more people to live in urban centres since there will be the benefit of reduced car ownership and commuting times (Duarte and Ratti, 2018). Modelling studies show that on-demand shared AVs could lead to increased urban density, but these are based on assumptions for a high share of ride-sharing services, good integration with public transport and marginal changes in the value of time (Soteropoulos et al., 2018). If the introduction of AVs was used as an opportunity to replace parking space with new buildings, it might also lead to denser urban development (Papa and Ferreira, 2018).

Researchers to date have not explored the implications of AVs for the location decisions of older people in the UK (e.g. ageing in place in rural areas as discussed by (Fitt et al., 2019)). The effects on land use could be quite disparate across different areas of the UK. Fitt et al. (2019) and Kovacs et al. (2020) argue that opportunities and risks exist. Increased urban density can improve the accessibility

of older people, while dispersal would lead to worsened accessibility and automobility dependence (ibid). Proximity to services and amenities can reduce barriers to accessibility for older people (Luiu et al., 2018b). However, beyond the increased density of city centres, where older people will live and how mixed and diverse the land uses will be, will also matter. City centres may become denser, but less diverse in activities or demographics (i.e. attracting younger people).

3.4.4. Individual component

AVs could interact with various factors that influence the accessibility levels of older people (e.g. health, access to a driving license and a car, income). The effects could be both positive (opportunities for the accessibility of older people) and negative (risks for the accessibility of older people). AVs are also likely to affect different segments of older people differently, given the heterogeneity within the group in terms of individual resources (e.g. income) and contextual conditions (e.g. where they live and how AVs influence their place of living).

3.4.4.1. Access to cars, holding a driving license and health condition

It is argued that (fully) AVs will provide social inclusion benefits for those without a driver's license, older people that cease driving, and people with disabilities (Anderson, K. et al., 2014; Harper et al., 2016; Fagnant and Kockelman, 2015). AVs could improve the accessibility of individuals who do not have access to a driving license, or restrict and cease driving due to health and psychological reasons (e.g. motor, visual, cognitive issues, stress about the driving task) (Musselwhite and Haddad, 2007; Musselwhite and Shergold, 2013). The benefits would be relevant for individuals who cannot use public transport, due to physiological issues that make the use of public transport inconvenient (e.g. not being able to walk to the bus stop or carry shopping in the vehicle). Therefore, AVs could reduce or compensate for the accessibility barriers posed by health issues affecting older age. Given that older old individuals may be disproportionately affected by health issues that restrict their access to driving and alternative transport modes (e.g. walking, buses), they could experience significant accessibility benefits. For individuals who do not own a car, on-demand shared AVs in different forms could allow them to access places with greater ease.

The extent to which these groups can use these vehicles will strongly depend on the level of technological progress to enable self-driving under all conditions and environments, the cost, the physical accessibility of these vehicles and these groups' digital literacy level and willingness to use

such a vehicle. The effects would also differ in terms of supply forms of AVs. Private and on-demand shared AVs could have rather disparate effects both in terms of AV adoption by the older population and wider travel behaviour and accessibility, as highlighted in the earlier sections.

3.4.4.2. Low income

The barrier of cost has been analysed in section 3.4.2.2 that discusses the effects of AVs on the transport component. For lower-income older individuals, a purchase of a private AV may not be an affordable option, particularly for those that voluntarily or not participate in a low number of out-of-home activities. Currently, lower-income older drivers cannot afford cars that provide advanced technologies (Harvey et al., 2019). If (automated) car dependence prevails, these groups may be forced to own a private AV, even if this means sacrificing other expenses or restricting the use of the car. On-demand shared AVs could be a more affordable option for lower-income groups. However, the need to have a bank account and a mobile phone to access a mobility service can inhibit low-income individuals from accessing any type of app-based service and can be an increasing barrier with a transition to smart mobility (Clark and Curl, 2016; Ofcom, 2018).

3.4.4.3. Familiarity with and access to digital technologies

Experience with the use of technologies may affect the adoption of AVs by the older population. Digital technologies will be required to access on-demand AVs (i.e. smartphones and Internet connection). Moreover, experience with digital technologies appears to influence the attitudes and acceptance towards AVs (Lee, C. et al., 2017). The proportion of UK older people who make use of digital devices has been increasing over the last years, although there are still gaps, for instance, in the use of Internet particularly among women, lower-income individuals and older old adults (Matthews et al., 2018). Smartphone ownership is lower among older people comparing to other age groups, whereas it decreases with lower income and the existence of disabilities (Ofcom, 2018). Beyond cost and user interface barriers, the lack of opportunities to understand how computers, smartphones and social media platforms work, discourages older people from embracing these technologies (Marston et al., 2019). The intergenerational digital divide is likely to reduce as future cohorts of older people will have used extensively digital technologies for their jobs and personal lives (Office for National Statistics, 2018). Therefore, in the future digital exclusion may be increasingly associated with some segments

of older old individuals who face higher vulnerability due to cognitive and other impairments or lower-income groups.

3.4.4.4. Mobility, cognitive and sensory disabilities

Some barriers may be pertinent to some segments of older people that face mobility, sensory and cognitive barriers. The use of AV services without human assistance is likely to require a certain level of independent mobility from older adults (Fitt et al., 2019). The extent to which AVs will be able to address the needs of individuals with anything beyond mild cognitive impairments (e.g. dementia, Alzheimer's disease) is unclear (Shergold et al., 2016). The human-machine interaction interface and the vehicle design would also make AVs more or less suitable for diverse groups of older people (Huff et al., 2019; Shergold, 2019a). On-demand shared AV service providers may exclude - intentionally or unintentionally certain groups of users, for instance, by not providing for wheelchair access (Docherty et al., 2018). Trust in the driving style of AVs, and the extent to which the in-vehicle design takes into consideration specific health issues and disabilities are argued to be critical for future adoption (McLoughlin et al., 2018).

The abovementioned opportunities and barriers are related to the abilities and resources of older people (e.g. health, technological skills, driving ability, income level) to adopt AVs in their different forms.

Through the understanding of accessibility within this thesis, the extent to which different groups of older people are willing to use AVs also matters. The willingness to use AVs is integrated into the conceptual framework of accessibility not to assess the future adoption of AVs per se. Realised mobility extends the accessibility concept that is concerned with the potential for physical mobility to reach a destination (Martens, 2015). However, a) the level of willingness to use AVs may relate to perceived ability to adopt the technology, b) AVs may have adverse consequences for the accessibility of older people who do not want or cannot use AVs. The following section discusses the current evidence and gaps around the acceptance of AVs from the perspective of the older population.

3.4.5. Studies exploring older people's perceptions and acceptance of AVs

Several studies have explored public perceptions of AVs. As observed in the literature review of Becker, F. and Axhausen (2017), studies on public perception are most often quantitative (specifically

online surveys). Most of the studies involving the public explore perceptions of and attitudes towards fully and partially AVs, intention to buy or use, willingness to pay for different use cases of AVs (private cars, shared), time use on-board (Schoettle and Sivak, 2014; Payre et al., 2014; Schoettle and Sivak, 2016; Kyriakidis et al., 2015; Lee, C. et al., 2017; Wadud and Huda, 2019). Recent studies have also explored the impact on housing locations, vehicle ownership (Kim, S.H. et al., 2020b) and changes in activity patterns (Pudāne et al., 2019; Kim, S.H. et al., 2020a).

The majority of cross-age surveys on public perception of AVs indicates that older people are less receptive to the technology comparing to younger generations (Becker, F. and Axhausen, 2017; Kovacs et al., 2020), although the reasons underlying these differences are not examined in depth. Studies suggest that older people are less likely to perceive benefits from the deployment of AVs (e.g. improved congestion, reduced travel time), to be willing to ride or own an AV and to be concerned about AVs (Ipsos MORI, 2014; Schoettle and Sivak, 2014; Duncan et al., 2015; Lee, C. et al., 2017).

Differences in the information received about AVs and the level of knowledge may partly explain the attitudinal and acceptance differences (Shergold et al., 2016). Studies have shown that older people have a lower (self-reported) level of knowledge comparing to younger age groups (Duncan et al., 2015; DfT, 2019h). Awareness around AVs has appeared to be linked to higher acceptance, trust and perceived usefulness of the technology (Rahman et al., 2019; Robertson et al., 2019). This can be both explained as that those individuals with high interest in the technological development search for more information about it, or that having some information leads to higher acceptance (Robertson et al., 2019). The last point stems from the belief that a lack of knowledge may entail fear of the technology (ibid). Technology experience and confidence in using new technologies that are also associated with age have also appeared significant determinants in acceptance and intention to use AVs (Lee, C. et al., 2017). Concerns about learning how to use new technologies and AVs, specifically, appear to be more prevalent among older people (Duncan et al., 2015).

The perception of safety risks may also partially explain the lower willingness to use AVs among older people comparing to younger groups, although studies point to different directions. A UK online survey study with participants of ages 18 to 85 (drivers/non-drivers) found that younger people were less strongly opposed to AVs comparing to older people, although there was no significant age difference in the perception of risks for road accidents (Hulse et al., 2018). However, older people have also appeared to have higher levels of acceptable fatality risks comparing to younger people, suggesting that safety can be an important concern for older people (Liu et al., 2019). Nielsen and Haustein (2018) also identified that Danish older people were overrepresented in the segment of 'sceptics' about AVs. Only a minority of this group perceived safety benefits from the introduction of

AVs on public roads, in comparison with the 'enthusiasts' who belonged more often to younger demographics.

A few studies have explored the public acceptance of automated transport services that involve synchronous sharing; sharing a taxi (i.e. ride-sharing), buses and shuttles. In an experimental study in Berlin, older participants showed higher willingness to use the automated shuttle comparing to younger groups (Nordhoff et al., 2018). Nevertheless, they were more likely to rate the service as less effective than their current transport modes. In the study of Dong et al. (2017), people aged over 45 years were less willing to ride an automated bus than participants that belonged to younger age groups. The study, in general, found that people were overall unwilling to ride an automated bus without an employee onboard. Concerns about vehicle safety, personal security and lack of human assistance seemed to influence these responses (ibid). Other studies have found similar age differences in intention to use on-demand automated services (taxis and shared taxis) (Krueger et al., 2016), or shared taxis only (Clayton et al., 2020).

These surveys provide limited insights about how older people's accessibility will change in an AV future. The surveys do not link acceptability with the mobility and accessibility levels of older people. Therefore, it is not always clear if such a technology would improve the travel options and mobility of participants. Moreover, the only relationship that is explored is that of age and AV acceptance. This does not allow to explore how AVs might impact on the accessibility of the heterogeneous older population.

Studies on attitudes and perceptions of AVs (as driverless vehicles) focusing on groups of older people are limited. Past studies have examined the experience and benefits of existing advanced driver assistance systems (ADAS) for the mobility and independence of older people (Musselwhite and Haddad, 2007; Eby et al., 2016). In-vehicle technologies that are designed according to older drivers' needs can help them address driving difficulties associated with physiological, cognitive and psychological issues (Musselwhite and Haddad, 2007). Older drivers tend to prefer systems that provide feedback while allowing for a continued sense of control in the driving task (ibid). The lack of opportunities to learn how to use in-vehicle technologies and about their potential benefits is a common barrier for their uptake from older drivers (Eby et al., 2015). Given that older people are also more experienced drivers, they learn in different ways and make different use of in-vehicle technologies than younger and therefore, inexperienced drivers (Yang and Coughlin, 2014).

In addition, studies have explored the human – vehicle interaction in conditionally AVs that allows the driver to engage with other non-driving tasks while requiring some manual control under specific conditions (Level 3 as defined by (SAE International, 2018)). Older drivers appear to perceive benefits

from these assistive technologies in terms of improving their driving experience in long journeys, at night or with adverse weather conditions (Li, S. et al., 2019b). Nevertheless, older drivers tend to prefer keeping the control of these vehicles and the choice to manually drive and using these vehicles as *'driving companions'* (Schoettle and Sivak, 2014; Li, S. et al., 2019b).

As far as fully AVs are concerned, few studies have focused on older people, with only some of them addressing both acceptance and perceived mobility/accessibility implications of AVs. For instance, Hassan et al. (2019) explored through an online questionnaire survey the willingness of older adults (defined as aged over 65) in Canada to use AVs (cars) and the socio-economic and travel characteristics influencing this. Willingness to pay for autonomous technology was overall low for the majority of participants and declined with age (ibid). A strong preference for a level of control in the driving task was also observed. The study did not investigate specific concerns or benefits for the mobility of older people.

In contrast to the abovementioned study that concluded that older people in Canada are not overall acceptant towards the prospect of AVs, other studies have suggested that older people would be somewhat willing to adopt the technology. In a UK study that involved a self-selected sample of individuals over the age of 50 who also volunteered to take part in trials of pods, around half of participants (n=69) stated that they were likely to use AVs (before the trials) (Shergold, 2019a). Following the trials, acceptance had risen, but this may imply that participants based their opinion on the specific trial and simulation experiences (ibid). Similarly, the majority of participants in four focus groups that took place across the province of Utrecht, Netherlands, were interested in using at least one type of an AV or service (Faber and van Lierop, 2020). An online questionnaire survey with participants aged over 60 across the US aimed to measure acceptance and underlying factors, using and adapting elements of various relevant theories of technology and automation acceptance (Rahman et al., 2019). Acceptance was overall rated as positive as well as attitudes towards AVs, while attitude, perceived usefulness and trust appeared to explain acceptance to a satisfying level (ibid). It should be noted, though, that researchers who carried out these studies have urged for further research and noted possible limitations of the studies in terms of the sample (Rahman et al., 2019; Shergold, 2019a) and focus group dynamics (Faber and van Lierop, 2020).

Beyond acceptance levels, a few studies have engaged with older people to understand how their mobility would change in a scenario of automated transport. Participants in relevant studies have expressed the view that AVs would allow them to make more leisure trips and meet friends and family members with convenience (Musselwhite, 2019; Shergold, 2019a; Faber and van Lierop, 2020). AVs have been described by older individuals as a solution to transport disadvantage, either because of the lack or loss of driving license or the difficulty to access and use public transport (Huff et al., 2019;

Shergold, 2019a). In terms of individual barriers to adopt AVs, the cost of private or on-demand/public AVs is a critical factor to adoption and a potential exclusion factor (Huff et al., 2019; Shergold, 2019a; Faber and van Lierop, 2020). The availability of training opportunities to learn how to use AVs has also been raised as a key precondition to acceptance (Shergold, 2019a). The human-machine interaction interface and the vehicle design would also make AVs more or less suitable for diverse groups of older people (Huff et al., 2019; Shergold, 2019a).

To date, few studies have explored the willingness of older people to use different types of automated transport services. Studies from other countries have found higher willingness to use hypothetical on-demand options (public transport, e.g. shuttles, community transport, shared cars and taxis) than a private car (Faber and van Lierop, 2020; Rahman et al., 2020). In contrast, in a small focus group study in the UK, older people seemed unwilling to use AVs in shared models (with other travellers) or taxis due to concerns about cost, waiting times and preference for independence (Musselwhite, 2019). In the study of Shergold (2019a), some participants showed interest in a shared ownership model (e.g. taxi or car club) but were strongly opposed to the idea of sharing with strangers.

There is some preliminary evidence that current drivers or individuals who depend mostly on driving for their mobility needs have less positive attitudes comparing to those who cannot drive or use a variety of transport modes (Hassan et al., 2019; Musselwhite, 2019). On the other hand, older drivers have shown higher interest and willingness to pay for a private AV comparing to their counterparts (Faber and van Lierop, 2020; Rahman et al., 2020). The extent to which older men and women differ in their perceptions and acceptability is not clear from the literature. Shergold (2019a) found that women that belonged to the 50 to 70 group were less likely to adopt AVs comparing to men, while over 70 there was an opposite trend.

In conclusion, little is known about older people's perception of accessibility benefits and barriers to AV adoption. Given that AVs is a future technology, and the public is asked to respond to hypothetical scenarios, researchers must explore these issues in different settings and with various methods.

3.5. Synthesis of literature review findings for the accessibility implications for older people

Based on a synthesis of the findings from chapter 2 and 3, the accessibility implications of AVs for older people can be separated into four main categories.

a) Benefits from the adoption of AVs for older people

The ability of older people to use transport:

AVs can improve the accessibility of older people with certain health problems and people with different forms of mobility/ sensory impairments. Older people who cease driving or cannot use public transport due to health issues would be benefitted. (Related factors from chapter 2: health, access to transport, age).

Availability of on-demand shared transport across places:

On-demand public or community transport services tailored to older people's needs could improve their accessibility. On-demand shared/public AVs may be available and enable door-to-door mobility in a wide geographical coverage, particularly in areas and at times not served by conventional public transport as a result of reduced operational costs. (Related factors from chapter 2: access to cars and holding a driving license, access to public transport).

Affordability of AVs:

There may be a reduction in the operational cost and fares of buses and on-demand shared vehicles (cars, taxis) (Bösch et al., 2018; Wadud, 2017; Tirachini and Antoniou, 2020) or community transport (Kovacs et al., 2020). (Related factors from chapter 2: access to public transport and door-to-door services, income).

b) Barriers to adoption of AVs for older people

This category includes various barriers to adoption of AVs for older people. It should be noted that the category does not include plausible wider disbenefits from the adoption of AVs for older people such as social isolation and adverse health impacts due to air pollution or physical inactivity (Fitt et al., 2019), as these are not directly related to the concept of accessibility. However, these impacts would

be important to be considered in any assessment of AVs' implications for societal desirability or older people's well-being.

The willingness of older people to use AVs:

Older people (or sub-groups of the older population) may not be willing to use AVs because of lack of trust in the technology (Nielsen and Haustein, 2018) or may not be willing to use specific AV services (e.g. shared taxis) (Shergold, 2019a)

The ability of older people to use transport:

The use of AV services without human assistance may still require a certain level of independent mobility from older adults (Fitt et al., 2019). The extent to which driverless vehicles will be able to address the needs of individuals with anything beyond mild cognitive impairments (i.e. dementia, Alzheimer's disease) is unclear (Shergold et al., 2016). On-demand shared AV service providers may exclude - intentionally or unintentionally - certain groups of users, for instance, by not providing for wheelchair access (Docherty et al., 2018). (Related factors from chapter 2: health)

The adoption of smartphones and transport applications may remain low among some segments (low-income, older old, individuals with disabilities) (Matthews et al., 2018), inhibiting their access to on-demand shared mobility services. (Related factors from chapter 2: income, age, health - individuals with disabilities)

Affordability of AVs:

Private AVs may not be affordable for lower-income groups. For on-demand, shared AVs, dynamic pricing structures cannot assure services are affordable for lower-income individuals (Atkinson-Palombo et al., 2019). Lack of ability to buy a smartphone may be a further barrier for lower-income groups (Clark and Curl, 2016; Ofcom, 2018) (Related factors from chapter 2: income)

Availability of on-demand shared transport across places:

If there is an introduction of shared AV services, there could be differential availability in urban/peri-urban, rural settings. Transport companies may choose not to serve deprived communities, as currently found with TNCs in some US areas (Jin et al., 2019). (Related factors from chapter 2: land-use system, access to public transport).

c) Benefits for accessibility by other modes of transport (e.g. walking)

Improved road safety:

AVs may bring about safety benefits from eradicating human error, reducing road danger for older people, both as AV users and other road users (particularly pedestrians). Depending on regulations, other road users, for instance, pedestrians, may feel safer in their interaction with AVs than human-driven vehicles (Millard-Ball, 2016). This could improve their ability to access places by walking. (Related factors from chapter 2: walking and cycling).

Built environment and road space allocation to walking and cycling:

AVs (shared) could free-up spaces for development, supporting the reallocation of space to active travel (Alessandrini et al., 2015) (Related factors from chapter 2: walking and cycling).

Land-use development and proximity to activities:

AVs (with a high proportion of ride-sharing) could also increase urban density and proximity to services and activities, making it easier to get to places by walking or cycling (Soteropoulos et al., 2018). (Related factors from chapter 2: land-use system, walking and cycling).

d) Disbenefits for accessibility by other modes of transport (e.g. walking)

Worsened road safety:

AVs may not be equally safe for all road users, with pedestrians, cyclists and vulnerable older people being particularly disadvantaged (Millard-Ball, 2016). They may create new types of accidents due to malfunction, equipment failures or cyber-attacks (Anderson et al., 2016). Older people (or sub-groups) may not accept the safety risk imposed on them, with implications for their adoption and mobility (e.g. as pedestrians) (Rahman et al., 2019). (Related factors from chapter 2: walking and cycling).

Competition with public transport:

If private AV models prevail (and they are affordable to buy and accessible), there could be a decline in public transport, as more groups have access to a car (Kovacs et al., 2020). On-demand shared AVs could also compete with mass transit, making the latter one less economically viable (Curtis et al., 2019). (Related factors from chapter 2: access to cars and holding a driving license, access to public transport).

Built environment and road space allocation to walking and cycling (severance):

The road environment could become more traffic-dominated due to increased travel demand and a mode shift from mass transit and active travel (Zhang and Wang, 2020; Fraedrich et al., 2018). Older pedestrians could experience more barriers in their mobility, with issues in accessing local activities or public transport stops and stations. (Related factors from chapter 2: walking and cycling).

Land-use development and urban sprawling:

AVs (particularly in private modes) could increase the accessibility of exurban and rural areas, leading to further sprawling (Meyer et al., 2017; Soteropoulos et al., 2018) (Related factors from chapter 2: land-use system, walking and cycling).

Figure 3.1. summarises the key findings from the literature review around the accessibility implications of older population groups. From this synthesis, it becomes evident that AVs will not only interact with older people's accessibility as new transport modes, but they can also affect the use and access to other transport modes (e.g. walking) and the location of activities. Second, their impacts will largely depend on the use cases of AVs and the commercial and operational models (i.e. private AVs, on-demand shared AVs that can be in the form of ride-hailing or ride-sharing).

There are also some cross-cutting themes across the various implications when they are categorised regardless of whether they are positive or negative for older people (see table 3.1):

a) The ability to access transport;
b) The willingness to use AVs;
c) The affordability of AVs;
d) The availability of public/shared transport across places;
e) Road safety;
f) Built environment, land-use development and ability to walk and cycle.

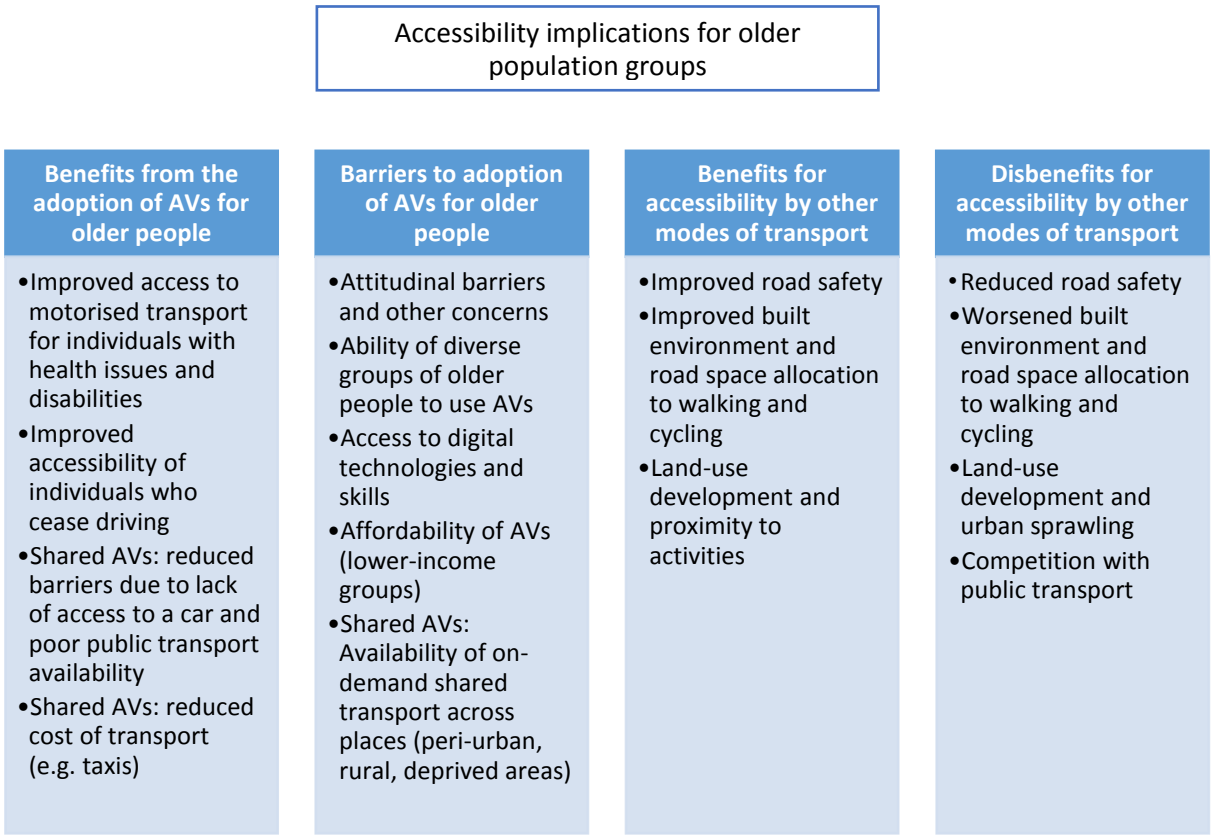

Figure 3.1: Key accessibility implications for older population groups

3.6. The governance of AVs and the influences of policies and regulations

The previous section showed how the direction and magnitude of AVs' impacts would be influenced by the policy and planning context. The synthesis of the literature review through the lenses of older people's accessibility shows that their exact impacts are impossible to be predicted with any degree of certainty. Yet, lack of anticipation and action from the side of public authorities can be risky; for instance, it can lead to the technological exclusion of some older population groups or widened inequalities in the provision of transport services. As Cohen and Cavoli (2018) point out, although it cannot be certain that a well-managed deployment of AVs will be adequate to avoid any undesirable effects, by shaping the development and implementation, the public sector may be better positioned to achieve any imagined opportunities for the public good.

Table 3.1 illustrates examples of policy instruments as found in the relevant literatures that demonstrate how interventions can steer the development of AVs to potentially more beneficial outcomes for older population groups.

AVs present numerous challenges to public authorities. Managing the safety, data protection and cyber-security of AVs are only some of the most direct and, therefore, evident challenges of public authorities. Beyond managing these risks, though, public authorities have a critical role in steering the development of AVs and other 'smart mobility' innovations towards socially desirable outcomes (e.g. reduced inequalities, sustainability). However, automation of the transport sector is only one of the trends that challenge the control of public authorities over transport provision and equity outcomes. Given that most mobility innovations are commonly market-driven, without appropriate intervention from the public sector, innovative business modes such as ride-hailing and MaaS can lead to higher mobility for higher profits (Docherty et al., 2018; Legacy et al., 2018; Pangbourne et al., 2018). The conflicts with goals for sustainability and equity in the transport domain are evident.

Table 3.1: Examples of policy and regulatory measures to manage the accessibility implications of AVs

Key accessibility implications (cross-cutting categories)	**Examples of policy and regulatory measures to achieve positive outcomes**
The willingness of older people to use AVs	Engagement with older people to understand attitudes, perceptions, develop opportunities to co-design innovations according to older people's needs.
The ability of older people to use AVs	Ensure that on-demand shared AVs provide for wheelchair access (Docherty et al., 2018)
Affordability of AVs	Mobility credits for on-demand access of AVs (Cohen and Cavoli, 2018), Integrated pricing and planning of the various forms of non-private transport (Becker, H. et al., 2020).
The availability of on-demand shared transport across places and door-to-door mobility systems	Encourage or regulate the location and timing of on-demand shared AV services in a way that complements public transport (Cohen and Cavoli, 2018; Papa and Ferreira, 2018).
Road safety	Regulations bout the safety features of AVs and the extent to which these prioritise the safety of vulnerable road users (Millard-Ball, 2016).
The impact on the built environment and the ability to walk and cycle	Reallocation of space to walking and cycling (Papa and Ferreira, 2018), Reduction of speeds (Cohen and Cavoli, 2018)

Docherty et al. (2018) discuss the implications of a 'smart mobility' transition for accessibility inequalities and transport-related social exclusion. They argue that both opportunities and risks exist, and government intervention is likely to be required to ensure individuals and places are not underserved or excluded by private operators and new mobility services. The role of the government cannot merely be the facilitator of 'smart mobility' initiatives. The state needs to consider if and how new mobility services and technologies contribute to spatial and social equity objectives, which are not commonly tackled by the markets (ibid).

Researchers have urged for proactive governance and planning approaches for AVs to ensure that their development aligns with equity, social inclusion and sustainability goals. Cohen and Cavoli (2018) explore the long-term impact of non-intervention from the public authorities at the national, regional, and local level on the deployment of AVs. They demonstrate how a "laissez-faire" approach, in which the governments choose only to facilitate market penetration of AVs without intervening in the roll-out of AVs, would lead to the worst outcomes in terms of accessibility inequalities. They observe that these adverse outcomes could emerge in a future where competing private interests (Legacy et al., 2018) are left uncontrolled; those pushing for private ownership of AVs and those offering increasing on-demand access of AVs. Papa and Ferreira (2018) develop two 'utopian' and 'dystopian' scenarios of AVs development for accessibility. Through a backcasting approach, they show how each future scenario is constructed through different policy routes (what they call as "critical decisions").

The regulatory settings and the extent to which governments seek to integrate AVs within multi-modal transport services are also argued to be critical factors for the mobility and well-being of older people (Fitt et al., 2019; Kovacs et al., 2020). Kovacs et al. (2020) identify four regulatory themes beyond older people's preference for different types of AVs that will determine older people's travel behaviour in a transition to automated transport. Their regulatory themes relate to some of the key accessibility implications of AVs for older people outlined in figure 3.1.

It appears, therefore, critical that public bodies assess the social and distributional implications of AVs and consider ways to promote their opportunities and control for their risks. However, research from the UK and beyond raises critical questions about the extent to which public bodies have chosen to proactively steer the development of AVs (Guerra, 2015; Hopkins and Schwanen, 2018; Legacy et al., 2018; Freemark et al., 2019). The risk identified by the relevant studies is that planning and regulatory authorities may end up reacting to a future constructed by the automotive industry and technological companies. From the perspective of this thesis, the previous section discussed why such an approach could lead to further exclusion of certain older population groups.

Early evidence from the US suggests that uncertainty inhibits public sector planners from integrating AVs in their long-term plans and investment decisions (Guerra, 2015). Guerra (2015) proposes that planners should not assume that AVs will solve all transport problems, and they should make decisions about policies and investments that make sense under different scenarios of AV deployment. Planning tools to address uncertainties in a more proactive manner exist. However, they require recognising uncertainty and developing flexible policy frameworks to achieve 'desirable' futures (Lyons and Davidson, 2016). Several scenario planning and backcasting exercises have attempted to show that policymakers and planners have some power to construct the future of AVs based on their own strategic goals (Papa and Ferreira, 2018; González-González et al., 2020; Nogués et al., 2020).

It is important to note the constraints of public sector officials reported in a different context (i.e. Australia) to influence both the governance arrangements and outcomes of AVs (Legacy et al., 2018). Australian planners recognise that leaving the private sector to lead AV development may lead to negative consequences for spatial equity or sustainability. Nevertheless, there are concerns that market-led development will prevail, with public authorities reacting in response to the effects of AVs (ibid). Evidence from other settings suggests that public bodies may opt for different approaches in the governance of AVs. For instance, officials from German local government authorities are quite sceptical that AVs will support their visions for their cities, particularly if they are not developed as on-demand shared transport (Fraedrich et al., 2018). The study suggests that although federal government aims to promote the alleged economic and efficiency benefits through tests and trials, the interest of local actors is in AV experiments that can build their understanding about their impacts on the public welfare of cities. A US study suggests that disparities in officials' opinions about the impacts of AVs will play a role in the extent to which cities attempt to influence the roll-out of AVs (Freemark et al., 2019). Similarly, the size of the city and the resources available to a planning authority may also influence the policy responses of lower levels of government bodies in that policy context (ibid).

The UK central government aims to place the country as a global leader in the development and deployment of CAVs. Maintaining global advantage in the development of CAVs with an aspiration for economic growth, efficient human and goods mobility are expressed as critical goals in the website content of the Centre for Connected and Autonomous Vehicles (CCAV); a policy team within DfT created in 2015 to facilitate the networking among academia, industry and government and support the market development of CAVs (CCAV, unknown). Regulations or non-binding standards have been developed in response to specific risks (e.g. safety, liability, cyber-security). These are done in a cautious way to avoid stifling innovation (Taeihagh and Lim, 2018). Aspirations to boost the automotive industry and economic growth appear as critical factors in the UK's interest and

involvement in AV experimentation (Hopkins and Schwanen, 2018; Mladenović et al., 2020). Hopkins and Schwanen (2018) suggest that although the UK government has taken several actions to enable experimentation and network building among stakeholders, the governance process appears to be too technology-focused. Moreover, there appears to be a narrowly defined positive vision for the future of automation, without always considering the social and distributional aspects of it or allowing engagement of the publics (ibid).

In conclusion, studies on the governance of AVs in the UK context are limited. These show that there is a construction of a positive vision from the UK government with actions taken to promote technological experimentation. However, current studies have not focused on how the accessibility of specific population groups and future inequalities are imagined in an AV future by UK public authorities. The positions (visions, expectations, actions) of UK public authorities operating in the sub-national level are also underexplored.

3.7. Development of the conceptual framework

Figure 3.2 illustrates key elements and relationships to examine the accessibility outcomes for older population groups. The figure shows the accessibility implications categorised as a) accessibility by/ to AVs and accessibility by other motorised and non-motorised modes, and b) opportunities and risks.

The risks falling under the category of accessibility by/to AVs for this thesis are conceptualised as "barriers to adoption of AVs for older people" instead of "disbenefits from the adoption of AVs for older people". This is because this thesis is concerned with the accessibility implications of AVs for older people. Nevertheless, if the focus was on the wider well-being consequences of AVs for this population group, the category of disbenefits from the adoption of AVs for older people should be integrated into the framework. The disbenefits could include reduced physical activity, increased loneliness (depending on the types of automated services/vehicles that will be employed) (Fitt et al., 2019). It is also recognised that some of these wider implications of AVs could be perceived as important by older people. Hence, they could indirectly affect their perceptions and acceptance of AVs.

From the perspective of public authorities (central government to local authorities), the figure shows that these stakeholders influence the outcomes in two ways. The first is that they can anticipate and imagine the impacts of AVs, including those related to the accessibility of older people. Critical engagement with the uncertain outcomes of AVs for mobility and accessibility inequalities can allow public authorities to reflect if and how AVs can be deployed. The second is that the policies and

regulations set by public authorities will influence the supply forms of AVs (use cases) and specific outcomes relevant to the accessibility of older people. The literature review demonstrated that there are key gaps in understanding the expectations and responses of UK transport authorities.

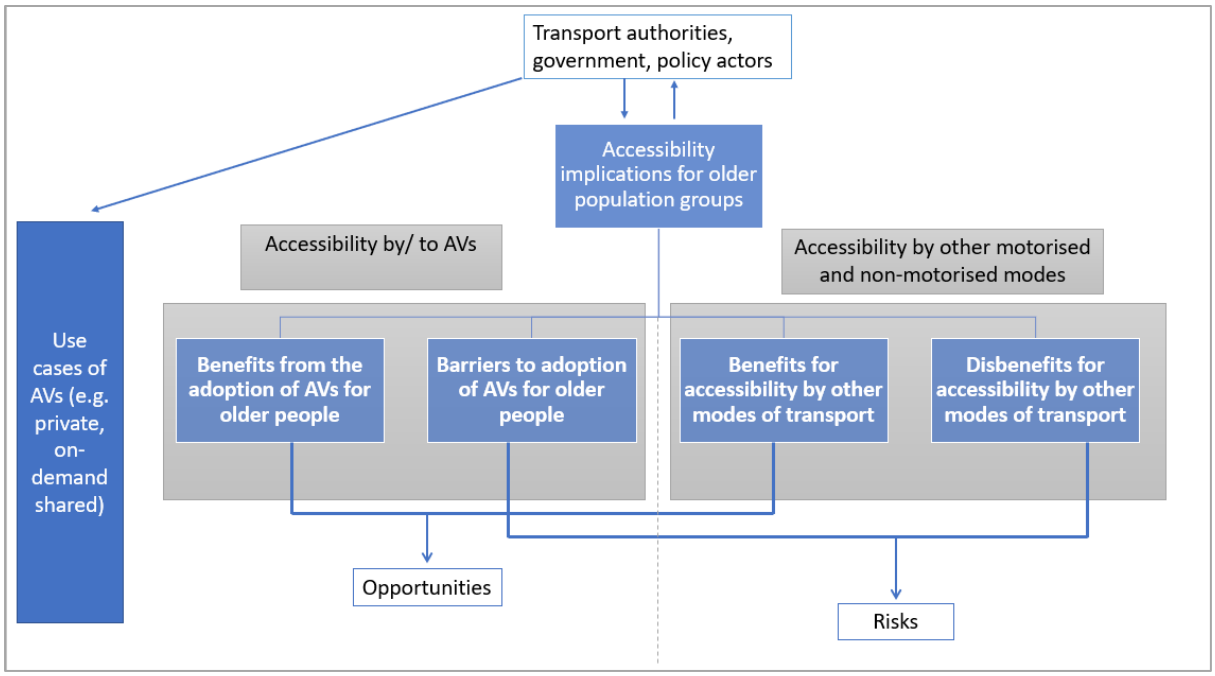

Figure 3.2: Conceptual framework of AV policy influence and outcomes for older people's accessibility

Through my literature review, I also identified gaps in our current understanding of how the UK older population perceives AVs and, particularly, different use cases of AVs. There are gaps in how older people imagine AVs would impact on their mobility and accessibility. The willingness to use AVs could relate to the perceptions of the accessibility benefits of older individuals and the barriers they would face in a transition to automation. Another key gap in our understanding relates to preferences and needs of different automated transport services. Although AVs are discussed as different uses cases (i.e. private modes, automated taxis, shuttles), there is limited research on how older people perceive different use cases.

4. Methodology

4.1. Introduction

In this chapter, I describe the methodology of the research, including the methods, the data collection, and analytical processes that I followed. I refer to the practicalities of data gathering and discuss how I addressed the ethical issues of the research.

My research draws from Realism, and specifically the critical realist philosophical stance (Robson and McCartan, 2016). The critical realist perspective in future studies posits that the role of social science is to enable socially desirable futures (Patomäki, 2015). These are understood as a subset of real future possibilities, while our empirical observations are only a subset of actualised futures (ibid). From this understanding, the empirical research does not aim to predict the future accessibility conditions of older people in a transition to AVs. The data in this research illustrate possibilities for the accessibility of older people, by providing knowledge about relevant mechanisms (i.e. AV policy dynamics and citizens' perceptions). The realist philosophical underpinnings also entail the selection of methods that are best suited to the problem and research questions at hand (Robson and McCartan, 2016).

I used a flexible research design (Robson and McCartan, 2016), combining a qualitative case study of the AV governance and policy context in the UK, and specifically, England, and an interview study involving older citizens in Greater Manchester. Case studies are appropriate methodological approaches to explore contemporary, real-world phenomena in-depth (Yin, 2018). The data collected and used consist of policy documents and semi-structured interviews with a) key transport professionals and, b) citizens aged over 55 years. Figure 4.1 provides an overview of how the data sources and methods were linked to the five overarching questions.

Before getting to a detailed description of the research methods, it is worth reflecting on why I chose to use qualitative research methods. Qualitative inquiry is concerned with a contextual and deep understanding of a phenomenon (Robson and McCartan, 2016). It is less hypothesis-driven, in the sense that it allows the researcher to explore unexpected themes and challenge/develop hypotheses. Objectivity is not a concern, per se. On the contrary, the values and positionality of the researcher are recognised as integral elements of the research process (ibid). Furthermore, it is usually small-scale and requires non-probability but systematic sampling approaches (Ritchie and Lewis, 2003).

The policy document analysis and interviews with transport professionals allowed to explore not only expectations and viewpoints of stakeholders but also underlying factors and consequences (for

instance, how their current experience with AV studies have affected these opinions). Moreover, a qualitative method of data collection was considered as the most appropriate approach to explore older people's perceptions to understand how they may impact on their accessibility levels. Qualitative research would produce detailed descriptions from participants' narratives that would enable a better understanding of the under-explored issue. Qualitative inquiry offers the opportunity to discover and search more in detail unexpected themes that might not be found through a fixed format of questioning.

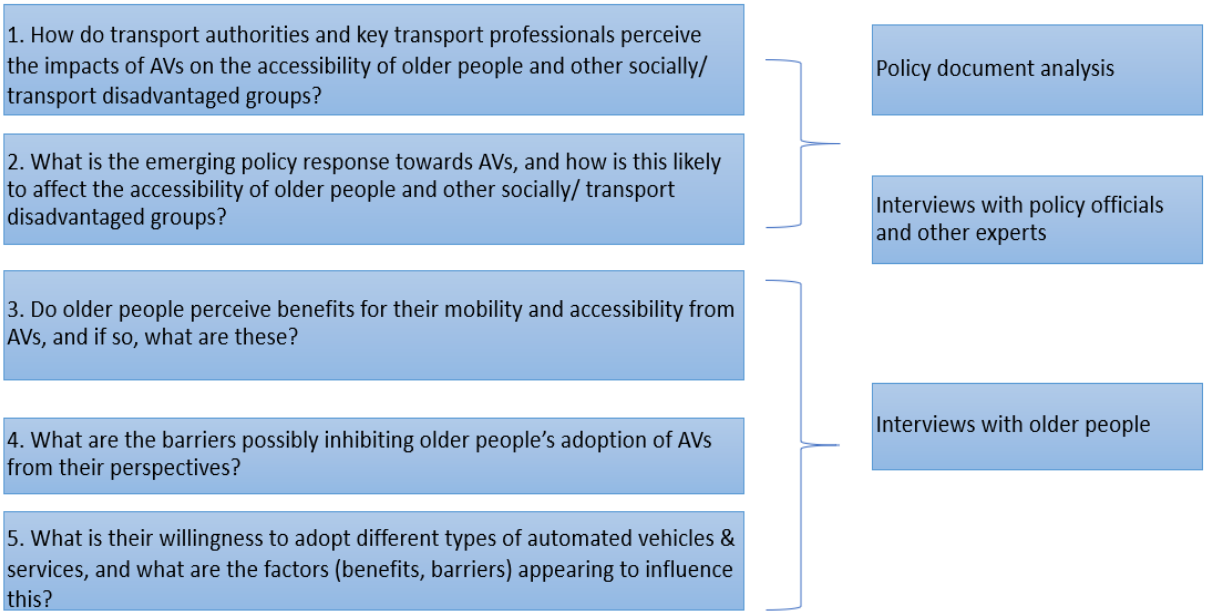

Figure 4.1: Research questions/ Methodology diagram

4.2. *Document analysis*

The decisions around my research methods to explore the first two research questions involved the identification of the study population and sample (i.e. organisations, individuals and secondary material) as well as the data gathering and analytical processes.

The study population here refers to UK transport government bodies, including the individuals and secondary material that can provide information about the opinions and actions of these organisations. In addition, other transport experts and professionals with an interest in AVs or the future of transport and accessibility inequalities are part of the study population. This is, first, because they are likely to play a role in decisions made by public authorities. For instance, non-profit organisations, campaign groups and other research organisations are likely to participate in consultations for AVs. Similarly, transport planners working in the private sector offer consultancy

services analysing their impacts on people and places. Hence, they will also influence how AVs shape future spaces, behaviours and inequalities.

Although the sampling approach could be described as influenced by the multi-level governance approach (Marsden et al., 2014), the thesis does not explore the jurisdictions and relationships among the different territorial levels. For this exploratory research, the aim was to study perceptions and actions of the most relevant stakeholders, without engaging with questions of how different actors interact with each other.

The first stage of my data analysis involved document analysis, using in total 26 strategy and supporting planning documents from 12 government bodies, representing different government levels, from national to local authorities across England. Gaps in our knowledge about how government bodies beyond central government perceive AVs and their implications for society led to this sampling approach. The sampling approach of the government bodies and documents was purposive and done based on criteria, as I discuss in the following section.

Document analysis refers to the systematic analysis of the text in various types of documents (e.g. books, diaries, newspapers, institutional papers). Although it can be a stand-alone method to generate data, it is frequently used in combination with other qualitative or quantitative research methods to supplement or corroborate data (Bowen, 2009). In this case, I used it as the primary step of data generation and as supplementary data to the interviews. Hence, it provided the initial data to understand the extent to which AVs are a concern to transport authorities at the time being. In conjunction with the literature review, it allowed for the development of the interview guide.

Strategy documents have been used by transport researchers to provide evidence about how transport government bodies consider equity in transportation plans (Lee, R.J. et al., 2016; Manaugh et al., 2015) or plan for automated vehicles (Guerra, 2015; Freemark et al., 2019) and other transport innovations (Pangbourne et al., 2020). Transport government bodies publish transport strategy and supporting documents, such as individual transport mode or equality assessment documents. These documents set the vision for future transport and often outline specific plans. Strategy documents are often written to inform the public and undergo public consultation. For all these reasons, they were considered a valuable data source to begin exploring the questions around the governance of AVs and the accessibility of older population groups. I also used supporting documents that make references to AVs and outline the evidence-base of future visions and plans.

4.2.1. Sampling approach – the government bodies

The first decision that needed to be made was about the sample; which government bodies should be included and which policy documents?

Sampling and selection are necessitated within the qualitative research regime, first, due to practical reasons (Mason, J., 2002). A document analysis with transport strategy documents from all transport government bodies in the UK would require developing a full list of authorities from national to the local level, all relevant strategy and background documents and qualitative analysis of all these textual datasets. Qualitative inquiry is concerned with depth, as we seek nuance and complexity. Therefore, the focus is justified, yet through strategic sampling and selection processes (Mason, J., 2002). I chose a non-probability sampling approach, as commonly applied in qualitative inquiry. The sample would not be statistically representative but needed to have these characteristics that would make it pertinent to answer the research questions (Ritchie and Lewis, 2003). The sampling approach selected was purposive, and specifically criterion-based (ibid); I selected the sample units because they have some characteristics that make them particularly pertinent to the research questions.

The U.K has complex systems of governance, with the situation getting further perplexed the last years due to the development and involvement of more institutions with different interests and focus in specific modes at the sub-national level (e.g. Transport for the North, Local Enterprise Partnerships between local authorities and businesses) (Government Office for Science, 2019). There are different types of local authorities, e.g. county councils, district councils, unitary authorities, London Boroughs, Metropolitan Districts and then Greater London Authority with its Mayor's strategy delivery agency, Transport for London, and the recently formed nine Combined Authorities (Marsden and Docherty, 2019). The latter have received additional powers and funding from Central Government and aim to integrate transport with other policy areas. They are local government institutions that were created after the Local Democracy, Economic Development and Construction Act 2009 (*Local Democracy, Economic Development and Construction Act 2009*, 2009)

The intention was to capture the 'leading' governmental actors in AV development in England. From the beginning, I restricted the qualitative study to England. As mentioned above the transport governance structures are rather complex and disparate across the UK. The fact that I was based in Leeds meant that I had more opportunities to get information and access to organisations and people in this geographical area. Besides these reasons, the first local authorities to take part in AV-related projects were all from the south of England.

The central government and particularly, the DfT was, firstly, part of the sample. The DfT has created the Centre for Connected and Autonomous Vehicles (CCAV) to support the market for CAVs. It has facilitated the development of CAV technologies through investments in various projects undertaken by mixed consortia (academia, industry, government bodies) (CCAV, 2018). The DfT has published a code of practice for automated vehicle trialling. The UK Law Commission is also in the process of developing a regulatory framework for the safe deployment of AVs including their use as part of public transport networks and on-demand passenger services (Law Commission, 2019). AVs are also part of the Industrial Strategy which announced that *'The government wants to see fully self-driving cars, without a human operator, on UK roads by 2021.'* (HM Government, 2017, p. 49). In addition to DfT, the sample included Highway England as the government company with a responsibility to maintain and improve the strategic road network of England. Highways England has been part of AV projects - consortia, such as Midlands Future Mobility – a real-world testing environment (Midlands Future Mobility, 2019).

The criteria for inclusion of sub-national (regional, local) transport government bodies were a) having published (from 2016 and onwards) strategies with well-articulated visions and policies for the next 15 to 20 years, b) authorities with significant powers in transport policy delivery, c) the inclusion of AVs within this strategy, and d) more importantly, having participated in studies on AVs. In addition, access to the authorities and interviewees played a role in the development of the final sample. Although the sampling process was flexible with some degree of interplay between the sampling and data collection, the criteria remained pertinent throughout the whole research process.

In the initial search for government bodies, combined authorities were considered more likely to have staff and financial resources to think about the implications of future transport technology. A similar sampling approach was taken by Guerra (2015), who investigated the planning processes for self-driving vehicles in the U.S. context. Guerra (2015) did a document analysis focused on metropolitan areas because they are more likely, first, to plan with a long-term horizon, and second, to have adequate resources to incorporate them in their strategic planning.

Table 4.1 illustrates the scan of combined authorities as it took place initially in September 2017 and as it was updated in March and November 2019. The initial scan of transport strategy documents that took place in September 2017 included a scoping of the documents, looking at features such as the time frame of coverage, the existence of background analysis and references on automated vehicles (even different levels). The light pink colour in the table symbolises authorities which were found to satisfy certain criteria for the selection process (i.e. recently published strategy, references to AVs). The light blue colour shows which combined authorities (including TfL) were included in the final sample. For the final selection of authorities, I took into consideration these criteria in addition to

Table 4.1: Sampling of combined authorities as an interactive process of policy document analysis

Combined Authority and Greater London Authority	Relevant transport organisation	Initial scan of documents (September 2017)				Scan for new/ additional documents in March 2019	Scan for new/ additional documents in November 2019	(Known) Participation in pilots and studies (as in November 2019)
		Published transport strategy (from 2016 and onwards)	Timeframe	Supplementary documents	References on AVs			
Greater London	Transport for London (TfL)	Yes (published in 2017, with detailed policies and projects)	2041	Yes	Yes	Yes - New (post-consultation) strategy document was included	Yes – CAV-related documents	Yes
Greater Manchester Combined Authority (GMCA)	Transport for Greater Manchester (TfGM)	Yes (published in 2017, with detailed policies and projects)	2040	Yes	Yes	Updated/Supplementary documents added	No	Yes
West Midlands Combined Authority (WMCA)	Transport for West Midlands (TfWM)	Yes (published in 2016, less detailed policies and projects)	Mentions 20 years (2036)	Yes	Yes	Supplementary documents added	Supplementary documents added	Yes
Cambridgeshire and Peterborough Combined Authority	Cambridgeshire and Peterborough Combined Authority	No (Interim Local Transport Plan)	N/A	N/A	N/A	No	A detailed strategy has been published, there are references on AVs	Yes, the city councils appear to have participated.
Liverpool City Region	Merseytravel	No (last one published in 2015)	N/A	N/A	N/A	No	No	No
Sheffield City Region Combined Authority	Sheffield City Region Combined Authority	No	N/A	N/A	N/A	No	A detailed strategy has been published, there are references on AVs	No

Combined Authority and Greater London Authority	Relevant transport organisation	Initial scan of documents (September 2017)				Scan for new/ additional documents in March 2019	Scan for new/ additional documents in November 2019	(Known) Participation in pilots and studies (as in November 2019)
		Published transport strategy (from 2016 and onwards)	Timeframe	Supplementary documents	References on AVs			
Tees Valley Combined Authority	Tees Valley Combined Authority	No	N/A	N/A	N/A	A detailed strategy, under consultation	No	No
West Yorkshire Combined Authority (WYCA)	West Yorkshire Combined Authority	Yes (published in 2017, with detailed policies and projects)	2040	Yes	Yes	No	No	No
North East Combined Authority (NECA)	NEXUS	No (transport manifesto - vision published in 2016)	N/A	N/A	N/A	N/A	No	No
North of Tyne Combined Authority (founded in 2018, previously part of NECA)	NEXUS	N/A	N/A	N/A	N/A	No	No	No
West of England Combined Authority	West of England Combined Authority	No (a Joint Transport Study was published in 2017 informing the forthcoming plan)	N/A	N/A	N/A	New document was included (under consultation)	No	Two constituent city councils have participated.

opportunities to gain access to interviewees from relevant authorities. Based on these criteria in September 2017, the policy document analysis began with Transport for London (TfL), Transport for Greater Manchester (TfGM) and Transport for West Midlands (TfWM). In November 2019, the strategy of West of England Combined Authority (WECA) was also included in the sample.

I also included county (Oxfordshire County Council) and city councils (Bristol City Council, Coventry City Council, Milton Keynes City Council) that had taken part in AV-related trials and projects. I sought relevant information through published documents from DfT (CCAV, 2018), key informants (e.g. individuals from the Government Office for Science). Their strategies might not be equally detailed, but, as seen from the interviews' findings, interviewees from these authorities could share valuable insights from their experience with the pilots. Finally, I included a sub-national transport body, Transport for the North (TfN), as its documents also appeared to consider the implications of AVs to an extent. TfN's role in planning for local connectivity may be limited (Marsden and Docherty, 2019), but policies to influence AV development in the strategic road network across the North could influence the adoption and accessibility within the region.

Information about potential interviewees and granted access also shaped the final sample of transport government bodies. For instance, it was not possible to identify individuals from the Cambridgeshire and Peterborough (see table 4.1), and as such, the authority was not part of the final sample. In the case of TfL, access was not granted when sought through key informants and gatekeepers; however, the documentary material of TfL was quite rich to be excluded from the sample. Similarly, although informants helped identify potential interviewees from Highways England, there was no further response to the request. Nevertheless, the authority has been part of various consortia and CAV projects, and its strategic documents included several references to AVs.

4.2.2. Sampling approach – the strategy and policy documents

The selection of strategy and supporting documents to be analysed was not straightforward in all cases and required a critical sampling approach similar to what was previously discussed. In addition, it involved an iterative process throughout the research; from the sample to the documents and the opposite direction as well as updating and adding documents to the final sample. For instance, table 4.1 illustrates the three phases of sampling and document analysis for combined authorities. In all cases, the websites of the transport organisations were consulted across the research process, checking for new documents with long-term planning vision and references on AVs.

The central government and Department for Transport (DfT)

The recent activity of the UK government with CAVs appears to begin in 2013-2014 (DfT, 2015b). In 2014 the UK government initiated a 'driverless vehicles competition' for UK cities to formulate partnerships with businesses and other key leaders and host trials of CAVs. In the same year (2015), the DfT created a new policy team, the Centre for Connected and Autonomous Vehicles (CCAV) to facilitate the networking among academia, industry and government and support the market development of CAVs (CCAV, unknown). The activities of CCAV have focused on developing regulations that allow for safe testing and operation of CAVs on public roads, research and development initiatives and developing suitable testing infrastructures.

The UK has reviewed the regulatory frameworks of various other countries, e.g. USA, Germany, Sweden, for AV testing (DfT, 2015b). It has also published a non-statutory code of practice for AV trials (DfT, 2015a), which was updated recently (CCAV, 2019). The code provides non-statutory guidance for any organisations that wish to undertake trials of AVs on public roads or places. It sets requirements for complying with traffic laws, safety and insurance standards and recommendations about engaging with transport authorities and the public. The central government has also carried out legislation amendments in the area of liabilities in case of an accident (HM Government, 2018a) and developed principles for cyber-security (HM Government, 2018b).

Additionally, since 2018 the Law Commission of England and Wales and the Scottish Law Commission have been carrying out a series of consultations with the aim to develop the legal framework for AVs (Law Commission, 2017). The project is ongoing with plans for the development of recommendations for the regulatory framework in 2021. The first programme of consultation focused on safety, civil and criminal liability and the adaptation of road rules. The second programme of consultation focused on AVs as public transport, defined as Highly Automated Road Passenger Services (HARPS) (Law Commission, 2019). It touches upon issues of accessibility, disabled and older people and certain impacts of AVs on other transport modes.

For the purposes of this research, the abovementioned documents were not analysed, as their content fell outside the scope of the thesis (e.g. dealing with safety of trials, liability or cyber-security) or they present a synthesis of consultation responses.

In terms of vision and strategy development, the most recent document from the central government (DfT) is the '*Future Mobility: Urban Strategy'* which was published in 2019. The document, also, draws from the '*Industrial Strategy'*, which is highly supportive of AV demonstration and development. The Industrial Strategy mentions AVs as key part of the automotive sector deal, a new programme of partnership between the automotive industry and the government. I have also included in the sample

and analysed the *'The Inclusive Transport Strategy: Achieving Equal Access for Disabled People'*, published in 2018. The document refers mainly to disabled but also older people and engages with the topic of the future of transport.

Other authorities

Highways England

Highways England referred to AVs in the Road Investment Strategy for 2015 - 2020 published in 2015. This strategy document and supporting material were not included on the grounds that the newest strategy has been included. However, two more recent long-term planning documents with references on AVs were sought from the website and included in the sample.

Transport for the North (TfN)

TfN produced its strategy 'Strategic Transport Plan' in 2019. Prior to the delivery of the final strategy document, the drafts and policies/plans they included were assessed in terms of sustainability and equality. The outcomes of this assessment are described in the *'Integrated Sustainability Appraisal Report'* produced by the private consultancy firm Atkins on behalf of TfN.

Transport for London (TfL)

TfL produced its draft transport strategy that went through consultation processes, an integrated impact assessment. It was also supported by evidence base reports. A scoping of the evidence base and integrated impact assessment documents did not identify (significant) AV-related material. Therefore, the main strategy document was only included in the sample. In addition to this, TfL published last July two important for this analysis documents, a *'Connected & Autonomous vehicles statement'* and a *'Connected & Autonomous vehicles - guidance for London trials'*.

Transport for Greater Manchester (TfGM)

A similar process was evidenced in TfGM's website for the development of its 2040 transport strategy. The *'Greater Manchester Transport Strategy 2040'* was adopted in 2018 after a consultation process and an evidence base report published in 2017, which was updated in 2018. The updated evidence-base was included in the sample of documents as it included AV-related sections. Beyond these two documents, the second in order, '*Draft Delivery Plan for the period 2020 to 2025'* was added in 2019 and used for the document analysis. The 2020-2025 Draft Delivery Plan has been informed by evidence base studies to support the development of *'Greater Manchester Spatial Framework'*. The *'Greater Manchester Spatial Framework Transport Study. Addressing the Issues'* published by the private consultancy firm Mott MacDonald on behalf of TfGM discusses potential transport network, social and policy implications of AVs. Therefore, it has also been analysed.

Transport for West Midlands (TfWM)

TfWM adopted its *'Movement for Growth. The West Midlands Strategic Transport Plan'* possibly in 2016, with a vision for the next 20 years. The plan outlines the vision for the transport system of the future; it is a quite high-level document with limited details about specific plans and policies. It is supplemented by a *'Movement for Growth: 2026 Delivery Plan for Transport'*. In addition, a document named *'Connected & Autonomous vehicles are the future - the West Midlands is leading the way'*, possibly dated in 2018, sets the vision for CAV development in the region and as such has been analysed here.

Oxfordshire County Council

Although Oxfordshire County Council adopted its local transport plan (LTP) in 2015, which is earlier than the other cases examined here, it was the first in England local authority known to mention AVs – as also reported by the relevant interviewees. The *'Connecting Oxfordshire: Local Transport Plan 2015-2031 Volume 1: Policy & Overall Strategy'* was later supplemented by a 'Science Transit Strategy' in 2016 which aimed explore new technologies and data innovation for intelligent mobility. The *'Service and Community Impact Assessment'* document of the LTP was not found to include any references on AVs and as such has not been analysed.

Milton Keynes City Council

The *'Milton Keynes Mobility Strategy 2018-2036'* was adopted in 2018, based on an evidence base report used in this analysis as well as an equality and environmental impact assessment (no references on AVs found in the latter). A *'Transport Infrastructure Delivery Plan (TIDP)'* has also been published to describe the development and delivery of transport infrastructure required for Milton Keynes over next 15 years. This in addition to its evidence-base report produced by the private consultancy firm WSP have been used for the policy document analysis.

Coventry City Council

The city council integrated transport plans in its wider *'Local Plan'* published in 2016. Given the very high-level aim and scope of this documents and the limited number of references to AVs it is was not incorporated in the sample of documents.

Bristol City Council

The Bristol City Council strategy was adopted in 2019. In the website a public consultation which took place in 2018 is mentioned. Other supplementary documents were not identified.

West of England Combined Authority

In the beginning of 2019, the North Somerset Council, the West of England Combined Authority and its constituent authorities (Bath & North East Somerset Council, Bristol City Council and South Gloucestershire Council) published the *'Draft Local Transport Plan 4. 2019 – 2036'*. The plan went through a public consultation, and the final, adopted plan was published in March 2020. I have analysed the adopted *'Joint Local Transport Plan 4 2020-2036'*. Moreover, I used the *'West of England Joint Transport Study. Final Report'* which includes several references on AVs and informed the plan.

Table 4.2: Final sample of documents gathered and analysed

Number	ID of document	Authority	Document title and Reference	Time
1	HM 1	HM Government	Industrial Strategy. Building a Britain fit for the future (HM Government, 2017)	2017
2	DfT 1	Department for Transport	The Inclusive Transport Strategy: Achieving Equal Access for Disabled People (DfT, 2018b)	2018
3	DfT 2	Department for Transport	Future of Mobility. Urban Strategy (DfT, 2019a)	2019
4	TfN1	Transport for the North (Atkins)	Strategic Transport Plan. Integrated Sustainability Appraisal Report (Atkins, 2018)	2018
5	TfN2	Transport for the North	Strategic Transport Plan (TfN, 2019)	2019
6	HE 1	Highways England	Strategic Road Network Initial Report (Highways England, 2017b)	2017
7	HE 2	Highways England	Connecting the Country Planning for the long term (Highways England, 2017a)	2017
8	TfGM 1	Transport for Greater Manchester	GM Transport Strategy 2040. A sustainable urban mobility plan for the future (TfGM, 2017)	2017
9	TfGM 2	Transport for Greater Manchester	GM Transport Strategy 2040. Evidence Base 2018 Update (TfGM, 2018)	2018
10	TfGM 3	Transport for Greater Manchester	GM Transport Strategy 2040. Draft Delivery Plan (2020-2025) (TfGM, 2019)	2019
11	TfGM 4	Transport for Greater Manchester	Greater Manchester Spatial Framework Transport Study Addressing the Issues (Mott Macdonald, 2018)	2018
12	TfL 1	Transport for London	Mayor's Transport Strategy (TfL, 2018)	2018
13	TfL 2	Transport for London	Connected & Autonomous vehicles statement (TfL, 2019a)	2019
14	TfL 3	Transport for London	Connected & Autonomous vehicles - guidance for London trials (TfL, 2019b)	2019

15	TfWM 1	Transport for West Midlands	Movement for Growth: The West Midlands Strategic Transport Plan (TfWM, no date)	No date
16	TfWM 2	Transport for West Midlands	Movement for Growth: 2026 Delivery Plan for Transport (TfWM, 2017)	2017
17	TfWM 3	Transport for West Midlands	Connected & Autonomous vehicles are the future - the West Midlands is leading the way (TfWM, 2018)	2018
18	OCC 1	Oxfordshire County Council	Local Transport Plan 2015-2031. Volume 1: Policy & Overall Strategy (Oxfordshire County Council, 2015)	2015
19	OCC 2	Oxfordshire County Council	Science Transit Strategy (Oxfordshire County Council, 2016)	2016
20	BCC 1	Bristol City Council	Bristol Transport Strategy (Bristol City Council, 2019)	2019
21	MKC 1	Milton Keynes Council	Mobility Strategy for Milton Keynes 2018 - 2036 LTP4 (Milton Keynes Council, 2018a)	2018
22	MKC 2	Milton Keynes Council	Mobility Strategy for Milton Keynes 2018 - 2036. Detailed context and evidence base (Milton Keynes Council, 2018b)	2018
23	MKC 3	Milton Keynes Council	Mobility Strategy for Milton Keynes 2018 - 2036. Transport Infrastructure Delivery Plan (Milton Keynes Council, 2018c)	2018
24	MKC 4	Milton Keynes Council (WSP)	Infrastructure Plan. Stage 1 Evidence Review (WSP, 2019)	2019
25	WECA 1	West of England Combined Authority (Atkins)	West of England Joint Transport Study. Final Report (Atkins, 2017)	2017
26	WECA 2	West of England Combined Authority	Joint Local Transport Plan 4 2020-2036 (Travelwest, 2020)	2020

4.2.3. Coding and content analysis of documents

The analytical approaches used for all data sources were similar. I analysed the textual data of policy documents and interviews using the qualitative content analysis method (Hsieh and Shannon, 2005). I imported all textual data in a computer-assisted qualitative data analysis software (CAQDAS), NVivo12. The software was beneficial for the data management and analysis process. CAQDAS reduces the time required for the coding and sorting of qualitative data, by allowing researchers to organise effectively, inspect and edit their coding frameworks at any time. Although the software cannot do the analytical work of the researcher, it reduces the time and effort required for the analytical process comparing to manual analysis, if used appropriately. Functions such as searchers and queries of coded excerpts enabled me to make comparisons between different transport authorities or individuals, identify patterns and interpret the data.

I discussed issues related to the coding structure with my supervisors, showing to them how I had coded excerpts of the textual data. I also shared parts of transcripts after an initial coding with a colleague from the University of Leeds who had a qualitative research background. The advice sought from this meeting was not directly related to the definitions of codes. The colleague's advice helped me become more systematic and rigorous in my data analysis, after pointing to me issues related to loose definitions of codes and repetitions in the coding structure.

In the case of policy documents, I followed both a deductive and inductive approach of category and sub-category formation (Elo and Kyngas, 2008; Mayring, 2000). The method allows understanding the phenomenon under study by organising large amounts of texts into a manageable number of categories that share similar meanings (Hsieh and Shannon, 2005). In this way, it allows us to understand the patterns in the data. The analytical method shares many common characteristics with thematic analysis which purports to develop themes drawn from the data and follows similar steps in the analysis. Qualitative content analysis is often associated with more quantitative analytical techniques than thematic analysis (Braun and Clarke, 2006). In reality, the frequency of codes or categories can be used in conjunction with qualitative styles of analysis. Here, I used quantitative content analysis for an initial exploration of the data (for instance, which impacts are mentioned more frequently, are these risks or opportunities?).

The first step of data analysis was familiarisation with the texts, which had begun through the document selection process. I checked the structure of the documents for paragraphs entitled with relevant themes and used additional text search commands in NVivo using the words 'automation', 'automated', 'driverless', 'self-driving', 'innovation(s)', 'automation'. I read along these paragraphs or

chapters to recognise and register all relevant material (whole pages or paragraphs). This step also helped develop some initial categories (as described below). I kept some notes of preliminary insights, themes that seemed particularly relevant or interesting, some ideas around different approaches among the authorities. Following that, I also decided that a suitable unit of analysis would be from one sentence to a few short paragraphs, observing the patterns in topic changes across the texts.

Commonly the next step of the analysis involves the development of the coding frame (Schreier, 2014). I analysed the documents using deductive and inductive qualitative content analysis (Hsieh and Shannon, 2005). The deductive content analysis allowed me to explore if and how the transport authorities think about the accessibility implications of AVs for older people. Although the focus of the thesis is on older people, given the heterogeneity in older people's mobility and accessibility patterns, I also consider references on other socially and/or transport disadvantaged groups. I specifically look into lower-income and disabled people which can be transport disadvantaged sub-groups within the older population. In addition, as a whole, these population groups are expected to experience substantial changes in their accessibility as a result of automation (Milakis and van Wee, 2020).

The codes and categories of accessibility implications for older people are informed by the literature review. I specifically sought to understand if the documents mention benefits from the adoption of AVs, barriers to adoption of AVs, benefits and disbenefits for accessibility by other modes of transport for older people. The following cross-cutting categories of implications were also useful to compare the content of documents with the outputs of the literature review:

a) Ability to access transport;
b) Willingness to use AVs;
c) Affordability of AVs;
d) Availability of non-private transport across places;
e) Road safety;
f) Built environment, land-use development and ability to walk and cycle.

Therefore, the more deductive approach of analysis allows us to compare the policy discourse with the outputs of the literature review. The inductive approach is useful to capture the broader viewpoints of policy actors surrounding AVs. Moreover, an inductive approach with open coding was useful to allow categories of policy responses to emerge from the textual data. Inductive approaches in qualitative data analysis are appropriate when knowledge about a research phenomenon is limited (Hsieh and Shannon, 2005). Despite the use of open coding techniques to explore policy responses, the background literature informs both the categorisation and critique of these responses from the perspective of older people's accessibility.

The inductive process involved, first, open coding of impacts discussed across the documents and, second, grouping these coded data into broader higher categories. The grouping of the data, certainly, involves interpreting the content of the codes to see how groups can be formulated (Elo and Kyngas, 2008). I used an iterative process to develop and apply the categories and codes across all documents examined, as described in Hsieh and Shannon (2005).

For the second question, I followed a data-driven approach. Nevertheless, my open coding case and initial category formation were influenced by what I knew from the literature review, about the role of the public sector in smart mobility transitions (Docherty et al., 2018), or about specific policy instruments to ensure accessibility inequalities are not worsened as a result of AVs (Cohen and Cavoli, 2018; Papa and Ferreira, 2018). I did open coding across the documents and some iterations to organise the data across categories. As the analysis was progressing, I checked the content fitted under each code and the grouping of codes, to ensure that I used the same coding criteria throughout the process.

4.3. Semi-structured interviews with transport professionals

The second method used was semi-structured interviews, also called responsive, qualitative, or in-depth interviews or conversations with a purpose (Robson and McCartan, 2016; Rubin and Rubin, 2005; Mason, J., 2002). I interviewed fifteen individuals who represented twelve different organisations (public authorities that also belonged to the sample of policy document analysis, public/private organisations (Zenzic) and non-governmental organisations (RAC Foundation, Sustrans, Living Streets). The sample was purposive – I selected my interviewees due to their expertise and relevance for the topic. I chose to stop interviewing more individuals after I noted repetition in what I had heard from others, and I was confident enough that I had interviewed individuals with diverse opinions and experiences about the topic. Moreover, practical issues played a role, the difficulty of getting access to more interviewees, the limited number of people who have had experience on the topic, and a consideration of the time I would need to transcribe, analyse and interpret the findings.

This method was chosen to understand the beliefs and actions of policy officials from the transport government bodies and other transport experts. Interviews allow the development of situational and contextual knowledge by asking interviewees questions relevant to their specific knowledge, expertise and experience with the research topic. There are many ways to structure the interviews, but qualitative interviews are characterised by high flexibility (Robson and McCartan, 2016). In this research, they offered the opportunity to ask the same main questions to all interviewees, while

allowing the exploration of specific or unexpected themes according to the interviewees' background, role and experience with the research topic. This means that the questions asked to interviewees are not identical in their wording and underlying theme, but they still focused on the interest of this research. The non-static structure of interviews is a valuable characteristic of the method that ensured rich and contextual insights were shared with the interviewer by the interviewees. However, interviews can present challenges, especially for unexperienced qualitative researchers (Mason, J., 2002). To prepare for my interviews, I sought advice from colleagues and had unofficial discussions with transport experts on the topic. These allowed me both to improve my listening skills and think about my ability to handle emotional aspects of the conversation (e.g. disagreement, sense of insecurity about talking to experts) and learn more about the topic.

4.3.1. Selection of interviewees and conducting the interviews

Table 4.3 shows the full list of interview participants with their codes and the interview method (in person, phone, Skype). I do not link individuals to their specific roles to protect the anonymity of the interviewees. The consent signed and agreed with the interviewee from the DfT made explicit that the specific unit would not be mentioned. The sample includes individuals from Innovation and Future Mobility, policy and strategy teams within regional and local authorities. Interviewees included Innovation officers or project managers, planners, policy and research officers, and analysts. All of the organisations and individuals interviewed were either closely involved in AV-related research and development projects or discussions around the policy implications of AVs. The sample is balanced in terms of transport technology expertise and transport planning, policy development, particularly in the field of accessibility, with some interviewees having experience in both domains.

Table 4.3: The list of participants – transport professionals

Code	Organisation	How was the interview conducted?
1, DfT	Department for Transport	In-person
2, Zenzic	Zenzic	Phone
3, TfGM	Transport for Greater Manchester	In-person
4, TfGM		In-person
5, TfGM		In-person
6, TfWM	Transport for West Midlands	In-person
7, OCC	Oxfordshire County Council	In-person
8, OCC		In-person
9, MKC	Milton Keynes Council	In-person
10, CCC	Coventry City Council	Phone
11, BCC	Bristol City Council	In-person
12, Living Streets	Living Streets (own opinions, not necessarily organisation's)	Phone
13, RACF	RAC Foundation	In-person
14, Sustrans	Sustrans	Skype
15, TfN	Transport for the North	In-person

The participants were identified either through publicly available documents from the organisations' websites and public events, or through informants, specifically the supervision team and colleagues from the Institute for Transport Studies. Snowballing was used in one case (one interviewee suggesting one other potential interviewee respectively). In the majority of organisations, I interviewed one individual. In the course of the interview meeting, I asked interviewees to suggest others from the same organisation that could or should take part in the study. However, interviewees did not usually suggest or provide information about others from their organisations. This possibly relates to the fact that they were high-level staff in the organisations and had expertise on the topic. An exception was the case of interviewees from TfGM, but this can also be an issue of how this organisation works (e.g. how different teams collaborate). In other cases, the participation of one interviewee followed after a call for participation to a specific team (for instance, TfWM, Living Streets).

For TfL and Highways England, which I included in the sample of authorities for the policy document analysis, I sought interviewees through different 'gatekeepers'. In the case of TfL, three different informants gave information about policy officers from the strategy and innovation teams that could provide information. However, the only response was given from a high-level policy official from the

Innovation Team who declined access for the research because the topic is a matter of governmental inquiry. Key individuals from Highways England were similarly identified through informants and publicly available documents. Nevertheless, there was no response from their side. One policy officer from the Strategy and Planning Directorate responded but considered s/he would not be the most appropriate person to discuss and politely declined and pointed to the already identified individuals. Similar issues of non-response are mentioned by Legacy et al. (2018), who interviewed public sector planners in Australia to understand AV planning processes in this context. Legacy et al. (2018) achieved an interview pool of six participants "*public sector employees with an active role in developing AVs within their jurisdiction or on a national basis*." They similarly discuss at length refusals from top-level officials, but also potential interviewees who pointed out to others or official policy and planning documents.

Beyond the eleven participants from transport government bodies, I interviewed an employee of the organisation Zenzic. Zenzic is the continuation of former Meridian and it "*was created by government and industry to focus on key areas of UK capability in the global connected and self-driving sector*." As such, here the interviewee is considered to reflect both (central) government and industry perspectives (in addition to personal views which are difficult to separate from the professional identities). The role of Zenzic is to "accelerate the self-driving revolution by uniting industry, government and academia" (Zenzic, 2020)

In addition, I interviewed three other individuals as experts/stakeholders beyond government. I decided to include experts beyond the government sector to check the extent to which different organisations share the same views as those of professionals from government bodies. I recognise that their role may have some influence on AV planning and policies, since research organisations, private consultancy firms and campaign groups, deliver a range of activities to consult or influence the public sector. Based on my prior knowledge and discussion with key informants, I identified four different organisations. I contacted potential interviewees or teams. Experts from three of these organisations agreed to take part.

The first interviewee was from the Royal Automobile Club (RAC) Foundation, a transport policy and research organisation that explores the economic, mobility, safety and environmental issues relating to roads and their users. The interviewee confirmed that the RAC had commissioned research related to behavioural aspects of self-driving. The second interviewee was from Living Streets, a UK charity organisation that delivers projects and campaigns to improve the walking environment and public attitudes towards walking. The interviewee informed me that the organisation has participated in the public consultation for CAVs by the Law Commission. Finally, I also interviewed a member of the staff from Sustrans, a charity that aims to support active travel through research, projects and policy

consultation submissions was chosen. Sustrans responded to the UK Government's Future of Mobility call for evidence, mentioning AVs and some of its social and policy implications (Sustrans, 2018).

Doing the interviews required several email communications with informants and potential interviewees, travel arrangements that had to change in some cases in the last minute as the interviewees were busy. I contacted all interview participants through email. I gave them information about the research, and I explained why I had approached their organisations and them. I sent the information letter and the consent to them from the initial email. I also decided to send some indicative interview questions so that interviewees would be more comfortable with the situation of the interview. I encouraged potential interviewees to suggest anytime for the interview to be carried out face to face. I also gave them the alternative option of phone or Skype interview. As table 4.3 shows, three of the interviews were conducted by telephone and one by Skype. The rest of them were conducted face to face in the cities where interviewees were based.

4.3.2. Interview design

The first two interviews were conducted in order to refine the research questions and were used as a training opportunity. In these, I asked policy officials for various innovations' accessibility equity impacts. The interview was a conversation about the future of mobility and particularly, transport innovations covering from AVs to mobility-as-a-service etc. and how these will impact the accessibility levels of different social groups. These interviews made me reflect on the breadth of my research and interview questions. Following these, I had to revise these aspects in order to ensure that the research is feasible and contributes to existing knowledge. I developed a new interview protocol based on this experience. These two pilot interviews, though, yielded some rich data and therefore parts of them were also analysed.

The interview structure followed the logic of what Rubin and Rubin (2005) call 'tree and branch'. The research problem is divided in parts, each of them explored through a main question. The Appendix A shows the list of main questions. The questions stem from the conceptual framework and the research questions and aimed to capture both opinions and experiences with AV experimentation.

The interviews were developed to last up to an hour. This was necessary as the participants were typically high-level officials, with significant time constraints. Although I had sent the information sheet and consent form prior to the interview dates, I also spent some time in the beginning of the interviews to discuss any issues or concerns. Following the granted consent, the audio recording and note-taking would start. The first questions were what Robson and McCartan (2016) call 'warm-up'

asking interviews about their background and current positions within the organisations. The main body of the interview begun with asking about interviewees' perceptions around the benefits and threats of AVs to get a first idea of how they think about the topic. The second part included questions for the government bodies that have already participated in studies to understand the scope, the motivations and the outcomes of these. The third part was organised under the question of 'How may automated vehicles (AVs) impact on inequalities in accessibility among different social groups?'.

It is important to mention that I chose to ask interviewees questions about the accessibility implications for older people and other groups; specifically, disabled and low-income groups. Income and disability can be disadvantages affecting the accessibility of older people. These questions allowed me to get deeper insights into how interviewees think about future transport inequalities. They also gave me the opportunity to understand how they think about older people´s accessibility – which barriers (e.g. health, income) they perceive as critical for their ability to access key services and opportunities.

Finally, the fourth part discussed the policy responses. The sequence allowed me to maintain the discussion within the focus of the study. In the end of the interview, I checked if these themes have been well covered or if some of them required more questions to be asked. Nevertheless, the structure – sequence - could change during the course of the interview. For instance, some of the participants would mention accessibility inequalities from the first main question or others began discussing at length their involvement in studies by asking about their roles in the authority.

4.3.3. Audio recording, note taking and transcription

The empirical data organisation and analysis process began with the audio recording and note-taking. The audio recording was essential to make sure that the data represented the conversations with interviewees. The audio quality was good because almost all interviews took place in private offices or other spaces. In one case that the interview took place in a coffee shop, there was background noise that led to minor losses but not to a significant extent. Notes were also useful to account for these losses.

I kept notes of all conversations, first, to be able to cross-check the information in case there were issues with the recorder. It was also a useful technique to make sure that the conversation does not go outside the scope of my research questions. At the end of the interview, I would take a look at these notes to see if I had covered all major questions with the interviewees. I also used the notes as an easy way to familiarise myself with the data before the stage of transcription. Following every

interview, I would listen to the recording, read and add to these notes. Given time constraints and lack of equipment while I was travelling during the fieldwork period, I was usually able to transcribe the interviews only days or weeks after they took place. By taking notes and listening to the audio recordings, I could get to know my data better and prepare myself for the analysis. As a novice researcher, I also had the chance to observe myself as an interviewee and improve my interviewing technique. I could reflect on the questions I asked or did not ask and about the sequence of the interview.

Transcription was a beneficial analytical process as I became even more aware of my data. In this way, I felt that when I was able to start the analysis, I had a better idea about some primary codes, and I could remember if more than one interviewee had mentioned something. However, it was also a time-consuming task. I observed that my ratio was between 1:6 to 1:8 (one minute of audio to six or eight minutes of transcription). This was partly related to the fact that I am not a native English speaker, and I wanted to make sure that I have made an accurate transcription.

In the case of interviews with transport professionals, I transcribed the texts fully (word-to-word). In some cases, I had arranged with the interviewees to return the transcript to make sure they feel it represents the conversation. In one case, the interviewee made changes to account for grammar mistakes and make the conversation sound less informal, without, though, changing the content of it.

4.3.4. Coding and content analysis of interviews with transport professionals

For the analysis of these fifteen interviews, I followed a similar approach to the content analysis of documents. The categories followed the structure of the research questions. Therefore, the first category included codes and sub-categories that related to the accessibility implications of AVs, either discussed as directly related to older people or beyond this group (disabled and low-income groups). I used the initial conceptual framework and the findings from the previous stage of the policy document analysis to develop an initial structure.

For the second research question, I followed an inductive coding process. However, I also used a deductive approach to link potential interventions as mentioned by interviewees with certain accessibility benefits and barriers to older people (for instance, I searched whether interviewees mentioned policy interventions to ensure that AVs are affordable to be purchased or used by lower-income groups).

The analytical process was iterative. During the analytical process, I regularly checked the content labelled under each code to validate or change the coding structure. After analysing six of the 'richest'

transcripts, I returned to check the categories, the sub-categories developed, and decide if some codes should be broken down to illustrate nuance in the data. I continued the analysis and added to the coding framework when it was necessary until all transcripts had been analysed.

4.4. Exploring the perceptions of people aged over 55 years concerning AVs

The data gathering process to explore older people's perceptions and attitudes around AVs was designed in direct relation to the gaps in knowledge and key issues with AV use for older people identified in the prior literature review. I conducted twenty-four semi-structured interviews with individuals aged from 55 years and over who resided or worked in different areas of Greater Manchester. I stopped interviewing after I had noted a level of repetition of key themes and I had interviewed individuals of different age groups, as age was the main criterion of sampling.

A qualitative method of data collection was considered as the most appropriate approach to explore older people's perceptions to understand how they may impact on their accessibility levels. Qualitative research would produce detailed descriptions from participants' narratives that would enable a better understanding of the under-explored issue. Qualitative inquiry offers the opportunity to discover and search more in detail unexpected themes that might not be found through a fixed format of questioning.

I chose to use qualitative interviews instead of focus groups, as individual responses were required due to the questions sought to be answered (for instance, current travel behaviour and experiences, socio-demographic details). In addition, given that the influence of travel behaviour and socio-demographic factors on perceptions of AVs and likely accessibility impacts has not been studied in-depth, a decision to develop a focus groups study would come with many challenges in creating groups with robust criteria.

Prior to carrying out this interview study, I undertook a research placement at the Centre for Ageing Better (Leeds partnership) and the Leeds City Council. The placement was outside the context of this research and explored whether and how a proposed door-to-door transport service would meet the mobility needs of Southern Leeds older citizens. This experience helped me, first, to make valuable connections with organisations that work on ageing within the Greater Manchester area, where I undertook this study. Second, I had the opportunity to engage with older citizens in the context of a face-to-face questionnaire study. Given that I am outside this age group and of a different nationality, this experience was useful to reflect on my own biases about how I perceive this group. It allowed me

to better understand the diversity of this age group. This was particularly critical as the interview sample for this research belonged to different age cohorts, as described in the next section.

4.4.1. Sampling and recruitment of participants

The target population for this study was individuals over 55 years, with caution taken to include individuals that belong to younger old and older old age groups (over 75 years). The older population is very diverse in terms of mobility and levels of social participation (Luiu et al., 2017). Defining a group of 'older people' who might be most affected by the introduction of AV technologies is not straightforward (Shergold et al., 2016). Typically, the term older population embraces people over the age of sixty or sixty-five with a further distinction between 'younger old' and 'older old' population groups, with the age threshold dividing the two groups when unmet travel needs are considered being at seventy-five (Luiu et al., 2017; Shergold, 2019b).

Individuals under the age of 65 cannot be placed under the older age group category and are usually characterised as middle-aged. I selected an age threshold of 55 because individuals of this age could be over sixty-five when level 4 or level 5 are on the roads. The Foresight Report on the Future of Mobility reviewed the related evidence and suggests that level 4 AVs will be emerging from 2030 when level 5 will be still a niche development. The same report suggests that level 5 AVs will become widespread by 2040 (yet, as the review has discussed according to some counterarguments, level 5 AVs, as commonly defined by SAE International (2018) may never be developed or deployed). Care was taken, though, to avoid a sample geared to younger older people who might be more mobile (Holley-Moore and Creighton, 2015). Health problems that impact on older people's ability to walk, use public transport or drive, increase with age (Hjorthol, 2012). Poor health condition has been associated with a reduction of older individuals' modal choices (Ryan et al., 2019). Physiological decline and health issues are also significant causes of driving cessation (Musselwhite and Shergold, 2013; Haustein and Siren, 2014).

The literature review showed that mobility and accessibility are affected not only by age and health but also access to a car and driving ability, the built environment, the gender, the income, the marital status and living arrangements (Luiu et al., 2017). Given that the study was exploratory with a qualitative design, it would not be possible to develop a sampling approach that captures all these factors that are likely to play a role in the research question. The aim of the study was not to compare the views of different sub-groups per se. Rather, it was to ensure that the group is as diverse as

possible to identify themes which cut across all cases and themes that may be specific to individuals with particular characteristics and experiences.

For the purposes of the study priority was given in achieving heterogeneity in terms of age and holding a driving license and then gender. Holding a driving license is a key factor that influences mobility and accessibility barriers, as the literature review showed. Additionally, although few studies have included drivers and non-drivers in their samples, one study has found differences with respect to attitudes towards AVs – with those without a driving license being more interested to use and purchase and AV (fully self-driving) (Lee, C. et al., 2017). It is not certain though if this would apply in the UK context and for a group of older people who may have already reduced their driving horizons and distances.

Gender was included in the sampling criteria because women are found as more likely to be sceptical about the impacts of AVs compared to men (Acheampong and Cugurullo, 2019). Males appear keener on the prospect of using AVs in some studies (Kyriakidis et al., 2015; Payre et al., 2014; Ipsos MORI, 2014) and perceive them as less risky (Hulse et al., 2018). However, there is contradictory evidence for the gender effect on older age groups (women over 70 stating more willingness to use AVs).

Table 4.4 shows how the sample achieved differed in these characteristics. In total 24 interviews were carried out, with the majority being women and drivers. Given that participants were self-selected, it is likely that drivers showed more interest in the study and willingness to volunteer. The sample was also quite diverse in terms of income and walking capabilities. Although I did not collect data about the urban/rural classification of the area of residence, I asked participants to state the town of residence. The majority of participants resides in towns that are characterised as mainly urban (with some rural parts), although in the periphery of Manchester.

Table 4.4: Sample characteristics, interview study with citizens in Greater Manchester

	Women		Men	
Age	Drivers	Non-drivers	Drivers	Non-drivers
55-64	-	2	2	1
65-74	6	3	4	-
75 and over	3	-	2	1

The participants were sought and recruited in Greater Manchester area. In order to decide about where to carry out the study and how to recruit participants, I consulted informants from the Centre for Ageing Better, which recommended the Greater Manchester area because Greater Manchester Combined Authority (GMCA) – was perceived as quite active on ageing policy within transport. Greater

Manchester is the UK's first age-friendly city-region (Greater Manchester Combined Authority, 2018). The GMCA has issued an 'Age-Friendly Strategy' that includes various strands of work to improve social inclusion of older population, recognising its heterogeneity (ibid). From my discussions with key informants, I understood that there is good engagement between the combined authority, not-for-profit organisations that provide activities to older people and networks of older citizens. As such, the selection of Greater Manchester as a case would allow me to identify organisations, networks and activities to recruit participants from. In practice, recruitment eventually took place through various networks.

First, the call for participation was distributed through my personal network to employees in a Greater Manchester company. Second, civil servants from the Manchester City Council and Greater Manchester Authority that work on age-friendly policy issues, helped promote the call for participation through a post on their e-bulletins (Greater Manchester Ageing Hub and Age-Friendly Manchester). Through these calls, I was contacted by one individual who was interested to participate herself and by a person who acted as a gatekeeper for participants from a not-for-profit organisation that organises various community activities and volunteering schemes for older people across towns of the north-eastern part of Greater Manchester (e.g. Rochdale, Middleton). In this case, the gatekeeper forwarded the poster and information letter to individuals that might be interested and organised the meetings for the interviews in the organisation's offices.

The key informants also brought me in touch with other two organisations (a charity organisation and a network of members aged over fifty) from which participants were approached and recruited. In the first case, the gatekeepers from the charity forwarded the poster and information letter to individuals that might be interested. They also organised the meetings for the interviews in the organisation's offices in a suburban town in the south of Manchester (Wythenshawe). In the second case, the gatekeepers allowed me to attend a meeting of older people to give them the information letter and my contact details. They also helped me to set up the meetings and provided the space.

The majority of interview meetings was carried out in public spaces that belonged to the abovementioned organisations. Only two of the meetings took place in coffee places. The recruitment led to 24 volunteers - participants, with 23 of them living in Greater Manchester towns (a mixture of towns characterized as predominately urban, but some described as suburban by participants) and one of them working at Manchester and living in rural Derbyshire.

4.4.2. Interview design

The interviews were structured to last up to one hour. At the beginning of the interviews, I reiterated the purpose of my research and what the interview would include. I gave and explained to them the content of the consent form. I explained in a lay language how their anonymity and confidentiality would be protected. Since many individuals had been recruited through gatekeepers, I explained to them the risk to be identified by individuals who are aware of their participation, despite the protocols being kept. The participants were informed that their participation was voluntary, and they had every right to withdraw from the interview at any time or refuse to answer specific questions. No participant expressed a wish to withdraw, however questions around income were left unanswered by some participants.

I referred to AVs as driverless vehicles both in the information letter and during the interview meetings, as this was considered a more straightforward and easier to communicate term comparing to AVs. Others (e.g. McCool, 2019) have also advised in favour of using the term driverless or self-driving in public communication of AV technology (if the intention is to refer to Level 4/5 automated vehicles, which is the focus of this thesis). Driverless vehicles were defined as vehicles, cars, buses and taxis that will not need a driver at all. The information letter mentioned, "*This means that when and if they are developed, it will be possible to be used by people who do not have a driving license and people who cannot drive for any reason, either because of ill health or any sort of physical and other disabilities*." This was to explain the purpose of the research. Given that participants might not have heard anything about the innovation, I considered necessary to provide some further background information to stimulate their thinking. For this reason, I showed photos/images of driverless vehicles to them and gave them some background information. This material was not associated with specific scenarios of driverless vehicles (although two photos/images portray a vehicle that resembles a car and one photo shows a mini-bus).

First, I mentioned that driverless vehicles are not available yet to be purchased or to operate on public roads and it is uncertain when they will be, but many trials are going on in the UK and abroad. Second, I mentioned both common arguments in favour of them (safety, use by people who cannot drive) and counterarguments (technical failures). The level of information that I should provide to participants to avoid bias but enable a discussion on a future technology was a challenge, particularly because participants in many cases posed questions to me to understand how the technology will work or where these vehicles will be able to go. In order to make sure I am not 'pushing' participants towards any direction, I aimed to be neutral in my responses, emphasising it is a technology currently being developed with uncertainty around its technical and other aspects.

The interview protocol and the photos used during the interviews are presented in Appendix B. I developed an interview guide that began with questions around current mobility and accessibility and driving experience for the drivers. The questions were used to understand the particular characteristics of the individuals and the extent to which they influence their attitudes towards using AVs or their perceptions about how these will impact on their accessibility (e.g. as pedestrians).

Following that, I asked them about their current level of knowledge about driverless vehicles and their opinions about them (benefits, concerns). Subsequently, I used techniques of abstraction following the approaches of questioning found in (Musselwhite, 2017a; Musselwhite, 2019). Abstraction is defined as the questioning technique that takes the participant out of their current practice "*to ask them what would happen if their world was different*" (Musselwhite, 2017a). It includes two styles of questioning, counterfactual detail, for instance, to ask participants what would change if they were older and future scenario testing (ibid). In my design, I used primarily future scenario testing, trying to elicit different data from the participants.

Before discussing the specific scenarios, I asked participants to *"[…] think that these [driverless vehicles] are safe to use in these scenarios both for the persons inside the vehicles as well as for the pedestrians, cyclists and users of other vehicles. The price of the service would be similar to what you pay today for these options – if not, I will suggest a different cost.".* The first scenario (figure 4.2) was targeted to drivers only, aiming to elicit their experiences and attitudes towards the task of driving (aspects of enjoyment and sense of control). The second scenario asked about their perceptions and intentions to use driverless buses. The third scenario aimed to elicit their views and experiences of new and future types of taxis and shared services (app-based). In the fourth scenario, I asked participants about a hypothetical driverless neighbourhood car club, without suggesting the use of smartphones or applications. This again aimed to understand perceptions, willingness to use and underlying factors concerning a type of shared mobility service. The fifth scenario focused on driverless private cars, perceptions, willingness to use and own. Figure 4.2 shows the text used in the first scenarios (shown only to drivers). The texts used to describe scenarios of different driverless vehicles and services are presented in figure 4.3.

If you had the option to choose between these two what would you prefer?

1. Driverless cars. You wouldn't need to manually drive – a wheel and driving system wouldn't exist, you would just need to step in and choose your destination. While you were in the vehicle you could do other activities.

2. Driverless cars that allow you to manually drive. The vehicle would mostly be able to drive on its own. While doing so, you could do other activities inside the vehicle. However, the car would have a steering wheel and you could choose to drive it.

Figure 4.2: Scenario (driverless car with or without steering wheel)

Scenario A: Imagine that there were *driverless buses* operating in your area. These would be buses that you could get on and off just as you do today from a bus stop but they would not be driven by a driver.

Scenario B: Imagine that there were *driverless taxi services* that you could book through an application in a smartphone. They would be operated by a taxi company that would set up the rides. It would come and pick you up and it would leave you wherever you wanted it to.

There would also be the option to share the ride with someone else that has booked a journey from and to nearby places. If you shared the ride, it would be quite cheaper.

Would you be interested in sharing a driverless taxi?

Scenario C: Imagine that there were *driverless neighbourhood car clubs.* These would be driverless cars that you could rent out for a short period, for instance some hours when you needed to go do a specific activity. You would not have to buy them and own them, you would just be able to use them once in a while. There would be a parking spot in your neighbourhood with these driverless cars where you could access them and then you would command them to take you to your destination.

Scenario D: Imagine that there were *driverless cars* available in the market to buy and cars driving themselves on the roads. You could access them, command them to take you where you need and then allow them to be parked or command them to return to a parking spot close to your house. Think that the price was similar to that of a good brand-new car.

Figure 4. 3: Scenarios of different driverless vehicles and services

The final scenario testing involved the comparison between two alternative transport futures; the aim was to explore how participants compare a future where driverless private cars are available to own and a future that the technology is not available, but there are options to ensure good levels of mobility and accessibility. This scenario task was used, first, as an opportunity for participants to discuss in an open manner any issues they may experience with the transport system and to allow them to imagine alternative transport futures, beyond car-based solutions. Second, the intention was

to capture their attitudes towards driverless vehicles and triangulate the data elicited throughout the earlier stages of the interviews. The text used is presented in figure 4.4.

In this last task I will give you two options for your transport experience sometime in the future and you can tell me which one you prefer and why. Please think what option would suit more your needs in your later life, which can be similar or quite different from your current needs.

Which of the two would you be happier if they were a reality? And why is that?

Option A

In this transport future cars are much fewer; everything is designed to make walking, cycling and using the buses and trains easier for us. The buses and trains are more frequent and usually have lines that take you where you need and stops nearby your house. Walking is more enjoyable because the sidewalks are in a good condition, there is not much traffic around and the crossing time in the traffic light gives priority to the pedestrians. If you have difficulties to move around there are options to call some taxi or minibus services and pick you up to take you where you need.

Option B

In this transport future the situation for walking, cycling and public transport is not much different to what you experience now around you. However, driverless vehicles are available and on the roads. You can either hire or buy one to move around at a cost similar to what someone pays today for these options. They have been designed to be suitable for people that may have various issues with their health and they are quite easy to use. There are driverless car lanes – just as the bus lanes today - and therefore people that use them do not get stuck in the traffic.

Figure 4.4: Alternative transport futures scenario

4.4.3. Audio recording, note taking and transcription

The audio quality of these interviews was good because they took place in quite spaces. I kept notes of all conversations to be able to cross-check the information in case there were issues with the recorder.

For the interviews with the members of the public, I chose a more flexible approach in the transcription comparing to that with transport professionals. In occasions where the interviewee discussed issues remotely related to the topic, a summary and some quotes would be used. For instance, one interviewee discussed at length the sense of losing independence when you begin experiencing difficulties with driving or walking to bus stops. Although it was an important mobility experience, it was outside the scope of the study to transcribe all actual words.

4.4.4. Coding and content analysis of interviews with members of the public

For the interview transcripts of older citizens, I organised and structured the coding framework two times. First, I interpreted the data in relation to the different stages they were produced. As mentioned in section 4.4.2., the interview design included different scenarios about the use of different automated transport services. The development of categories, in this case, reflected not only the nature of the qualitative data but also the context in which they were discussed. In particular, I chose to code under different categories of data that were found in the context of scenarios of automated vehicles and services comparing to data found in the initial part of the interview. The primary reason for that is that the scenarios described particular services and some issues discussed could relate only to these. Coding the data in this way helped illustrate better factors that are influencing opinions for specific automated use cases.

Some of the initial categories were:

- Perceptions of AVs. This category included sub-categories, such as concerns, perceived benefits, perception of how they will work or be implemented. Many codes under these are similar to those belonging to category 2.
- Willingness to adopt driverless cars and other transport services: The sub-categories and codes under these describe textual data in which the participant specifies willingness to use a driverless use case. This category reflects responses to the scenarios A to D (e.g. driverless buses).
- Factors affecting willingness to adopt driverless cars and other transport services. This category is linked to category 2.
- Comparison between semi-driverless and fully driverless vehicle (scenario 1). This textual data refers to scenario 1 in which participants were asked to choose between a semi-driverless and a fully driverless vehicle.
- Alternative transport futures (final scenario exercise). The sub-categories here reflect the choice between the two scenarios chosen (A or B or uncertain), and the criteria based on which these choices were made.

This first analytical approach and coding structure helped summarise data while displaying them within the context in which they were produced. However, 'breaking down' the data in this way is problematic when aiming to identify themes and categories related to the research questions. Therefore, the data were further organised under overarching themes of critical importance to understand the accessibility implications for older people. In this case, the categories and codes were

structured around the main research questions; e.g. mobility and accessibility benefits, barriers to adoption.

During the analytical process, I regularly checked the content labelled under each code to validate or change the coding structure. After analysing eight transcripts, I returned to check the categories, the sub-categories developed, and decide if some codes should be broken down to illustrate nuance in the data. The analytical process was repetitive, even though the structure of the coding framework remained fairly stable after around 16 interviews. This was also evaluated throughout the analytical process as an indication of achieving data saturation to a satisfying extent (Mason, M., 2010).

4.5. Ethical considerations

Ethical considerations are of critical importance for any academic research. After demonstrating how I would meet the ethical standards of the University of Leeds, I was granted permission to carry out the research. The information letters and consent forms that were given to and signed by the interviewees are presented in Appendices A and B.

A key ethical consideration of this study was the anonymity of interviewees. I discussed at length with interviewees (professionals and members of the public) about the processes of anonymisation. I explained to them the risk of being identified by others when the material is published, either because of the position they hold or because others (e.g. gatekeepers) were aware of their involvement in the study. As mentioned in the previous sections, at the beginning of all interview meetings, I would take some time to make sure that participants had read and understood the information letter and signed the consent form. Consent for participation and data use was obtained by all interviewees. In two occasions, participants made some notes in the consent that they gave. In the first instance, the interviewee from DfT asked for the specific unit/group to not be disclosed. In the second instance, the interviewee from Living Streets asked that the opinions expressed are interpreted as own and not necessarily as official views of the organisation. Other interviewees did not discuss any further ethical issues. All interviews were audio-recorded from the beginning to the end. In one occasion, a transport professional asked to pause the recording to share some insights off-the-record. I paused the audio recording, and I chose not to record the information for any research purposes.

I stored all digital records in line with the ethical review protocols, in the servers of the University of Leeds, the one drive system and only in encrypted folders in my personal computer.

5. Findings from the document analysis

5.1. Introduction

In this chapter, I present the findings of the document analysis. As discussed in the previous chapter, I used this secondary data analysis method to explore two research questions.

The research questions explored through the document analysis are:

1. How do transport authorities perceive the impacts of AVs on the accessibility of older population groups and other socially or transport disadvantaged groups?
2. What is the emerging response of the transport authorities towards AVs, and how is this likely to affect the mobility and accessibility of older people and other socially or transport disadvantaged groups?

In the next section, I present an overview of the main findings (section 5.2). Following that, I discuss how the documents address inequalities, the accessibility implications for older people, disabled people and lower-income groups (section 5.3). I further examine how the documents portray broader impacts of AVs that are likely to affect the accessibility of older people in a transition to automation (sections 5.4 to 5.6). In section 5.7, I illustrate the emerging policy responses of transport authorities. I conclude the chapter by critically discussing what these findings suggest for older people's accessibility barriers and opportunities in a transition to automation.

5.2. Overview of findings

All planning documents examined, discuss the implementation of AVs within their strategies' timeframes as a highly likely future scenario. The specific level of automation that is likely to be reached is not examined in detail. Overall, the key public bodies in AV planning for England appear to be more inclined towards optimism with respect to how AVs will affect their areas of responsibility. Notwithstanding that, the majority of authorities have chosen to communicate both opportunities and risks (or limitations) of AVs. Exceptions to this are the central government's positions as expressed through the Department for Business, Energy & Industrial Strategy and the document HM1, the documents examined by Transport for West Midlands (TfWM) and Oxfordshire County Council (OCC).

The central government published the Industrial Strategy (HM1) following the 2016 Referendum and the decision of the UK to leave the European Union. In this political and economic climate, the strategy refers to the critical industries for the UK economy and areas of technological development that will allow the country to gain global financial leadership. The future of mobility, including AVs, is one of the four *'Grand Challenges'*. The latter are areas of technological development that are of strategic priority for the future economy. The Department for Business, Energy & Industrial Strategy defines AVs as an opportunity for the UK economy and productivity, without though scrutinising their wider impacts. The Department for Transport's (DfT) position examined through its more recent strategy documents, appears as slightly different. AVs are again portrayed as an opportunity for the UK society, but there is more emphasis on unintended consequences that need to be carefully managed. In the sub-regional authority levels, TfWM appears as the most technologically optimistic authority compared to all other sub-regional and local authorities. Similarly, OCC refers only to opportunities, although in these documents references to AVs are quite limited. The next chapter (chapter 6) provides deeper insights into the positions of these authorities, through interviews with local authority officials.

The documents of West of England (WECA), Transport for London (TfL), Department for Transport (DfT) and Milton Keynes Council (MKC), include more references to risks compared to the other authorities. Transport for Greater Manchester (TfGM) appears to refer more frequently to the uncertainty of the overall impact (positive or negative) of AVs for Greater Manchester comparing to the other authorities.

The analysis of anticipated benefits of AVs from the public sector shows a strong focus on road safety benefits, reduced private car ownership and use, improved mobility for older people, integration among modes and improved door-to-door mobility, and traffic congestion. Beyond these, economic benefits, benefits for sustainability and the built environment are envisaged in the policy documents. As far as risks or limitations of AVs are concerned, the most important unintended consequences relate to increased travel demand and congestion. Discouraging active travel and public transport use is another related theme of unintended consequences frequently found across the documents.

As analysed in the next sections, the only social groups brought up in the documents are older and disabled people. The DfT and the regional and local authorities appear to have begun considering various accessibility effects of AVs, although these analyses are not systematic at this stage and within these documents. In the case of older people, for instance, there are omissions in terms of considering the affordability of services or the acceptance of new mobility services and technologies. Most transport authorities appear to recognise the need to explore the implications of AVs and shape their

development. Nevertheless, only a few of them have developed some high-level policy goals to guide the implementation of AV policies and regulations in the future. Finally, although several authorities refer to research and development initiatives, the documents avoid referring to specific policy instruments to manage the social and distributional consequences of AVs.

Table 5.1 shows which documents include textual excerpts that are coded under the categories of various AV impacts related to older people's accessibility (according to the conceptual framework as developed in chapter 3). When documents include coded excerpts that refer only to positive or negative effects, they are placed under the category 'positive' or 'negative' respectively. Documents that mention both opportunities and risks (e.g. benefits and barriers to adoption for older people), they are placed under the category 'uncertain or both positive and negative'. The category of 'principles' refers to documents that include policy goals for new mobility innovations related to these impacts. The documents that do not refer to these relevant impacts are portrayed in the last column of table 5.1. The table clearly illustrates that the majority of documents do not mention relevant impacts.

Table 5.1: Summary of impacts reported and categorisation of documents

Impact	**The document mentions the impact as:**				**The document does not mention the impact:**
	Positive	**Negative**	**Uncertain or both positive and negative**	**Principle**	
Mobility, accessibility of older people	HM1, HE1, HE2, MKC4, TfL1, WECA1	-	DfT1, DfT2	DfT2, TfL1	BCC1, MKC1, MKC2, MKC3, OCC1, OCC2, TfGM1, TfGM2, TfGM3, TfGM4, TfL2, TfL3, TfN1, TfN2, TfWM1, TfWM2, TfWM3, WECA2
Mobility, accessibility of disabled people	HE1, MKC3, MKC4, TfN1, WECA1, TfL1	-	DfT1, DfT2	DfT2, TfL1	BCC1, HE2, HM1, MKC1, MKC2, OCC1, OCC2, TfGM1, TfGM2, TfGM3, TfGM4, TfL2, TfL3, TfN2, TfWM1, TfWM2, TfWM3, WECA2
Cost and affordability	DfT2, MKC1, MKC2	MKC4	-	-	BCC1, DfT1, HE1, HE2, HM1, MKC3, OCC1, OCC2, TfGM1, TfGM2, TfGM3, TfGM4, TfL1, TfL2, TfL3, TfN1, TfN2, TfWM1, TfWM2, TfWM3, WECA1, WECA2

Impact	The document mentions the impact as:				The document does not mention the impact:
	Positive	**Negative**	**Uncertain or both positive and negative**	**Principle**	
Integration among public/shared transport modes and availability of public/shared transport	DfT2, HE2, MKC1, MKC2, TfGM2, TfGM4, TfN2, TfWM3	MKC4, WECA2	-	DfT2, TfL1	BCC1, DfT1, HE1, HM1, MKC3, OCC1, OCC2, TfGM1, TfGM4, TfL2, TfL3, TfN1, TfWM1, TfWM2, WECA1
Motorised travel demand	MKC3, OCC2, TfWM3	DfT2, TfGM1	BCC1, HE2, MKC2, MKC4, TfL1, TfL2, WECA1, WECA2	TfL1	DfT1, HE1, HM1, MKC1, OCC1, TfGM2, TfGM3, TfGM4, TfL3, TfN1, TfN2, TfWM1, TfWM2
Impact on active travel and public transport	-	MKC3, TfL1, TfL2, TfN2, WECA1, WECA2	-	DfT2, TfL1	BCC1, DfT1, HE1, HE2, HM1, MKC1, MKC2, MKC4, OCC1, OCC2, TfGM1, TfGM2, TfGM3, TfGM4, TfL3, TfN2, TfWM1, TfWM2, TfWM3
Built environment (freed-up space, space for walking and cycling)	BCC1, MKC2, MKC4, OCC2, TfL2, TfGM2, WECA1	-	-	TfL1	DfT1, HE1, HE2, HM1, MKC1, MKC2, MKC3, OCC1, TfGM1, TfGM3, TfGM4, TfL3, TfN1, TfN2, TfWM1, TfWM2, TfWM3, WECA2
Land-use system (density)	OCC2	DfT2, HE2	-	-	BCC1, DfT1, HE1, HM1, MKC1, MKC2, MKC3, MKC4, OCC1, TfGM1, TfGM2, TfGM3, TfGM4, TfL1, TfL2, TfL3, TfN1, TfN2, TfWM1, TfWM2, TfWM3, WECA1, WECA2
Road safety	HE1, HE2, TfGM1, TfWM1, TfWM3, TfL1	TfGM2	DfT2, MKC2, MKC4, TfL2	DfT2, TfL1	BCC1, DfT1, HM1, MKC1, MKC3, OCC1, OCC2, TfGM3, TfGM4, TfL3, TfN1, TfN2, TfWM2, WECA1, WECA2

5.3. The accessibility implications for older, disabled people and lower-income groups

References to plausible equity implications (equity in mobility and access to opportunities across society) are limited across the documents. DfT refers to "*opportunities to address disparities in access to travel, tackle loneliness and achieve a more inclusive society*" (DfT2, p.41), although it discusses specific factors potentially inhibiting some groups from benefiting from a transition to automation. Other documents present disparate viewpoints around the impact of AVs on future mobility and

accessibility inequalities (for instance, HE and TfN make positive assumptions, while MKC mentions potential social exclusion outcomes due to the cost of private and on-demand AVs).

With respect to specific social groups, older and disabled people are the only groups brought up in some strategy documents. By contrast to what the literature review shows for the heterogeneity of older people's mobility needs and barriers (Haustein and Siren, 2015), the documents portray this population group as somewhat homogeneous. Although overall public bodies anticipate mobility benefits, there are concerns about factors that may hinder these groups from accessing smart mobility technologies.

In all the documents produced by/for the central government, AVs are proposed as a solution for the mobility barriers experienced by older population groups. The 'Industrial Strategy' which places a strong emphasis on national productivity growth, frames the ageing society as both a challenge and an opportunity for the economy. The strategy portrays AVs as one of the business opportunities that will make the UK a 'global leader' in the development of age-related technology (HM1, p. 51).

The other documents produced by DfT (DfT1, DfT2) also refer to older people and other groups that cannot currently drive, such as people with disabilities, as potential beneficiaries of AVs.

> *"A move to connected, automated and zero emission mobility […], if well managed […] It could make city centres greener and quieter, as well as increasing the convenience and affordability of travel, and widening access to mobility for disabled people and older people." (DfT2, p.41)*

However, the recent DfT strategy documents (DfT1, DfT2) recognise certain potential factors inhibiting the ability of older people to access AVs. The focus is mostly on barriers to future adoption posed by the design of AVs for individuals with mobility, sensory and cognitive impairments. The barriers mentioned include the lack of wheelchair and mobility scooter accessible vehicles, especially in on-demand shared AV services and interface design that does not meet the needs of people with sensory or cognitive disabilities. The strategies mention engagement with the relevant groups and industrial actors to create accessible vehicles and services. A review of the relevant regulations for the accessibility of vehicles and services will also assess the need for any changes in the future.

> *"Without active engagement and consideration of the needs of an ageing population or those with visible or non-visible disabilities, innovations risk accidentally 'designing out' sections of society who might benefit most. New mobility services and technologies should be accessible and inclusive by design, in line with our Inclusive Transport Strategy."* (*DfT2, p.41).*

The central government appears to emphasise some of the potential barriers related to the physiological and cognitive factors that can affect the adoption of some segments within the older population. In contrast, the documents do not mention the potential lack of willingness to use AVs or affordability of AVs. The only other barrier to AV adoption linked to older people is Internet and smartphone use. The DfT strategy proposes that the transport needs of individuals who do not have access to the Internet, a smartphone or bank accounts should be catered for in the future, even though that does not mean that automated services would not exclude people without these resources. Despite these gaps, governmental action to ensure that AVs are designed with inclusive design principles is important to avoid the technological exclusion of older people. A market-led approach in the development of automation and mobility services might not capture the needs of some groups, particularly if this means personalised vehicle design for a small group of people (Docherty et al., 2018).

Beyond the central government, four other government bodies included in the sample make references on older people's mobility in their policy documents (HE, TfL, WECA, MKC). Some of the references appear to perceive these benefits as certain, while others point to the need to steer the innovation towards this direction. These statements are very brief, though, without further analysis of unintended consequences for older people. The contradiction between increasing the opportunities for the mobility of older people and policy goals to reduce motorised travel demand are also evident in some discourses.

> *"Shaped in the right way, connected and autonomous vehicles can make travel easier for older and disabled people […]" (TfL1, p. 283)*

> *"CAVs could extend the benefits of car access to new groups of potential users, including older people, increasing the pressures caused by increased numbers of cars on the network." (WECA1, p.38)*

It is of note that potential barriers that may relate to a lack of acceptance from the perspective of older people are not considered within any of the documents. The lack of public acceptance is a concern for some transport authorities, but the documents do not mention potential differences in perceptions and acceptance of AVs across age and other socio-economic characteristics.

Affordability of AVs for lower-income groups is only briefly mentioned in an evidence review report from MKC. MKC makes some contradicting assumptions across its documents; from the prospect of the reduced cost of travel (MKC1, p. 3) to social exclusion as a result of the cost of access and ownership across its documents (MKC4, p. 80). It is not clear from the content of the documents if these contradictions stem from a genuine perception of uncertainty.

The DfT that discusses the issue of operational cost in more depth makes optimistic assumptions for the future.

> *"Lower running costs enabled by automation and the transition away from conventional fuels, along with a more competitive mobility market, offer the prospect of more affordable travel." (DfT2, p.26)*

Specific operational and business models that could bring about these benefits are not discussed further. An interesting use case considered by the DfT – from the perspective of older people that cannot access private cars or public transport, concerns driverless dial-a-ride services (DfT2, p.26). The document cites research showing that the deployment of driverless dial-a-ride services with an onboard steward can become cheaper than current services. If this innovation materialised, it could mean that these specialised services are more viable operationally for the public sector and provide a better service for some older population segments. Studies partly support the expectations of DfT for reduced operational cost and fares of buses and on-demand shared vehicles (Bösch et al., 2018; Wadud, 2017; Tirachini and Antoniou, 2020). Nevertheless, the passenger costs will also be influenced by other policies and market effects (e.g. if/how dynamic pricing structures are regulated, competition among modes) (Becker, H. et al., 2020). The DfT has not demonstrated in its documents how national and local policies could manage the cost of different transport services to ensure affordability.

This section demonstrated that some planning documents have acknowledged some of the potential accessibility implications for older and disabled people. These refer to benefits from the ability to access transport and some barriers to adoption (i.e. vehicle and user interface design, smartphone and Internet use, replacement of human assistance).

The documents do not acknowledge other plausible impacts of AVs on older people's accessibility as identified by the literature review. Specifically, the opportunities and risks for the availability of public/shared transport across places, road safety, and the impacts on the built environment, land-use development and ability to walk and cycle. Nevertheless, the strategy and planning documents acknowledge some of these potential impacts on their transport network, without linking them to the accessibility of older people and other social groups. The following sections (5.4 to 5.6) demonstrate how transport authorities perceive these impacts.

5.4. Availability of public/shared transport across places

The lack of reliable public transport provision is a critical accessibility barrier for the UK older population, particularly in areas outside city and town centres (Shergold and Parkhurst, 2012). The documents do not mention how older people would be influenced by the introduction of on-demand door-to-door services. However, they describe some plausible impacts on the availability of public/shared transport.

The transport authorities frequently refer to the potential for a transition away from private car ownership and greater availability of public and shared transport, capitalising on automation, MaaS and shared mobility. As table 5.1 illustrates, transport authorities appear to be quite optimistic about the increased availability and integration of non-private transport options. Only a few of the authorities discuss unintended consequences related to competition among new mobility services and conventional public transport and spatial equity outcomes (Curtis et al., 2019; Docherty et al., 2018).

The DfT has developed a principle for the deployment of any types of transport innovations which suggests that any new mobility services should play a complementary role towards mass transit, for instance by improving accessibility to transport hubs (DfT2, p. 43). The inclusion of this principle suggests that the central government recognises the potential competition of on-demand shared transport with conventional public transport services. Beyond this, though, the DfT does not examine in detail different supply forms of AVs (operational, business models) and how these could improve or reduce public transport provision across geographical areas. Given that some of these effects are already evident with ride-hailing (Shaheen et al., 2018; Marsden et al., 2019; DfT, 2018c), it could be argued that the principle could also point to some specific actions.

The regional and local authorities who refer to on-demand AVs, appear to be making mainly optimistic assumptions about the future of public/shared transport. These relate less with automation and more with the anticipation for a radical shift to shared mobility and multi-modality (UITP, 2017). Automated demand-responsive services are anticipated to facilitate better integration among transport modes. TfN, TfWM and MKC anticipate that these services will help them achieve better first-, last-mile connections to their transport hubs. Improved public transport offer in areas that are commonly poorly connected by public transport, such as rural areas, is another opportunity perceived by some authorities (TfN, TfGM).

> *"New demand responsive transport business models will be created, and link seamlessly to the public transport system to give the public a reliable, safe and value for money alternative to private car ownership." (TfWM3, p. 11)*

> *"This could include support for journeys on the strategic network, or for rural and last-mile connectivity where other options are not available." (TfN2, p. 82)*

Some of the regional and local authorities' documents bring up concerns about a mode shift from conventional public transport to on-demand AVs (TfL1, TfL2, TfN2, WECA2). This mode shift is framed more as an issue of sustainability than a threat to public transport provision in less profitable areas, such as urban peripheries (Curtis et al., 2019). The possibility for uneven development of automation among urban and other areas on the grounds of profitability is also a concern for the rural communities within WECA.

> *"We recognise the high cost of widespread implementation of new mobile technologies and will work with suppliers and other partners to help ensure that it does not only benefit areas or users where the highest level of financial return can be gained, and that rural areas, in particular, are not overlooked." (WECA2, p.31)*

5.5. The built environment, land-use development and the ability to walk and cycle

The policy documents have explored accessibility inequalities in the transition to AVs in relation to unequal levels of AV adoption across society. Therefore, older people are portrayed as users of the technology and their ability to access places by other modes is not further examined. Nevertheless, the impacts of AVs on the built environment and the land-use system are likely to influence the accessibility of older people by non-motorised transport (Kovacs et al., 2020). The impacts on traffic dominance, the built environment, and land use development will shape automobility dependence phenomena and the associated social exclusion of those who do not own or have access to an AV. The outcome of AVs for car dependence and the built environment is highly uncertain at this stage and dependent on many factors. For instance, the extent to which AVs are used in private or shared modes (either as shared cars or shared journeys) will affect density impacts, with private modes more likely to increase distances travelled and urban sprawling (Meyer et al., 2017; Duarte and Ratti, 2018).

The uncertainty and complexity around these effects, as evidenced in the literature review is also seen within these texts. Although expectations around a shift away from private car ownership and use are prevalent across documents, many transport authorities appear to be concerned about the prospect for increased motorised travel demand.

> *"The progressive move to mobility as a service could mean that more people are able to choose walking, cycling and public transport. It could also mean that fewer*

> *people own cars but more people are able to access cars for journeys, potentially increasing the number of vehicles on the road." (WECA1, p.17)*

The DfT 'Urban Strategy' document briefly refers to unintended consequences on the location of services. The concerns expressed relate to increased sprawling.

> *"Most studies into the impacts of private self-driving vehicles on people's location choices suggest that passengers will value the cost of travel less highly and be willing to commute over longer distances. The negative consequences of sprawled development patterns are well documented. For instance, they increase the costs of providing public services including public transport, which in turn exacerbates reliance on private vehicles." (DfT2, p. 36)*

Changes in the location of activities and how these may affect proximity and accessibility are not much discussed within the documents of regional and local authorities. Although there are some concerns about further urban sprawling (HE2, WECA2), most local authorities focus on improvements from the quality of urban built environments. The assumption stems from the belief that AVs would be used in shared models. In this way, they may require less parking space. The benefits perceived from this for the transport authorities are mainly that the freed-up space can be used for other development purposes or active travel, public transport infrastructure, and increased density (Alessandrini et al., 2015; Duarte and Ratti, 2018).

> *"On-street parking could be removed or reduced significantly and reallocated for public realm, cycling routes or public transport priority lanes." (WECA1, p. 38)*

> *"One of the impacts of this might be that ownership and use of private vehicles is very different to today, with greater focus on the use of public vehicles (be they mass transit, demand responsive or autonomous) and therefore less demand for parking in city and town centres, and at innovation and business parks. This would create an opportunity for using land currently taken up by parking for more productive and valuable use, thereby increasing density, with positive impacts on the commerciality of transit services, and land values, creating additional revenue for re-investment in Science Transit." (OCC2, p. 39).*

It is of note that relevant studies also refer to negative impacts on the development of the urban environment. AVs could also exacerbate conditions for pedestrians and cyclists due to the increased number of pick-up/drop-off areas (Zhang and Wang, 2020) and platoons of vehicles driving close to each other (Fraedrich et al., 2018).

5.6. Impact on road safety

The impacts of AVs on road safety are frequently discussed within the documents, although not linked to mobility and accessibility patterns. Moreover, there are very few references about how AVs will affect the road safety of different road users (e.g. pedestrians, cyclists). From the perspective of older people's accessibility, safety may affect their acceptance to use AVs (Nielsen and Haustein, 2018), and their accessibility by non-motorised modes of transport (Kovacs et al., 2020).

The texts focus on the anticipation for improved road safety as automation replaces human drivers, while some discuss the possibility for new safety and cyber-security risks. The DfT in its 'Urban Strategy' clarifies that even though AVs could help improve road safety, road crashes will not cease to occur simply due to technological improvements. The document also mentions cyber-attacks and data privacy risks as new safety and security threats as transport services become increasingly digitalised. Safety and security of AVs are reported as principles guiding the development of new mobility services according to the strategy. Although the strategy suggests that developers will have to demonstrate that AVs are safe to be approved for commercial use, it is not clear how DfT perceives the acceptable safety level. The development of these standards and regulations appear to fall into the responsibility of international forums and the Law Commission.

Among the other authorities and documents, some use highly technologically deterministic language and describe AVs as safer than human-driven vehicles (HE and TfWM). TfGM, TfL and MKC appear to think about the impact on road safety as uncertain, as they briefly describe both opportunities and threats.

> *"Improvements in car-to-car communication and other technologies (such as autonomous vehicles) could potentially see an improvement in journey time and safety." (MKC2, p.68)*

> *"Safety risk of driverless pods sharing space with pedestrians and cyclists." (MKC2, p. 84)*

TfL is the only authority mentioning the current level of technology and risk associated. The authority has developed its own guidelines for the safe management of trials (TfL3), explaining all the procedures that need to be followed to inform the relevant public authorities and citizens.

5.7. Responses of transport government bodies towards AVs

The levels of government examined are different, and as such, it was expected that they would differ in their responses, due to different power, resources and governance responsibilities. The previous section showed that some differences did appear among transport authorities in the extent to which AVs are envisaged to solve or create transport problems. This section addresses the second research question, which aims to explore the emerging response of the UK public sector.

My content analysis of the documents identified the following themes; 1. Facilitating the deployment of AVs, 2. Managing specific risks and setting principles for AVs and new mobility services, 3. Exploring the innovation and shaping it according to strategic objectives, 4. Policy and planning instruments to manage the social consequences of AVs, 5. Public engagement. I discuss each one of them separately below.

5.7.1. Facilitating the development of AVs

The UK government's *'race to automation'* stems from its aspirations for global leadership in AV development and adoption and economic growth (Hopkins and Schwanen, 2018). The 'Industrial Strategy' highlights these visions for productivity and economic benefits through self-driving experimentation and deployment. Given that in the strategic level the central government set the direction for the UK to *'assert global leadership in the demonstration and deployment of CAV technologies'*, it was likely that all levels of authorities examined here would be focused on enabling the innovation. Indeed, the public sector has taken several steps to facilitate the deployment of AVs. From the national government perspective, the DfT has announced that it will continue to support research and safe development activities, proposing new types of advanced experimentation, e.g. testbeds.

Among other public bodies, facilitating the innovation takes place, first, through exploring how current infrastructure needs to change to accommodate AVs in the future. HE perceives its role primarily as safeguarding the infrastructure to be fit for an automated future and developing the operating procedures for AVs.

> *"Connected and Autonomous Vehicles (CAVs) have different requirements on the SRN – communication between vehicles, vehicles and the infrastructure as well as vehicles and the control room. For example, we could improve cat's eye technology*

> *and line marking so that they can be detected by CAVs and vehicles with lane assist technology. Through the remainder of this road period and into the next we need to investigate and plan how we operate the roads as CAVs become a larger part of the fleet." (HE1, p. 69)*

Noteworthy is that all levels of government bodies have plans for trials and demonstration projects. In quantitative terms, experimentation appears to be the most discussed policy response within the strategy documents. It can be argued that experimentation also serves as a means to critically evaluate how AVs and new mobility services can help achieve desirable futures. However, most documents describe AV-related projects as necessary to support their development. There are only a few examples of how authorities are using the insights from their projects to inform their wider strategies – although not to inform any planning or policy responses to AVs.

> *"These questions are already being considered with the ground-breaking VENTURER and FLOURISH projects, with the ambition for the West of England to become a European leader in the progressive roll-out of new technologies and new forms of mobility. The Transport Vision has considered these major changes in mobility, including changes in future trip rates reflecting the impacts of technology on demand for travel." (BCC1, p.31)*

TfWM is the only transport body that proposes incentives to ensure a quicker adoption of AVs to accelerate their development. This policy suggestion, in combination with the fact that the authority has chosen to communicate only opportunities of AVs and new mobility services, make the authority a distinctive case.

5.7.2. Exploring and shaping the rollout of AVs according to strategic objectives

The codes grouped under this theme were labelled to documents belonging to DfT, TfGM, TfL, WECA and one reference found in BCC strategy. They illustrate directions of policy, in the sense that they do not outline specific actions, rather an intention to act proactively to steer the development of AVs in a way that serves their strategic objectives. The theme suggests that the respective authorities perceive the need to intervene to shape the deployment of AVs in line with their strategic objectives.

It is worth noting that the DfT proposes a proactive approach to harness opportunities and avoid any unintended consequences of new mobility services and technologies (DfT2, p.38). To this end, it announces a framework of nine principles – objectives according to which innovation should be deployed.

The TfGM and TfL suggest similar approaches, which have also been visible in the way they anticipate AV implications (for instance, TfL uses expressions as 'if well managed' or 'shaped in the right way' frequently). WECA also proposes the development of a CAV strategy which may include a more detailed policy framework for AVs (WECA2, p.67).

5.7.3. Managing specific risks and setting up principles for AVs and new mobility services

This theme includes responses of the authorities to ensure that some of the perceived risks are mitigated, and opportunities can be harnessed. The TfL was the first public body (the Strategy was initially adopted in 2018), followed by the central government (in 2019) that set up a framework of principles to guide the development of new mobility services and technologies. The principles illustrate the strategic objectives of the authorities. Other regional and local authorities have included limited brief statements about their role in steering the innovation according to some goals or in order to mitigate some risks, for instance, data security or privacy.

The principles outlined in the DfT2 and TfL1 strategy documents share many similarities. They both suggest that new mobility services and technologies should contribute to greater equity and inclusion. Although these goals are somewhat vague, they illustrate some emphasis on equity issues in the 'smart mobility' discourse.

> *"The benefits of innovation in mobility must be available to all parts of the UK and all segments of society." (DfT2, p.41)*

> *"Opening travel to all: new services should be accessible to all Londoners and should not contribute to the creation of social, economic or digital divides in which some Londoners would have better travel options than others." (TfL1, p.280)*

The DfT and TfL have included some further guiding principles relevant to the accessibility of older people in the future. Some of these prescribe the role of transport innovations in relation to active modes and public transport. For instance, not competing with active travel and complementing mass transit are two of these overarching policy goals. These could guide further the thinking of public bodies with respect to what policies and regulations will be required to avoid further automobility dependence and make it easier to access places by walking for older people.

5.7.4. Policy and planning instruments to manage the social consequences of AVs

Studies on the impacts of AVs on cities, accessibility and inequalities have argued that authorities across different levels have options to control how AVs are implemented and used (Papa and Ferreira, 2018; Cohen and Cavoli, 2018; González-González et al., 2019). For instance, policy measures such as restriction of access to motorised vehicles in certain areas, fare and coverage policies for shared AVs, speed limits are some of the tools that planners can use to avoid unintended consequences of further automobility dependence (Cohen and Cavoli, 2018). The strategy documents examined in this study do not mention policy measures that could be selected to manage the social consequences of AVs. The gap is evident across all levels of authorities.

Although the DfT has outlined its vision and defined some policy goals for transport innovations, the strategy does not include a detailed plan of policies that may be required if highly and fully AVs are on the roads. Possibly the 'Future of Mobility Regulatory Review' announced in the strategy document (DfT2, p. 53) will look into these specific actions. The lack of any discussion about specific policy actions may also obstruct lower levels of governments to consider their roles and powers to shape the transition to AVs proactively.

The document analysis shows that other authorities have chosen not to suggest specific policies at this stage. Few exceptions are observed, for instance, TfL aims to assess its street space allocation and design to prioritise walking, cycling, public transport.

> *"In the future, if highly autonomous vehicles reach a higher concentration in the vehicle fleet, TfL will continue to work with the London boroughs and other key stakeholders to ensure future street design is focused on the Healthy Streets Approach, and reflects international best practice." (TfL2, p. 5)*

Stemming from that the authority also proposes taking advantage of automation to manage access to the kerb space, which will be essential if on-demand mobility services are deployed. Other interventions discussed involve licensing and road pricing mechanisms to restrict the empty running of vehicles.

It can be argued that the lack of references to possible interventions relates to scepticism about the level of technological progress in the AV domain. Nevertheless, the public authorities included in the sample are already involved in AV research and development activities. They also appear to perceive the transition to automation as a highly likely future scenario. Research in other contexts (Guerra, 2015; Legacy et al., 2018) suggests that uncertainty surrounding AVs inhibits planners and policy officials from integrating the innovation in their long-term plans (Guerra, 2015). The next chapter,

which presents the findings of interviews with local authority officials and other stakeholders provides some further explanations for this phenomenon.

5.7.5. Public engagement

A few of the authorities discuss issues related to public acceptability. These frame public acceptability as a critical barrier to AV development that needs to be resolved to enable the transition to AVs.

> *"However, there is work to do to gain public acceptance for them on our roads."*
> *(HE1, p. 50)*

Despite these statements, plans for engagement with the public are only reported within the DfT strategy, suggesting this has not been a priority for transport authorities over the previous years. Possibly public engagement takes place, to an extent, through trials and demonstration projects (for instance, BCC was one of the consortium partners of the 'Flourish' project which engaged with older and disabled people (Shergold, 2019a)).

The DfT has carried out research on public attitudes towards new mobility services and technologies (DfT, 2019h) and more recently, a public dialogue exercise that involves both experts and members of the public (McCool, 2019). In its current strategy, the authority announces plans for public engagement and the development of an external network that will provide impartial advice to the public on new technologies. If older people and other - less mobile - groups are involved in these processes, developers and policymakers could understand and design based on their accessibility needs, as discussed within the DfT1 and DfT2 documents. As far as older people are concerned, there is a risk that the engagement processes will focus (narrowly) on accessible design principles, given the emphasis on these barriers (see section 5.3).

5.8. Discussion and conclusion

The policy document analysis addressed two research questions:

1. How do the transport authorities perceive the impacts of AVs on the mobility and accessibility of older population groups and other socially/transport disadvantaged groups?
2. What is the emerging response of the transport authorities towards AVs, and how is this likely to affect the mobility and accessibility of older people?

Although most authorities have not carried out a thorough analysis of accessibility and distributional impacts, they discuss a range of plausible impacts of AVs on transport networks and people. The public authorities, as a whole, appear more focused on the potential of AVs to solve problems than to exacerbate current unequal or unsustainable transport conditions. Notwithstanding that, most authorities observe opportunities and unintended consequences from the introduction of AVs. The documents of the DfT, WECA, TfL, and MKC are somewhat more balanced in their description of opportunities and risks. TfGM also appears to refer more frequently to the uncertainty of the overall impact (positive or negative) of AVs for Greater Manchester comparing to the other authorities.

In terms of equity and inclusion impacts, older and disabled people are the only groups mentioned within the documents. AVs are perceived as an opportunity to remove current barriers to transport access for these two population groups. In the national government level, there seems to be an awareness of potential barriers to AV adoption for these groups. However, barriers to AV adoption are somewhat narrowly defined. First, there is a lack of discussion about the affordability of AVs for low-income groups. Depending on how AVs are deployed, their cost would likely determine adoption and accessibility inequalities among older population groups (Kovacs et al., 2020). Second, the emphasis of the central government on creating accessible mobility innovations may help ensure that individuals with certain physical and cognitive impairments are not excluded from the design of AVs and services. However, there seems to be consideration of other factors possibly underlying the willingness to use AVs, such as trust and safety issues (Nielsen and Haustein, 2018). Third, the strategy documents overlook that older people's accessibility can also be affected through changes in the broader mobility system. Although many authorities addressed impacts on walking and cycling, the impacts on the accessibility of older people, as other road users, are not addressed.

With respect to the second question, the differences among authorities are more pronounced, although it is recognised that this can be partly a result of differences in power and resources. Some of the authorities are narrowly oriented towards facilitating the transition to AVs (for instance, HE or TfWM). Other regional/local authorities have very few references that describe their policy approach (OCC, BCC). Others appear as recognising their role in shaping the outcomes according to a vision (TfGM, WECA) or thinking about how they want to use smart mobility technologies and services in a more holistic manner (TfL). The central government is likely to have a high responsibility in developing a vision for AVs to guide developers, operators and local authorities. At this stage, the DfT has responded with a framework of principles which touch upon inclusion, safety, effects on active travel and public transport. From this perspective, the principles can be interpreted as an effort to move to a more proactive approach considering public welfare outputs from the transition to AVs. It remains

unknown how transport authorities will interpret and use them to develop their own sets of actions for the transition to AVs.

Although some types of standards and policies will need to be coordinated in the national level (for instance, possibly operational standards for infrastructures, or economic policies, like tax frameworks), local authorities will still be required to manage implications of AVs and consider policies that fit their own context. Beyond TfL that has set some principles, most regional and sub-regional transport bodies do not appear to have set up a clear vision for AVs. The development of principles by DfT and TfL can be the first step to establish regulatory frameworks and policies. Specific policy and planning instruments stemming from these principles, though, have not been considered yet.

6. Findings from the interviews with transport professionals

6.1. Introduction

The document analysis chapter showed that transport authorities in England have not carried out a thorough analysis of accessibility and equity impacts of AVs. The relevant public authorities in England have begun considering how AVs may impact on the mobility and accessibility of older and disabled people. In comparison with the background literature review, though, barriers to AV uptake (e.g. acceptance, low income) and impacts on non-users of AVs (e.g. safety of older pedestrians) among the older population are overlooked.

The previous chapter also provided some early evidence that the public sector's involvement to date aims mostly to facilitate AV development, rather than to question or control for its social and distributional consequences. Specific planning and policy instruments that could be implemented to use AVs in line with strategic objectives are not articulated within the documents. However, there are some signs that the national government (DfT) and some metropolitan authorities aim to steer the development and deployment of AVs towards socially desirable outcomes.

In this chapter, I present the findings from the fifteen interviews that were used to supplement the document analysis. Most of the interviewees (ten) are staff members of local, regional authorities (metropolitan, such as Transport for Greater Manchester or non-metropolitan, such as Oxfordshire County Council) and sub-national (i.e. Transport for the North). One of the interviewees worked in the Department for Transport. I also included informants from other key organisations, non-governmental (e.g. Sustrans) or the public/private partnership Zenzic, which was created to accelerate AV development in the UK. As discussed in the methodology chapter, the sample is purposive, including key stakeholders in AV related research and development and policy formulation for AVs, within governmental and other non-governmental organisations (NGOs). I recognise that differences may exist in the values and positions of the interviewees concerning the rollout and adoption of AVs.

These interviews aimed to explore the following research questions:

1. How do transport professionals perceive the impacts of AVs on the mobility and accessibility of older population groups and other socially or transport disadvantaged groups?
2. What is the emerging policy response towards AVs, and how is this likely to affect the mobility and accessibility of older people?

My analytical approach in this chapter is similar to that described in the policy document analysis chapter. I analysed the interviews with the qualitative content analysis technique. The following chapter is organised under the main themes that represent interviewees' viewpoints, firstly, around the critical elements of the accessibility implications of AVs for older people, and secondly, around the policy responses of public authorities.

Table 6.1. shows the organisations in which interviewees are affiliated. To protect the anonymity of interviewees, I do not link their names to their specific roles. The sample includes individuals from Innovation and Future Mobility, policy and strategy teams within regional and local authorities. Interviewees included Innovation officers, planners, engineers, policy and research officers, analysts. All of the organisations and individuals interviewed were either closely involved in AV-related research and development projects or discussions around the policy implications of AVs. The sample is balanced in terms of CAV expertise and transport planning, policy development, particularly in the field of accessibility, with some interviewees having experience in both domains. I used the snowballing technique to identify individuals within the same organisations that could contribute to the specific research. Interviewees did not point further towards others from the same organisations as potential interviewees. In other cases, the participation of one interviewee followed after a call for participation to an organisation or a specific team (for instance, the Innovation team within a city council). The methodology chapter included further details about the sampling process.

Table 6.1: Interviewees and related codes by organisation and interview method

Code	**Organisation**	**How was the interview conducted?**
1, DfT	Department for Transport	In-person
2, Zenzic	Zenzic	Phone
3, TfGM	Transport for Greater Manchester	In-person
4, TfGM		In-person
5, TfGM		In-person
6, TfWM	Transport for West Midlands	In-person
7, OCC	Oxfordshire County Council	In-person
8, OCC		In-person
9, MKC	Milton Keynes Council	In-person
10, CCC	Coventry City Council	Phone
11, BCC	Bristol City Council	In-person
12, Living Streets	Living Streets (own opinions, not necessarily the organisation's)	Phone
13, RACF	RAC Foundation	In-person

Code	Organisation	How was the interview conducted?
14, Sustrans	Sustrans	Skype
15, TfN	Transport for the North	In-person

6.2. Overview of findings

The majority of interviewees are quite optimistic about the potential of AVs to provide solutions for several transport problems, although most of them recognise (at least some) potential unintended consequences. There are notable differences among the interviewees and their discourses around AVs. Those actors who are actively involved in AV experimentation projects make quite optimistic assumptions about AVs and their potential to solve transport problems. Actors who are either from public authorities or NGOs that are less closely involved in AV-related projects seemed to emphasise more the uncertainty surrounding AVs or scepticism about their potential to fix current problems.

Through the document analysis, I observed a variation in the opinions and narratives around AV futures among the transport authorities included in the sample. Nevertheless, I found a more significant variation in the views around AVs through the interview study. This variation echoes the conclusions of Freemark et al. (2019) that in the US context city officials from planning authorities are overall optimistic; nevertheless, there is a quite significant variation in the viewpoints among them.

6.3. The accessibility implications for older people

Most participants perceive some potential opportunities for the accessibility of older people, subject to barriers to adoption. Beyond a few exceptions, interviewees did not make links between how AVs may impact on road safety, the built environment and location of services, accessibility of active transport, the cost of mobility services and older people's accessibility.

In the following sections, I present how interviewees perceive the accessibility implications for older people. I also discuss their viewpoints about disabled people and low-income groups, which were on some occasions addressed in conjunction with older age.

6.3.1. Benefits for the accessibility of older people

The interviewees discussed the potential benefits for widened mobility and access for older people who do not drive, cease driving or have mobility impairments.

> *"We also have a huge ageing population. That ageing population may not have those same capabilities of driving as they have now. But with the autonomy coming in and with the connected vehicles coming in, that will give them the same patterns of lifestyle. There are the benefits of developing that with the ageing population increasing in all cities." (Interviewee 10, CCC)*

Opportunities for individuals with sensory and mobility impairments were also narrated by the participants, often linking this group to the older population. These are anticipated because AVs could expand door-to-door mobility for individuals with disabilities that impair their ability to drive. Individuals who currently face mobility barriers because of the traffic, the physically inaccessible surfaces and crossings, could be benefitted from widespread door-to-door solutions.

Although plans for particular operational and business models do not exist yet, participants refer to benefits from AVs that are available on-demand. Examples of ride-sharing models, shuttles, applications in the community transport sector and delivery services, were described as possible solutions to meet the needs of future older population groups. Another potential application which was described by a transport official in OCC included the delivery of social care services through AVs, possibly catering for needs of older people as well. Interviewees from local authorities anticipate that automation will facilitate widened availability of public transport, with cheaper to operate and more convenient for the public on-demand door-to-door services. Barriers that older people face due to long walking distances to public transport stops and stations or inadequate spatial and temporal coverage would cease to exist according to these views.

> *"If as an older person, you find it hard to move or you are fearful about walking in the street, then it opens an opportunity to go and do things and interact. We know from our Ring-and-Ride service that it is very popular, but it is not meeting the demand. There is a much bigger demand for this. Lots of older people now get a free bus pass, but the reality is that some of them have an excellent service, but some others have very poor service. There might be a more equitable way of providing a fair service because you are not bound to 'I cannot run this bus service here because it is not profitable'. It can open up opportunities that are not out there."* (Interviewee 6, TfWM)

One participant mentioned that the adverse consequences of driving cessation are mainly experienced by the rural older population. Therefore, the types of models and how inclusive they are of different income groups of older people should be examined with reference to the particularities of rural areas (i.e. low demand).

In conclusion, the benefits envisaged for the accessibility of older people stem from the belief that the future mobility technologies will expand the access to motorised transport options of people with particular personal characteristics (e.g. health issues, mobility, sensory disabilities, lack or loss of driving license) or located at specific places (i.e. rural areas). A new important finding is that actors from the regional and local authorities appear more focused on public and shared mobility automated solutions for older people.

6.3.2. Barriers to adoption of AVs by older and disabled people

6.3.2.1. Low uptake of digital technologies required for AV access

Although most interviewees perceived the abovementioned benefits for older people as plausible for the future, there were some concerns about the extent to which older people can adopt future mobility technology. The lack of smartphones, bank accounts and familiarity with the use of mobile phone applications, all of which will be prerequisites to use different emerging services and platforms in the future, was discussed by few interviewees (n=3) as a barrier potentially affecting older people among other social groups in the future.

> *"It can lead to this situation I described, but it is a transition period, and we can't have a two-speed city, leaving people behind because we are waiting for this to happen. So, we have to manage these two, and it is often cited that older people do not have access to a smartphone. I am not sure that is totally true. It is a bit derogatory to older people to suggest they don't have the capabilities. Perhaps a side of it is overplayed, but it is still an issue." (Interviewee 9, MKC)*

The policy official from TfWM mentioned that the authority had explored the lack of digital resources across its population to understand potential exclusion effects. In light of the findings from this study, the proportion of the population who do not have access to mobile phones or are choosing not to use payment cards and online banking is relatively low in the West Midlands, but still an issue for some people (not necessarily belonging to the older age group). The TfWM has worked with a company that

provides demand-responsive services that can be booked by phoning the call centre or other assistive technologies to help older people with routing. The interviewee from the organisation argued that this type of model could be applied if required in automated community transport services in the future.

Within the policy document analysis, the issue of low adoption of smartphones was only brought up in DfT 'Urban Transport Strategy'. The interview findings suggest that key actors within some regional and local authorities recognise this as a barrier for older people's adoption of AVs. A thorough understanding of not only the scale of this issue but also the profile of older people affected by this barrier is critical as transport services increasingly require familiarity with and use of Internet, smartphones and applications. The barrier is pertinent to future automated services and current public transport payment applications, MaaS, ride-hailing. The proportion of UK older people who make use of digital devices has been increasing over the last years, although there are still gaps, for instance, in the use of Internet particularly among women and older old adults (Matthews et al., 2018). The interviewees referred to this barrier without commenting on the particular socio-economic characteristics of older individuals that may be at risk of digital exclusion.

6.3.2.2. Accessible design of AVs

Some of the interviewees from transport authorities mentioned that their organisations are involved in research and development activities to design AVs that are accessible to diverse groups of older people and individuals with disabilities (mobility and sensory). Within the planning documents, the issue of accessible vehicle and user interface design was discussed within the DfT documents. Nevertheless, some of the interviewees from local authorities mentioned efforts within the context of AV trials to design vehicles and services that allow for wheelchair access and user interface suitable for sensory impairments.

The narratives of some officials from the local authorities suggest that there is some conflation between old age and disability when considering the design of AVs. Associations between these two groups are common in AV related discussions and, in general, transport policy (Marin-Lamellet and Haustein, 2015). Chronic health issues and disabilities increase with age (Centre for Ageing Better, 2019). However, older people (with or without impairments) may have particular needs in terms of AV design. Projects such as FLOURISH that focused on older people might have been better able to capture these aspects.

The interviewees from MKC, and CCC referred to engagement strategies to ensure that the AVs that are trialled on their roads can cater for the needs of mobility or visually impaired individuals (not specifically older people). The narratives of professionals from the national to the local level show that this is a process that requires collaboration among different parties; the 'users' that may have different needs and capabilities from the average 'customer' imagined, the automotive industry and the service providers and the public sector to facilitate this collaboration and ensure that the criteria for 'inclusion' are met.

> *"With the council being the client for this operation, we were able to influence the design and operation of the vehicles. So, we made sure the vehicles were wheelchair accessible, adhered to all the requirement in terms of visual and sound signal for impaired individuals to see and hear these vehicles. And actually, we enhanced that work by actually using the disability groups to come in and use the vehicles." (Interviewee 9, MKC)*

> *"But it's not just a policy thing. It is also the private sector leading these, the development of these technologies. It's worth saying that in some of the research we've done we have had private sector organisations involved, so, for example, Ford, Tesla, and they are taking away the findings from the research we're doing feeding into the development of their own products, or so they say. We hope that these issues are going to be considered; they're definitely going to be considered from a policy point of view, but we're hoping that they're going to be considered from a private sector point of view as well" (Interviewee 1, DfT)*

In conclusion, as interviewees suggest, transport authorities of different levels (central to local) aim to collaborate with the industry to ensure AVs are accessible to older people and people with certain impairments.

6.3.2.3. Need for human assistance

There were, though, contradictory claims about the potential of AVs to serve all mobility needs and, specifically, journeys of older people or people with particular cognitive problems. Two local authority officials suggested that human-driven mobility services may continue being essential for some people. The conditions (psychological, physiological and cognitive characteristics of individuals) that render AVs assistive or less appropriate than a human driver are not yet clearly understood. These are open questions both for researchers and policymakers.

> *"I also see the potential risk of increasing loneliness. Because one of the reasons that an older person may take a taxi for shopping is to have a chat with the driver and then some help with taking their shopping bags inside. There is a real balance to be had. I think there still need to be a range of mobility choices in the future." (Interviewee 7, OCC)*

> *"The example of the pods was that we recognised in the city centre older people, less able, with mental issues, fewer capabilities, how do we deal with that? So when we designed the service, we run alongside a traditional taxi, a supported service so anybody that wanted the journey could have it, we would expect the majority to be able to use the pods and we described how we are going to try to make that accessible for all, but it didn't capture all. So we would have a parallel service that would deal specifically with the groups of these people that couldn't access the service that we delivered." (Interviewee 9, MKC)*

It is of note that similarly to the discussion around smartphone use by older people, these narratives suggest that transport officials may be thinking about the psychological and mobility needs of the older population group, as relatively homogeneous.

6.3.2.4. Public acceptability and acceptability of older people towards AVs

The findings of the policy document analysis suggest that the DfT and other regional, local authorities are focused on creating the conditions for wide public acceptance, although plans for public engagement were only mentioned in the DfT strategy. At this stage, policy officials from different regional and local authorities argued that some programmes for public engagement have begun taking place. These were described as engagement processes with disabled people to ensure accessibility of the vehicles and research projects (surveys, such as from the project Autodrive in Milton Keynes (UK Autodrive, 2020)). Demonstration projects on public roads are also discussed as future engagement opportunities by local authority actors, although interviewees did not provide further details about the process and methods considered. In general, the programmes of public engagement or experimentation appear to be more focused on understanding some barriers to acceptance and ensuring future adoption.

> *"Because as I said before, similarly to the situation of manufactures who if they don't engage with the local authority, they will not get the benefits of the end*

> *result, the development can fail because we haven't engaged. We have to make them aware of what we are trying to develop. There could be negative and positive input. We need to work on both. Because sometimes those negative inputs are actually useful for us to understand about the future of this development and its exploitation." (Interviewee 10, CCC)*

The focus on public acceptance can help ensure that the exclusion of some groups is avoided. For instance, disability groups were consulted in the case of MKC trials after they had voiced concerns about AVs and their interactions with humans. The interviewee from MKC described this as an opportunity to improve the vehicle accessibility features of the automated pods. Further details about how the other concerns of the disability group were managed were not provided in the interview. On the other hand, if transport authorities and experts perceive the introduction of AVs as inevitable, there are arguably some risks. Any individuals or social groups that do not seem willing to adopt the technology may be excluded from the debate about AVs.

Interviewees did not discuss mobility and accessibility inequalities (e.g. gender, income) that could emerge from different levels of acceptance. The same gap was observed in the analysis of policy documents. Possibly at this early development stage, the interest is on exploring public opinion, without considering that different social groups may have different attitudes towards the technology or how this may shape future inequalities.

When discussing the implications for the older population, some participants (n=5) discussed particular issues related to the acceptance of older people. Participants commented on the possible reluctance of older people to use these future transport modes and services and their current low rates of adoption of new technologies within the transport domain (e.g. in-vehicle automated features, on-demand app-based services). In the following illustrative quote, the interviewee compared the impact of AVs on disabled people with that on older people, pointing to acceptance differences.

> *"I think they are quite different as well because they might not be as willing to accept a new form of transport. Because it is quite scary to get into something without a driver, you don't see someone there that operates the service. But, they are very open-minded, and it will be down to us, and to whomever the operator will be, to do a lot of marketing and educate people about what this does, how it works, that it is safe and there are not going to be any accidents, and have people ride some CAVs themselves and see themselves how they work." (Interviewee 5, TfGM)*

Finally, a few participants (n=4) commented on which types of services might be better suited to older people. These are mainly speculations extrapolating from the current mobility practices of some segments of the older population. Acceptance of different kinds of services by older people with different characteristics and experiences does not seem to be a matter of investigation. Three mentioned the application in the community transport sector as a service that may be preferred by some older individuals who value social interaction in the transport space.

> *"The older people are an interesting group. We know, again not from quantitative evidence, that people who use Ring-and-Ride they create a community of people on their way to go to Bingo, or shopping and they like that. It works really well; having a shared service is a positive thing." (Interviewee 6, TfWM)*

In contrast, one of the participants argued that older people might be more interested in private ownership comparing to younger generations. This was attributed to the fact that the current generations of older people have been quite dependent on cars and, therefore, may have more psychological barriers to accept shared use (synchronous or asynchronous) of vehicles.

6.3.2.5. Low income and affordability of AVs

In the policy document analysis, I observed that references on lower-income groups and affordability of private or shared AVs were lacking. Here, interviewees referred less frequently to benefits for the accessibility of lower-income groups comparing to these of disabled individuals and older population as a whole. In general, they perceived the impact on lower-income groups as quite uncertain, dependent on uses cases, cost structures, and widened availability of on-demand modes.

Additionally, when benefits for lower-income groups were perceived, these related mostly to the widened availability of on-demand shared transport rather than potential reduced operational and passenger costs.

Only two interviewees brought up the intersection between low income and older age. These questioned the commonly envisaged accessibility benefits of AVs for older and disabled people based on the uncertainty around the supply forms of AVs and their associated costs.

> *"Is it possible to say that either?* [asked about the impact on disabled individuals] *This depends on the form of disability, but at a generic level, transport accessibility has always been a barrier for people with disabilities for obvious reasons. Is it necessarily the case that CAVs will improve that? Potentially yes, but if there is price*

> *bar not necessarily for all. Older people. [short pause]. I think it is impossible. Until we say this is what we mean by CAVs and we have a few examples of what they are. And it could be that they are tools of regeneration and they are free at the point of access." (Interviewee 4, TfGM)*

As discussed across the previous sections, older people are seen as a single group or as a group that experiences accessibility barriers due to mobility difficulties, driving cessation and poor public transport provision. However, income can also be a significant factor affecting the mobility and ability to access essential destinations for older people (Kim, S., 2011; Ryan et al., 2019). Currently, there is a substantial proportion of older people over 65 years old (16% or 1.9 million people) that live in relative poverty and a further 1.1 million in severe poverty (incomes lower than 50% median income), with single women, ethnic minorities and adults aged over 80 overrepresented within this group (Centre for Ageing Better, 2019). Therefore, it is critical to consider this intersection when assuming benefits for the older population as a whole in the transition to automated transport.

In general, interviewees had different opinions about the affordability of on-demand shared AVs. Significant benefits in the reduction of costs for lower-income groups were not narrated. However, two interviewees (DfT, OCC) mentioned the potential for low operating costs per mile which would open up access across the income segments. Others stated that the services would need to be priced at an affordable price to ensure that the business models are viable or suggested the provision of mobility credits or other forms of subsidies, if necessary.

> *"If they are expensive, there will be large groups excluded, but that is arguably a political decision. It would be possible to subsidise them to the point that they are cheap or free. In terms of wealth, I think it is political. It is often quite difficult to subsidise more private transport. We tend to subsidise buses, but not taxis. And it is not clear where these sit." (Interviewee 11, BCC)*

In contrast to these, the exclusion of lower-income groups because of the high cost of new mobility services was stated as a plausible outcome by two interviewees. The DfT interviewee, who referred to the potential for lower operational costs held the view that the affordability impacts for lower-income people are highly uncertain. The relative pricing of on-demand AVs in comparison to conventional public transport and any competition among these services would determine how affordable non-private transport is for lower-income groups.

Conversely, there was an agreement among those who discussed the potential deployment of private AVs that there would be income inequalities in adoption, at least in the first years. In any case, though,

private AVs were not the main focus of interviewees from public authorities, which comes as no surprise, since they aspire to promote shared mobility.

6.3.2.6. Accessibility implications for older people - pedestrians

As mentioned in the introduction, interviewees focused on the accessibility implications for older people as users of AVs with less attention to the impacts on them as users of other modes of transport. Nevertheless, two interviewees from non-governmental organisations raised important concerns about the safety impacts of AVs on older and disabled pedestrians or users of mobility devices. In general, the interviewees from the three non-governmental organisations were more concerned about the road safety implications for pedestrians and cyclists, compared to other interviewees.

The interviewees from Sustrans and Living Streets noted that older people as well as disabled people face disproportionate risks and psychological barriers as pedestrians (or non-motorised mode users) and argued that the design of future transport systems needs to prioritise their safety. The ability of AVs to cope with the diversity and complexity of human behaviour was questioned. The interaction with humans as pedestrians, cyclists and drivers of non-automated vehicles was a concern shared among more interviewees (n=5). However, as the following quote suggests, specific groups and individuals who move slower or differently than whatever is perceived as a norm for the development of AVs may face a disproportionate risk in the interaction with AVs.

> *"Another concern for older people, mobility-impaired people, people with mental health issues is how the AV will interact with them, how they will detect people if they are used in a shared space. There is this algorithmic question where the AV is looking for items and people, walking or cycling, it may end up looking for able-bodied people, behaving in reasonably predictable ways. How is it going to know for a person with mobility impairment, identified as a pedestrian, that they may not be able to move quickly as someone walking at what might be considered a normal pace? How is it going to understand if someone with mental health issues may be behaving in a different way than what expected based on the algorithmic programming? It is really important to get all these right before we can confidently deploy AVs." (Interviewee 15, Sustrans)*

In the case of the majority of older adults, their slower walking speed has been neglected in the design of road infrastructures (for instance, in the guidelines for crossing times in the UK (Asher et al., 2012;

Musselwhite, 2014). If AVs are not developed with a consideration of the diversity in human movement, older people's safety and accessibility could be deterred.

Additionally, although many interviewees argued that road safety overall would improve as a result of a transition to automated transport, there were concerns about the level that the technology will reach and the AVs that will be authorised to be driven on the UK roads. The interviewee from Living Streets was concerned about the levels of AVs that will be allowed to be used and their place on the road environment (e.g. dedicated routes or shared road environments with other users) and the potential safety risks for vulnerable road users.

The following themes refer to critical implications of AVs for the accessibility of older people, as it has been conceptualised through the literature review. Interviewees discussed these issues in or outside the context of older people's accessibility. The next section describes one of the main motivations among sub-national authorities for their involvement in AV research and development. It affects older people as they are often imagined as users of on-demand AVs in different forms, as also discussed in section 6.3.1. Additionally, it highlights how planners and experts envisage the public transport system of the future.

6.4. Availability of public/shared transport and accessibility across places

Particularly for the interviewees from the regional and local authorities, the promise for door-to-door mobility by non-private transport modes seems to be quite critical for their support of AV deployment. Within the policy documents analysed in the previous chapter, transport authorities focused mostly on positive visions for improved accessibility across places by new mobility services (on-demand AVs). The interviewees frame the deployment of private AVs as an undesirable application of automation. At the same time, different forms of on-demand AVs are perceived as more likely to help meet policy objectives for accessibility, sustainability and network efficiency. Fraedrich et al. (2018) reported similar issues in a recent study of German planning authorities, with German municipalities, though appearing quite alerted about risks for increased competition with public transport.

In this study, some interviewees from public authorities employed the MaaS concept when they described their visions for a shift from personal car ownership to multi-modality.

> *"Really, it is about can autonomous vehicles be a benefit to our local population. It is not necessarily about a like to like replacement of private cars; it is more about shared mobility and demand responsive transport." (Interviewee 7, OCC)*

The majority of interviewees perceive the introduction of on-demand shared services as a key opportunity to improve access to conventional public transport (i.e. train stations and other major hubs) and increased accessibility by demand responsive automated transport. For a few policy officials, on-demand technologies would lead to benefits automatically. For instance, the interviewee from CCC argued that a demand-responsive transport model would serve better the needs of the community comparing to fixed-route buses. In this way, the expectation is that if the public accepts these new modes, there will be an alternative to private car ownership. All places would be served as algorithms would match the demand for mobility with the vehicles available across the area.

Other interviewees, for instance, officials from MKC and TfWM, argue that some sort of regulations and subsidies from the public sector would be required to address any gaps in provision, with the anticipation that AVs would entail reduced operational costs and therefore subsidies. The interviewee from MKC referred to the difficulties experienced by local councils in supporting with subsidies the operation of buses which are not commercially profitable. On-demand services, coupled with automation, would lead to improved transport provision across the area, reducing the expenses of the local authority for subsidies that address gaps in services.

> *"Milton Keynes is a city that is sometimes called polycentric. You have a strong city centre core, but the way the city is designed, there are centres of activity all over the city. Providing mass transit between all those points is not possible, not viable at all. Having an on-demand anywhere to anywhere service is where we feel public transport is going to go in the future. We then clearly have the duty of care to support of mobility needs of everyone. Instead of subsidising big buses, our subsidies may go into ensuring those that are not best by on-demand small vehicles, have a form of transport that caters for those. We might invest in specialist vehicles etc. to fill in the gaps which will hopefully be smaller than the gaps that we need to fill in with the big buses." (Interviewee 9, MKC)*

MKC has begun exploring initiatives to create the conditions for and attract new on-demand shared services. It is now one of the local authorities that have approved a trial of ride-sharing services (ViaVan). The city aims to *"expand options for sustainable public transit" (Milton Keynes Council, 2020).* The service also appears to be offered for free for older adults who hold concessionary bus passes (ViaVan, 2020). This is currently an experimental project without published evidence to date about its commercial potential and effects in the City's network.

More interviewees from the metropolitan authorities discussed the opportunity of on-demand AVs to improve accessibility for non-car owners, by supplementing conventional public transport provision

and integrating with the other transport modes. TfGM currently explores the possibility to use on-demand shared AVs, such as shuttles to improve first-, last-mile journeys to public transport stops and stations or accessibility at night-time. Similarly, TfWM aspires that on-demand AVs would ensure that transport is available in all communities, there are transport options for first-, last-mile journeys to rail stations and that any gaps in provision will be reduced. Projects for on-demand services (automated or not) to improve the accessibility to job locations currently underserved by public transport, targeted to the less affluent workforce were mentioned as examples of applications considered by the authority. Therefore, the positive vision of the future for interviewees, particularly from the regional and local authorities, is based on the perceived opportunities for reduced operational costs if automation feeds into public transport and shared mobility (Bösch et al., 2018).

Nevertheless, interviewees expressed broader concerns about the availability of transport across places and spatial equity in provision. This is slightly different from the narratives employed within the policy documents. The competition with conventional forms of public transport was a concern expressed by some interviewees. This was discussed as problematic more in terms of increased congestion but also reduced public transport ridership. The DfT interviewee, for instance, talked about the undesirable scenario in which a decline in public transport ridership would lead to a reduction in available services, disproportionately affecting the low-income groups who cannot afford to use the shared AVs.

> *"The other danger you have is in the way you introduce automation; you can undermine public transport and make it less profitable. So, it is no longer economical to run bus services into the city centre, and then this can affect many things, congestion can be worse, the access to the city can be worse, and you have an economic decline. So really interesting equation or balance between these." (Interviewee 6, TfWM)*

> *"One theory I've heard is what you find in terms of pricing and transport, you have cars more expensive than autonomous shared transport, which is more expensive than public transport, but more people will switch between public transport and shared and autonomous transport because the price difference will be much smaller. Then what you'll find is fewer people using public transport, more people on the roads, and it is an implication of that then that there is less investment in public transport infrastructure. […] So it could be then that you get people who can't quite afford that shared autonomous transport who have to use public transport, but there is not quite as much investment in that." (Interviewee 1, DfT)*

Other challenges described by some interviewees referred to the places and social groups that will be catered for by on-demand AV services. Some interviewees questioned the extent to which the deployment of AVs will reach areas that are not densely populated, particularly in urban peripheries and rural areas. The concern is that a market-led development of AVs would exclude areas deemed as less profitable, comparing to dense urban areas. Hence, although some interviewees argue that the introduction of on-demand services, particularly after the drivers will be substituted by automation, would reduce gaps in low-density areas, others are more sceptical about the extent to which these business models would emerge. For TfN that aims to support the regional and local connectivity across places in the north of England, the extent to which AVs and new mobility services will reach semi-urban and rural environments is a critical issue.

> *"There are also all these socio-economic and place issues. Arguably AVs could connect particularly more isolated, rural communities in a way that they are not connected at the moment, and provide much frequent, much cheaper, connected services, without having to invest in infrastructures. And equally, you could see it ending up in a market-led, city-centred solution." (Interviewee 15, TfN)*

The interviewee from the organisation Zenzic made the point that the roll-out of technology will be gradual, possibly with initially more uneven and eventually more equitable outcomes. This was based on the belief that the capability of the technology in combination with the need for profitable operational and business models would mandate the applications of automation. This means that initially environments with low operational complexity may be prioritised, for example, airports where interactions with other road users and humans can be limited. Automated on-demand services may be introduced initially in areas with high demand, city centres, towns. When these business models are proved profitable, they can spread to areas with low demand, for instance, in rural areas where flexible services are needed.

> *"The question is how quickly they can scale up. If it takes 15 or 20 years to scale up, then we have a real problem in inequality, only a few people and places will get the benefits, the others will miss out. If we have a technology that is able to scale up in five years, then ultimately that is much better." (Interviewee 2, Zenzic)*

The officials from OCC where AVs are envisaged as a solution to rural transport poverty were more concerned about technical and governance barriers for rural deployment. Trials in peri-urban and rural areas have been limited to date, which makes it difficult for rural local authorities to procure vehicles. AV developers do not clearly define space and capabilities (the operational domain features). In this way, it becomes challenging for public authorities to understand how trials may evolve in real testing

environments. Additionally, it is argued that rural authorities are less represented in strategic discussions about AVs and have more challenges in terms of financial and other resources.

> *"I think many of the trials up to now have been very focused on operating within the cities. That is a complex environment, but it is also a slow-speed environment, and there are also the campus-style, semi-closed environments. Whereas obviously, we think we want them to be able to be used in the rural, semi-rural, peri-urban environment. Not only being able to drive down the motorways at Level 4 and then having to hand back to the driver." (Interviewee 7, OCC)*

> *"The rural areas do not have the same capacity to input, and therefore the whole strategy goes down based on who is on the table. And again, when we decide and provide, the provision has to do with how much money you have to do something about it. I think Oxfordshire is a unique case because we have a lot of entrepreneurs and smart things, but we are also very affluent and rural." (Interviewee 8, OCC)*

One of the interviewees (Sustrans), suggested that AVs may bring new types of challenges in ensuring that services are available across different areas and to different income segments. The understanding from how recent private-led shared mobility platforms and services (e.g. ride-hailing and dockless bike-sharing) have been introduced to cities globally is that data harvesting consists one key revenue source (Spinney and Lin, 2018). The services, therefore, target individuals and areas which are more mobile and produce more data to be sold to other interested parties. Therefore, if these business models prevailed in the provision of on-demand AVs, similar issues might appear.

> *"The operating model is partly based on the ability to collect data from people using the service. People that are more affluent immediately have more valuable data. It is, therefore, more lucrative for the mobility provider to engage with wealthier people. Which immediately creates an imbalance and disadvantage for less affluent groups." (Interviewee 15, Sustrans)*

From interviewees' accounts, public authorities will likely aim to promote automation in on-demand shared/public modes, although it is unclear what the policy position towards private AVs will be. Local authorities may choose to support different on-demand shared models, subject to their policy and regulatory powers to influence these. Different models may have different implications for older people's accessibility, either because of what these may entail for their adoption or systemic changes (e.g. mode shift effects) that affect their mobility and accessibility indirectly. Kovacs et al. (2020) demonstrate how different use cases and supply form scenarios (owned by private individuals,

dominated by private operators without regulations, partly and strictly managed by the public sector) affect differently the mobility politics and, consequently, the mobility of older people.

Given the high uncertainty in terms of use cases, transport authorities may be better positioned in the future if they set a vision around the applications that would help them achieve their strategic objectives. Possibly the most proactive approach with respect to considering use cases, their impacts on strategic objectives and different social groups were observed by TfGM, as expressed in the following quote. Interviewees from TfGM discussed at length the need to define across the different levels of government what types of services, in which locations and with what operational characteristics should be sought.

> *"At the evidence base that we did, we looked at the different personas in GM and the different use cases that could potentially work. Of the personas, we identified the obvious, young people, people with mobility constraints, young professionals, families. We outlined the exact types of people that we could aggregate from the data; obviously, you can't include everyone because that is impossible from the data, but we used all the data that we could have that show travel behaviour, journey length, purpose, where they are going to and so on to come up with these personas. And out of those six personas, we tried to identify five use cases that these personas would be part of. The different use cases are looking at different types of CAVs, keeping that shared theme, we can't have single occupancy that would ruin our transport system." (Interviewee 5, TfGM)*

6.5. The built environment, land-use development and ability to walk and cycle

A majority of interviewees identified certain risks from AVs for increased automobility and a shift away from walking, cycling and mass transit. Similar concerns were noted through the document analysis. Nevertheless, many interviewees held the belief that the impacts on travel demand and mode shifts can be positive or neutral, and this will depend on the way AVs are introduced. As far as the impacts on the built environment and the location of activities are concerned, interviewees held different views around the extent to which AVs will affect positively or negatively their vision for built environment and location of activities. Most participants did not associate these impacts with the accessibility of older people or other social groups.

6.5.1. Impact on motorised travel demand

Interviewees discussed the risk for higher demand for motorised travel from widened access to AVs and replacing journeys currently undertaken by active travel and public transport, reflecting outputs from modelling and scenario planning exercises (Papa and Ferreira, 2018; Soteropoulos et al., 2018). Some interviewees talked about the need for public sector authorities to develop transport policies to address the risk for reduced active travel in a transition to AVs.

The interviewees from several transport authorities emphasised that a shift from walking, cycling and other forms of public transport (e.g. buses, trams, rail) to AVs would be undesirable. Understanding how to introduce AVs in a way that encourages a shift away from automobility dependence appears as a rather challenging task for local authorities. For instance, the interviewees from TfWM and TfGM recognise that decisions about the location of demand-responsive AVs need to be made in line with strategic goals, such as door-to-door mobility for groups with mobility impairments, integration with mass transit and encouraging walking and cycling. The official from TfGM mentioned that the organisation aims to facilitate three "first-,last-mile" connections to existing transport stops and stations, while the interviewee from TfWM referred to recent discussions about the design of the mobility hubs of the region, with no specific policies or plans yet in place.

> *"We decided that shared has to be included in any sort of communication about AVs, so shared and electric AVs will be the way forward and looking at three first/last miles, not one last mile because that leads away from cycling and walking. And again they have to be introduced in a way which doesn't affect other modes in terms of competitiveness and pricing, and doesn't take away from walking and cycling. As long as they are used as the glue to the existing network to make it more efficient for us and our operators." (Interviewee 5, TfGM)*

> *"That being said if we design our mobility hubs correctly and automation is not a door to door thing, but it is on core corridors, on motorways or core routes and we design these things correctly, people might decide to walk, cycle, or take a scooter to go to these mobility hubs. We might actually encourage active travel. Because we don't want to use the car, we know there is a very good automated service that gets you in the office, but in order to get there you have to walk, or cycle or use a scooter." (Interviewee 6, TfWM)*

6.5.2. Impact on road space allocation and accessibility by non-motorised transport

The extent to which AVs may affect the ease of movement of pedestrians and cyclists was also commented upon by participants. Some recognised the risk that AVs can take space from other road users and make it less easy to walk or cycle, if there is increased motorised mobility. For one of the interviewees, decisions about road space allocation will influence the progress towards healthy active ageing, which appears to be advocated by the central government.

A few participants discussed where AVs should be allowed to be driven in the street environment (for instance, footways or pedestrianised areas) and the extent to which AVs should be in segregated lanes from other road users, with conflicting views. For example, some interviewees expressed their opposition to the introduction of automation in pedestrianised spaces, while MKC is already experimenting with autonomous pods and delivery robots that drive in pedestrianised areas or on sidewalks. The trialled autonomous pods and robots are driven at slow speeds and possibly have negligible impacts for pedestrians, cyclists and mobility impaired individuals, as one interviewee from Livings Streets noted, but this could be different for vehicles that operate at higher speeds. The MKC interviewee emphasised that the introduction of the various forms of AVs should support a reduction in the number of car journeys. Different measures such as segregation of AVs from pedestrians and cyclists to improve their speed was advocated, based on findings of trials and simulation studies. Other interviewees, though, mentioned this measure and in general road space allocation to AVs as a risk to further hinder the mobility of pedestrians and cyclists.

> *"I can easily imagine that an AV solution might involve claiming part of the road as dedicated for AVs. If that means that other vehicles or pedestrians and cyclists can't cross it or use it, I see a massive restriction on people's local mobility." (Interviewee 15, Sustrans)*

Restriction of access to AVs in the city centre to create a car-free area, which could be served by a range of modes (cycling, walking, scooters, and automated pods) was also envisaged as a future solution for Milton Keynes.

Overall, at this stage, some of the authorities appear to consider different options for where AVs should be introduced. These may affect the accessibility of pedestrians (and therefore older pedestrians) differently at different areas of the cities.

> *"I think understanding where is the space for these services in the city at the moment, understanding whether they will operate on footpaths, cycle paths, bus*

lanes, open highways, really knowing exactly where they sit on the urban environment and then making the right decisions in terms of legislation. If they are going to be fast-moving shuttles, then it will have to be an isolated network, or a cab specific lane, while if they are going to be slow-moving shuttles that do not necessarily compete with cycling, or buses or taxis, then they could be going very slowly, like 10 km an hour and serving people with mobility constraints. First, it needs to be defined not only from us but also from the Department for Transport on a wider national scale, where is the place for these shuttles in the UK context, how do we want to implement them? […] The opportunities are endless, and I am sure more and more forms of them will come up. For us, it is understanding what needs we want them to meet and then making the right decisions in terms of legislation." (Interviewee 5, TfGM)

6.5.3. Impact on the land-use system and the location of services

Although some potential impacts on the built environment were discussed, interviewees did not give detailed accounts of how they believe the land-use system will be affected. This is most likely because these are longer-term implications and influenced by whether AVs will be used in private or shared models, how people will use their time in AVs, and the land-use and transport policies selected. Interviewees held different views about the implications for land-use development. The interviewees from the West Midlands authorities (TfWM, CCC) and MKC commented about the potential for increased density and development in the city centres, if automation is combined with shared mobility and parking spaces are freed-up. The change is also assumed to be influenced by the current trend towards increasing residential density in the city centres.

If the introduction of AVs was used as an opportunity to reallocate space currently dedicated to parking space for the construction of new buildings, it might lead to denser urban development (Papa and Ferreira, 2018). However, AVs (particularly in private modes) could also increase the accessibility of exurban and rural areas, leading to further sprawling (Meyer et al., 2017; Soteropoulos et al., 2018).

Some participants (n=4) discussed the possibility of increased travel distances and dispersal of activities, although this is not always perceived as problematic. The official from TfWM described several coexisting trends in land-use development as a result of AVs; increased development and density in the city centres, further dispersal of housing and job locations as a result of improved transport connectivity and new development around transit hubs.

> *"We know that developers already want to infill within the city centre, so they need to fill road spaces, or they need to allow people to move without owning a car. That is already happening, and automation certainly can help with that. I think the bigger driver is where you put mass transit. If I live 40 miles from where I am working, and I can get in my automated pod, but it takes me four hours to get in because everybody else is in an automated pod, why would I do that? While if I know that an automated pod is going to take me to a High Speed 2 Station and I'm in work in half an hour, then I would do that. And I could live a hundred miles away, and I could be quite comfortable doing that. I think it is probably the mass transit that would drive that. Once you get to that mass transit hub, it is getting more interesting as it could encourage different developments around that hub, because it would be much more convenient to get to. In the past cities, towns were developed quite historically; market towns were developed close to industry, etc. Say now a rural farm could be now very well connected to a high-speed mass transit hub because they could have an automated service that could get them there and this could be there whenever they needed. The transit hub is the key. If we remove them or reduce the benefit they give, you might see the opposite, people having to live in the city because they can't get in by an automated pod." (Interviewee 6, TfWM)*

In a somewhat contradiction to these accounts, other interviewees emphasised that the changes in the land-use system need to support proximity to activities and a reduction in the need to travel long distances.

> *"The problem is not so much enabling people to travel; it is how you create, things like the modern garden towns. How do you adapt these, so that cities become more healthy, walkable and liveable and people do not have to travel so much just to work or for basic provisions? That is a huge problem in the disjunction we have right now in planning for cities and transportation modelling. It is completely separate, and that is crazy. What is more, is we do not have any understanding about communication capabilities. What we need to aim for is not mobility; it is accessibility, which can be provided by proximity, urban design transportation or connectivity." (Interviewee 8, OCC)*

6.6. Emerging policy responses towards AVs

6.6.1. Adapting infrastructures and regulations to facilitate AV development

Similarly to what was seen within the policy documents, regional and local authorities have begun considering how they can facilitate the development of AVs. Beyond research and development activities, the authorities have begun thinking about changes in infrastructures, primarily digital, that will need to take place so that they are prepared for the roll-out of AVs. Some of the interviewees from public authorities that perceived CAVs as a solution to their transport problems were more focused on this aspect of policy, namely, in adapting infrastructures and regulations to allow for AV operation. Updating digital maps, digitising traffic regulation orders, considering how to accommodate vehicle-to-infrastructure communication systems were some of the key areas of work for the authorities to be ready for the deployment of AVs (and connected vehicles) on their roads.

Interviewees expressed different opinions about the extent to which the road environment will need to change to accommodate AVs. Some interviewees from transport authorities held the belief that only changes in the communication systems will be required, while others from non-governmental organisations mentioned additional changes in the street environment (e.g. maintenance of lanes). The issue of changes in infrastructures is important from the perspective of costs incurred to the public sector and cost-effectiveness. Again, the positions of interviewees seem to differ. Some of the interviewees (e.g. OCC10, CCC) emphasised that the changes in the infrastructures should be (and will be) affordable for the limited budgets of city councils. Others appeared as more concerned about the costs imposed on local authorities to support the changes in digital and physical infrastructures.

> *"The number one challenge for CAV is for it to prove that it is going to be better than what we got now. Because everyone is saying that the supporting infrastructure is going to be quite expensive, it is going to be very significant. So who is paying for that? And if we do pay for that, however the funding mechanism found, what is it for?" (Interviewee 4, TfGM)*

> *"We don't see this as a big infrastructure change for us, and it is not going to be really costly. If it is going to be costly, the local authorities will not be able to support that. Because we as a local authority don't have that much money to start changing the network and implementing a lot of things. So the manufacturers need to work with the constraints that we are under. They need to have developments operating within the existing infrastructure scenario." (Interviewee 10, CCC)*

The cost-effectiveness of AV development from the perspective of the ageing population's accessibility needs is a critical issue, and to my knowledge underexplored within the academic literature. Nevertheless, as Fitt et al. (2019) argue there are alternative interventions to improve accessibility for ageing societies that go beyond enabling access to AV (e.g. interventions to improve walkability for all ages and capabilities). The cost-effectiveness of these various options is arguably another issue that should be considered from the perspective of public authorities with constrained budgets.

6.6.2. Experimenting with AVs

From the perspective of the research questions explored in this thesis, the interest is in the extent to which AV-related projects contribute to the understanding and management of accessibility implications for older people or in general accessibility inequalities.

Several factors were mentioned as key motivations from the interviewees from the local and regional authorities for their participation in the trials and studies of AVs. A certain level of optimism about the potential of AVs was a driver for some local authorities. Supporting the automotive and technological industry, as well as wider economic growth aspirations, and solutions to transport problems were mentioned by some interviewees (TfWM, MKC, OCC) as key elements of the national and local agenda for AV research and development initiatives. In addition, the belief that a transition to automated transport is inevitable has pushed some smaller authorities to take part in trials to understand the needs in infrastructures to accommodate this trend (CCC).

> *"This is where we ended this study with our meetings with DfT, CCAV. It was, why is it only one or two local authorities interested in this? Oxford, Milton Keynes, Coventry, Cambridge, Greenwich. Why are the others not interested? Before we answer that question, part of it can be the process that the councils are going through in terms of cuts in budgets and this was seen as a luxury to look at, thinking we have enough to deal with, this is not a priority, whereas other authorities might have thought we have problems this might be the solution to the problem." (Interviewee 9, MKC)*

The experimentation of public authorities with AVs seems to have served, first, as a way to facilitate the development of AVs on the grounds of their anticipated benefits. Beyond this, some interviewees from public authorities perceived indirect benefits and necessity of these projects to be able to exercise influence in the governance of AVs. It should be noted that interviewees with quite different

positions concerning AVs advocated the involvement of regional and local authorities in AV projects. Some (OCC7, MKC) mentioned that these projects allow them to co-create with developers in line with their strategic priorities. Exposing the local authorities to the governance challenges of AVs and influencing the regulatory framework were other motivations expressed by one of the interviewees from TfGM.

> *"What we practically need is, within this decide and provide where we decide that what we want is an equitable, accessible, healthy future. We need to find out how to do it. This cannot be done in response to the technological advance; it needs to be done while the technology is being rolled out. This is really why we are getting involved. Because otherwise, what you will have is a technology push, where the local authorities will be presented with the requirements, providing not just for the market forces but for the system itself. By having a rear input into these projects and making the business cases, we hope to save both our own policies as well as the industry's understanding about how this can work." (Interviewee 7, OCC)*

Many interviewees perceived these projects as ways to expand their understanding of AVs and their impacts. Currently, the projects that regional and local authorities have undertaken are in their majority focused on technological capability and the most direct impacts of AVs on traffic flow, traffic and asset management, road safety (particularly through connectedness), insurance and cyber-security. Other topics of investigation include the economics of automated transport services and developing their business case as well as parking and curb side management, for instance, in MKC. More recent projects (e.g. led by OCC) test the development of a MaaS concept and the integration of different forms of AVs with other modes (mode shift effects). Beyond the Flourish project (Flourish mobility, unknown) which, among other issues, investigated the usability and acceptance of AVs for older people, there were no other examples of projects that address social or distributional questions directly. The extent to which trials and AV projects will allow local authorities to shape the transition to AVs and the accessibility of older people within their areas of responsibility remains an open question. It will likely depend on the specific research projects and how their learning outputs feed into future policies.

6.6.3. Setting a vision and shaping AV development

Many participants highlighted the urgency for public authorities to act proactively and shape the development of AVs in line with broader strategic objectives. This was a position shared among

interviewees with varying positions concerning how AVs will affect the transport system, people and places. Therefore, there seems to be some recognition that a certain level of intervention from the public authorities is required to achieve any opportunities envisaged and avoid unintended consequences. This was possibly expressed more intensely across the interviews comparing to the content of policy documents analysed. Some noted that progress with the development of a strategic vision among transport government bodies about the future of mobility has been limited.

> *"What I am saying is you frame what you want a form of mobility to do in a much broader public context. How do we do we want to shape our cities? And if it is agglomeration economics that we are interested in, if we think that the economy will thrive when space is densely occupied and you preserve green space that is not developed, if that is the model, then how do you serve relatively small geographic areas that have very intense and very particular transport needs? And again, we have to think about it carefully. As opposed to accepting that we are going to have CAVs and try to work out what it is for afterwards." (Interviewee 4, TfGM)*

6.6.4. Perceived constraints of local authorities to shape AV development

The interviews with policy officials and experts produced some insights on perceived limitations in the power and resources of local authorities in influencing the pathway of AVs. The uncertainty around AVs in combination with the leadership of private developers have been described as critical factors inhibiting the power of transport authorities to influence the transition to AVs (Guerra, 2015; Legacy et al., 2018). In this context, one interviewee from a local authority expressed the view that their capacity to influence the introduction of AVs in the short-term is limited.

> *"I guess we only have limited power. We are the highway authority, we are responsible for the local roads, but to a large extent implement national or international rules. Most rules about who can drive on the roads, are decided in the national or international level, so we have limited ability to influence that. It might be that in the future there are rules, specifically for CAVs, and then we might be able to implement them in the local level, to either ban CAVs or make CAV-only areas. That is for the future, not for the present moment. All the UK has some code of practice, there isn't primary legislation yet for the rollout of autonomous vehicles." (Interviewee 11, BCC)*

These challenges illustrate how some of the smaller authorities may feel powerless to shape the AV development, with potential risks for the accessibility of older population groups and increasing inequality. Although some standards will need to be coordinated in the national level or international levels, local authorities are likely to still be required to manage implications of AVs and consider policies that fit their own context (Urban Transport Group, 2020). This was also a belief shared by some interviewees who recognised that local solutions (for instance, use cases) should be developed based on contextual conditions. Nevertheless, several interviewees emphasised that the lack of resources and staff within local authorities mean that it will be difficult for them to prepare for an introduction of AVs on the roads. Some of them argued that the central government needs to provide some sort of guidance or a framework to build capacity within local authorities and to avoid complete inaction.

6.6.5. Policies related to older people's accessibility

In this last section, I outline the policies and measures that were mentioned by interviewees as possible or necessary to achieve opportunities and avoid risks related to key elements of the conceptual framework[1]. The list of policies is based on the narratives of interviewees around the potential implications of AVs that are critical for older people's accessibility. Therefore, they should not be interpreted as a holistic list of policies from the respective authorities. I interpreted this list as an indication of the degree and types of interventions envisaged by the interviewees.

[1] I do not discuss here the regulations for road safety, as they are perceived to be falling mainly within the remits of the central government (and therefore is less of interest to sub-national and local authorities that consisted a large proportion of the sample here).

Table 6.2: Policies and interventions as mentioned by different interviewees

Relevant implications for older people's accessibility	Policies	Interviewees
Willingness of older people to use AVs	Research projects to explore public acceptability	Interviewee 2, Zenzic Interviewee 5, TfGM Interviewee 6, TfWM Interviewee 9, MKC Interviewee 10, CCC Interviewee 11, BCC
	Projects targeted to older people (e.g. Flourish)	Interviewee 11, BCC
	Marketing and training for older people	Interviewee 5, TfGM
Ability of older people to use AVs	Design and use of AVs in trials with certain accessibility features (i.e. wheelchair accessible and/or inclusive user interface design)	Interviewee 1, DfT Interviewee 5, TfGM Interviewee 8, OCC Interviewee 9, MKC Interviewee 10, CCC
	Provision of alternative transport services (non-automated, services that can be booked by phone, human-assisted)	Interviewee 6, TfWM Interviewee 7, OCC Interviewee 9, MKC
Affordability of AVs	Mobility credits and subsidies for lower-income groups (on-demand shared AVs)	Interviewee 5, TfGM Interviewee 9, MKC Interviewee 11, BCC
	Pricing of AVs (on-demand shared AVs)	Interviewee 5, TfGM Interviewee 12, Living Streets
The availability of on-demand shared transport across places and door-to-door mobility systems	Filling the gaps in transport provision (providing subsidies for non-profitable services, specialised transport services)	Interviewee 6, TfWM Interviewee 9, MKC
	Trialling in rural areas	Interviewee 7, OCC Interviewee 8, OCC

Relevant implications for older people's accessibility	Policies	Interviewees
	Integration with active travel and mass transit (e.g. design of hubs, location of services)	Interviewee 2, Zenzic Interviewee 5, TfGM Interviewee 6, TfWM Interviewee 13, RACF
Road safety	Regulations of trials (central government)	Interviewee 2, Zenzic Interviewee 7, OCC Interviewee 9, MKC Interviewee 12, Living Streets
The impact on the built environment and automobility dependence	Integration with active travel and mass transit (e.g. design of hubs, location of services)	Interviewee 2, Zenzic Interviewee 5, TfGM Interviewee 6, TfWM Interviewee 13, RACF
	Encourage multi-occupancy	Interviewee 5, TfGM Interviewee 9, MKC
	Pricing of services (to discourage short-distance journeys)	Interviewee 5, TfGM
	Car-free city centre (including automated pods)	Interviewee 9, MKC
	Decisions about road space allocation to AVs (dedicated lanes for AVs, use of pods in pedestrianised areas, restriction of access)	Interviewee 5, TfGM Interviewee 9, MKC
	Road pricing to manage increasing travel growth	Interviewee 1, DfT Interviewee 13, RACF
	Curb space management to support active travel	Interviewee 4, TfGM

Regional and local authorities are involved in research projects that investigate public acceptance. This research did not explore in depth these procedures. In the near future, it is likely that a range of demonstration and/or engagement activities will take place. At this stage, there has been only one research project that focused on the perceptions and attitudes of older people (Flourish mobility, unknown). One participant also mentioned training opportunities and marketing as a long-term policy that could be implemented to promote AV adoption among older populations.

There is also some policy attention to issues that relate to the capabilities of different groups of older people to use AVs. For instance, at this stage, the vehicles that are trialled are designed to provide wheelchair access and user interface that considers the needs of individuals with sensory

impairments. Therefore, the involvement of the public sector in AV research and development appears as potentially beneficial in considering the needs of older people with different mobility and sensory difficulties. Cognitive impairments did not receive the same attention in the narratives of interviewees. The literature to date suggests that AVs and in-vehicle technologies, in general, may be able to play an assistive role in older individuals with mild cognitive impairments, with less evidence found about their potential for severe cognitive illnesses (e.g. Alzheimer, dementia) (Shergold et al., 2016). Also, some interviewees pointed out to the need to ensure that services are not fully replaced with automated transport services to avoid the exclusion of groups of older people or other individuals (potentially with cognitive issues). Low use of smartphones is commented upon by some but not always as an issue of transport policy. It becomes an issue of transport policy when authorities (e.g. TfWM) consider the introduction of services to fill in the gaps for those who cannot use or do not have access to smartphones.

As far as affordability of lower-income groups is concerned, the policies discussed relate to the provision of mobility credits and subsidised transport for on-demand shared AVs. Some of the interviewees from local authorities voiced criticism about the fact that the provision of subsidised public transport falls into their responsibility. Given the concerns expressed about the restricted budgets of local authorities, the extent to which subsidies will be considered is highly uncertain. From an ageing society perspective, there are also questions about the future of concessionary fares, whether these could expand on other modes of transport beyond conventional public transport and the extent to which they will keep covering pensioners across the income segments. Having a system of integrated pricing across the various non-private mobility services was mentioned by one interviewee from TfGM. The extent to which these authorities will be able to manage the cost of these services will depend on the development of regulatory frameworks and the powers given to local authorities. Some of the interviewees explained how the lack of or ill-defined regulations in the public transport, private-hire and new mobility services (e.g. ride-hailing) inhibits the ability of local authorities to influence the prices and availability of public transport.

Some perceive that the introduction of on-demand shared mobility services coupled with automation, will lead to better public transport, easily accessible across places, reducing inequalities and social exclusion. From this perspective, interventions from the public sector are not required as the market will fill these gaps by itself. For others, it is more likely that subsidies by the public sector will keep playing a role, only, in this case, these gaps will be smaller due to reduced operational costs. Other interviewees warn about market-led development and the exclusion of areas that are not profitable (e.g. rural areas, areas with high levels of deprivation). Managing the areas of on-demand service delivery was advocated by TfGM and TfWM as a way to ensure AVs are deployed to improve

accessibility across places without replacing buses and mass transit. Possibly the most proactive approach was described by TfGM that aims to create plans for use cases (all based on multi-occupancy) of interest to the authority. Given the risks of a market-led development for the exclusion of areas (Docherty et al., 2018) and the competition with buses and mass transit (Legacy et al., 2018), the lack of more detailed plans to avoid these is arguably disconcerting from a social exclusion perspective.

Finally, some interventions to avoid an increase in vehicle miles travelled and the dominance of automobility were described by a few interviewees. Detailed plans have not been produced with respect to these implications. Some of the interviewees suggested that the respective authorities have begun considering different options to avoid growth in motorised travel and a shift away from active travel and collective forms of transport. The set of options explored includes curb space design/management, pricing to discourage short-distance journeys, allowing only for multi-occupancy vehicles and services, considering the location of services to prioritise active travel and public transport. Road pricing was mentioned as a potentially imposed measure both because of the transition to electric vehicles and the need to find new demand management measures, but it was also described as a politically controversial topic. With regard to envisaged interventions on the street level, they may have both positive (e.g. allocating space from vehicles to pedestrians) and negative implications (e.g. segregated lanes) for the walkability and the ability of older people to access places by walking (Fitt et al., 2019). Land-use policies were not mentioned as such, although some referred to changes in the parking policy to create space for development in the city centres.

6.7. Discussion and conclusion

This chapter aimed to present the positions of key actors in AV governance concerning the implications of AVs for the accessibility of older people and other socially/transport disadvantaged groups.

Most of the stakeholders included in this sample were quite optimistic about the introduction of AVs on UK roads and their implications for efficiency, widened mobility and sustainability. Nevertheless, most recognised certain unintended consequences, such as a shift away from walking, cycling and public transport. In addition, there were significant differences among the interviewees concerning their positions towards this innovation and “smart mobility” in general. Those less closely involved in AV-related projects and trials and more interested in their policy implications appeared to emphasise more the uncertainty around the impacts of AVs.

As far as the older population groups are concerned, although a few interviewees focused only on potential benefits of AVs, the majority anticipated these opportunities but noted different barriers (e.g. adoption of digital technologies, low acceptance, need for assistance, low income). In general, most transport professionals appear to recognise some barriers to AV uptake, but they may have different ideas about what these could be. Additionally, interviewees focused more on the ability of older people to access AVs and much less on their ability to reach destinations by walking, cycling and conventional public transport.

The interviewees held similar views about how AVs may affect disabled people (with mobility and sensory impairments). Many appeared to think that AVs will benefit this group, but others described this scenario as uncertain, due to potential affordability and capability barriers. Most interviewees, overall, perceived the impact on lower-income groups as quite uncertain and dependent on the use cases (e.g. private or shared) and policies selected.

Another key issue that emerges through these interviews is that the UK transport authorities are more interested in deploying on-demand shared AVs with the aspiration to fill in gaps of conventional public transport and reduce private car ownership. Nevertheless, some recognised risks for increased socio-spatial inequalities from the deployment of on-demand shared AVs.

Understanding how the UK transport authorities respond to this innovation is critical to explore the potential outcomes for older people's accessibility. Following the research and insights of others (Cohen and Cavoli, 2018; Papa and Ferreira, 2018; Fitt et al., 2019), I have argued that a proactive approach, with policies and interventions linked to the opportunities and risks for older people's accessibility, seems more likely to lead to positive outcomes for the heterogeneous older population. The interviews suggest that there is some level of recognition by key actors in the regional, local government and NGOs that public authorities need to act proactively and shape the deployment of AVs. Among the interviewees within the regional and local authorities, there seem to be some actions (e.g. accessible design) and ideas of policies that could lead to positive outcomes for older people (e.g. training opportunities).

7. Overarching findings from the interview study with older citizens

7.1. Introduction

Chapter 7 is the first of the two chapters that present and discuss the findings from the twenty-four interviews with adults aged over 55 in Greater Manchester. This chapter specifically addresses the following research questions:

- Do current and future cohorts of older people perceive benefits for their mobility and accessibility from AVs, and if so, which are these?
- What are the perceived barriers (arising from individual resources, capabilities, for instance, perceived affordability and/or preferences, perceptions, attitudes) possibly inhibiting their adoption of AVs?

As explained in the methodology chapter, the interview included two parts. In the first part, I asked participants about their awareness of AV technology and their opinions about it (benefits and concerns about how it will affect themselves and society). In the second part, I presented to participants scenarios of different automated transport services and asked questions to explore their views and acceptance levels. In this chapter, I present the themes found across the interviews about the perceived benefits for the mobility and accessibility of older people as a result of AVs and the identified barriers to adoption. The themes emerged through an analysis of qualitative data collected during the course of the whole interview. The following chapter 8 presents themes and data collected through the second phase of this interview.

I analysed the data using qualitative content analysis (Hsieh and Shannon, 2005). I used an inductive approach to coding and organising categories and themes, although the literature review helped me to identify some initial codes and categories of importance to the topic.

The rest of the chapter is organised as follows. The subsequent section describes the key characteristics of the participants. Following that, in section 7.3, I present findings around the awareness of older people to illustrate the level of knowledge about this new technology. In sections 7.4 and 7.5, I discuss the main findings related to the research questions (benefits and barriers). In section 7.6, I discuss how the chapter has contributed to the relevant literature.

7.2. Description of the sample

Table 7.1 shows the background information for participants: accessibility level, age, gender, driver status, mobility difficulty, and personal income level.

To collect information about the current accessibility level I showed different common activities to participants (e.g. grocery and other shopping, meet my friends and family, visit my GP or go to other medical appointments) and asked the questions: “How easy is it usually for you to do these by your main mode of transport?” and “Would you like to do any of these more often but find it difficult to get there?”. For a first categorisation of accessibility, if participants expressed any difficulty or unmet needs, their accessibility level was labelled as “not satisfying”.

Particularly for accessibility and mobility difficulty, the content of their responses to direct questions related to these issues was further triangulated with the wider interview transcript. For instance, Grace did not report any unmet activity participation needs when she was asked the relevant question. Nevertheless, during the course of the interview, she noted difficulties to meet with family members. A note has been made in table 6.1 to denote this. For the mobility difficulty, participants were asked this question at the end of the interview, “Do you have any ongoing health issues that make walking/cycling or getting to a bus stop difficult for you?”. It was recognised that this question could not capture all the different experiences of interviewees’ mobility difficulties. To that end, I have integrated any further information they provided about their mobility difficulty, specifically the use of other assistive mobility devices.

The average age of interviewees was 70.3 years, with the mean age being 70.5, with six participants aged from 55 to 64, eleven participants from 65 to 74, five participants from 75 to 84 and two participants from 85 and over. Women constituted the majority of participants (14 female participants, ten male participants). Two of the ten male participants and five of the 15 female participants were not drivers (in total, 17 drivers, seven non-drivers). Of the 17 drivers, one man and four women reported difficulties with driving in specific environments and conditions (the youngest of those drivers was aged 67 and the oldest 85 years). Six of the participants mentioned long-standing mobility difficulties/disabilities (five drivers, three of which use “Motability cars” and one non-driver), one mentioned occasional issues (driver), and one mentioned temporary issues (driver).

An extended version of this table is included in Appendix C, also showing the frequency of car use (driver/passenger), and the use of other transport modes. All participants made frequent use of cars, either as drivers (either every day or few times per week) or as passengers (for non-drivers it was more common to get lifts few times per week or month, for drivers, the frequency varies widely). Most

interviewees occasionally walk or use other modes of transport, with some drivers (six in number) demonstrating high car use and low use of any other modes (low frequency or diversity among modes used). Four of these drivers reported some sort of mobility difficulty.

Table 7.1: Information about interviewees' characteristics

Person	Accessibility level	Age	Driver	Driving difficulties	Mobility issues	Personal income level
Alex	Good	61	No	N/A	No	up to 12,999
Alice	Good	68	Yes	No/ Did not mention	No	13,000 to 24,999
Anna	Not satisfying	58	No	N/A	No	13,000 to 24,999
Ben	Good	58	Yes	No/ Did not mention	No	50,000 and over
Brian	Good	84	No	No/ Did not mention	No	up to 12,999
David	Good	86	Yes	No/ Did not mention	Yes/ Uses Motability car and mobility scooter	13,000 to 24,999
Elena	Good	70	Yes	Yes	Yes	up to 12,999
Emily	Not satisfying	73	No	N/A	No	up to 12,999
George	Good	55	Yes	N/A	No	-
Helen	Good	84	Yes	No/ Did not mention	Yes/ Uses Motability car	-
James	Good	76	Yes	No/ Did not mention	Yes	13,000 to 24,999
Grace	Good (self-reported), not satisfying (as expressed during the	73	No	N/A	No	13,000 to 24,999
John	Good	72	Yes	No/ Did not mention	No	up to 12,999
Kate	Not satisfying	66	Yes	No/ Did not mention	No	up to 12,999

Person	Accessibility level	Age	Driver	Driving difficulties	Mobility issues	Personal income level
Linda	Good	63	No	N/A	Yes/ Uses mobility scooter and stick	up to 12,999
Lucy	Good	67	Yes	Yes	No	up to 12,999
Natalie	Good	69	No	N/A	No (only difficulty to walk long distances)	13,000 to 24,999
Nick	Good	77	Yes	No/ Did not mention	No	25,000 to 44,999
Olivia	Not satisfying	85	Yes	Yes	Yes (occasionally)	up to 12,999 or 13,000 to 24,999
Robin	Good	72	Yes	Yes	No	up to 12,999
Sally	Not satisfying	75	Yes	Yes	No	-
Tony	Good	55	Yes	No/ Did not mention	No	45,000 to 49,999
Victoria	Good	69	Yes	No/ Did not mention	Yes (temporary)	up to 12,999
Zoe	Good	71	Yes	No/ Did not mention	Yes/ Uses wheelchair and Motability car	-

As far as poor accessibility to activities is concerned, six women appeared to experience difficulties with getting to places. Three of them were drivers, two of whom (Sally and Olivia) had regulated their driving activity in specific environments. Kate, who was also a driver without any reported driving issues, expressed that she would like to take part in more hobbies and organised leisure activities, but the lack of frequent buses in close distance to her house makes it difficult for her.

7.3. Awareness around AVs

Previous research on the awareness levels of the public led by the DfT, has shown that older people have a lower (self-reported) level of knowledge comparing to younger age groups (DfT, 2019h). Most

of the participants in this study stated that they had already heard of 'driverless vehicles' before the interview. Nevertheless, many of them emphasised that their knowledge about these is limited. The sources of information reported were mainly mass media (e.g. television, newspapers, magazines) and in one case, a younger family member. When the geographical context of trials (or widespread operation, according to some) was brought up, participants were aware only of US projects. Only one of the interviewees happened to be aware of local trials taking place in Stockport involving a driverless bus.

> *"They have a driverless bus in Stockport. Stagecoach has it, doesn't go anywhere, just around the yard. I have seen they have sensors on, they can stop at an obstruction." (Robin, 72, driver)*

Some interviewees had inaccurate ideas about driverless technology, for instance, being unsure about the nature of human control required.

> *"It was on truck or something, a man was in like a driverless truck. […] I think he had his hand on something and if he took it off, it would stop. Or did he have his hands free? I think that's it." (Elena, 70, driver)*

Even though the participants had heard of driverless technology, only a few of them commented on the state of technological progress achieved to date. There were a few interviewees that noted that driverless vehicles are already operating in the US context, without making any distinction between trials of conditionally AVs and actual use of AVs. This confusion possibly relates to how AVs are portrayed in the media, with some developers overstating the level of their current capabilities. In contrast, some interviewees pointed out that they have heard that progress is required so that these can operate in fully driverless mode. Only a few, male participants were aware of different levels of automation and what these entail in terms of human – vehicle interaction. Some men, in general, discussed more confidently the technical aspects of technology. One of them made references to the five levels of automation, while others made a distinction between driverless and highly automated. This echoes gender differences in self-rated knowledge levels around driverless technology found among older participants in the Canadian study (Robertson et al., 2019).

> *"I read they nominated five stages and we are currently at level 3, and they hope to reach level 5 by 2023 or something, quite imminent really. The latter two stages will involve the more obscure but complex things that can happen on the road." (Nick, 77, driver)*

> *"I've seen a video of one of their cars that is not technically driverless, but this aspect only kicked in, the computer took over to stop the accident. I have seen both positive and negative. But, I've used a car in America that was much more automated. It had cruise control, and it could take you to the speed of the previous car. And the lane assist could take you back to the middle. Certainly, the cruise control that slowed you down was very useful." (Tony, 55, driver)*

Awareness around driverless technology has appeared to be linked to higher acceptance, trust and perceived usefulness of the technology (Rahman et al., 2019; Robertson et al., 2019). Interestingly, the only person who stated that she had never heard of these in the past, was somewhat anxious about the safety aspects of AVs and showed the lowest acceptance to any service. Nevertheless, awareness of AVs does not seem to create positive attitudes necessarily. Older people receive information from the media, which includes both utopian visions (e.g. platooning of pods to solve congestion) and accidents taking place in trials. Three participants mentioned safety features, while only one brought up opportunities for improved road safety. In contrast, seven interviewees referred to the accidents involving conditionally AVs that have taken place to date in the US. These were again narrated as accidents caused by driverless vehicles.

> *"No, I hadn't heard about them. Well just in the news reports, that there were crashes in America, that's the only bit, the bad bits." (Sally, 75, driver)*

> *"Well, I have seen something on the television that I wasn't very pleased at this driverless car. Because it knocked a cyclist down. They said it was something to do with the lighting and the computer wasn't recognising the person in front of the car. So, therefore, they suspended all testing things." (Brian, 84, non-driver)*

> *"I have, yes, I know they do a lot of tests in America. A couple of times it tells something about killing somebody. So how does that pan out with insurance? Is it your fault or the car's fault?"* (Natalie, 69, non-driver)

It is of note that interviewees raised several questions about how technology and future mobility services will work. In these instances, I had to consider my role as a researcher and how my answers can influence their responses. When interviewees posed questions directly to me, I decided to emphasise the uncertainty around the development of AVs and to explain that I am not sure how it will work out in the future.

The questions of interviewees illustrate potential aspects of information that are anticipated by older people to help them understand the technical aspects of AVs, but also their social implications. The

questions often express interviewees' concerns around matters that might influence their adoption level. For instance, the scenario describing a driverless bus brought up questions around how you can pay for the service, how the bus "realises" if everyone is inside the bus or if people are standing on the bus stop for it. Some posed questions around the safety and reliability aspects of the technology that are of concern to them. Others made questions that reveal concerns about the broader social consequences of AVs.

> *"What would the fuel it uses be? Would it cut down cars being stuck in traffic jams and burning fuel? I think that is the only thing I would have against. We have to see the advantages first." (Olivia, 85, driver)*

The study suggests that the public has received limited information about the state of development of AVs. Older people seem to base their beliefs about AVs on media reports and articles, mostly from the US.

7.4. Perceived benefits for their mobility and access to places

Participants discussed the potential of AVs to improve opportunities for mobility and accessibility of older people. They often reflected on their current and future needs, while in other cases, they narrated these benefits for the older population, in general. They also made distinctions between their current and potential future circumstances. For instance, younger interviewees, but also in general, participants with satisfactory levels of accessibility were more likely to discuss benefits for 'older people' and for themselves in the future. Irrespectively of age, though, the interviewees refer differently to their age and may or may not feel part of an 'older population group'.

The analysis of these responses shows that seventeen interviewees associated AVs with opportunities for older people's mobility and access to destinations. The main related themes are a) a solution to driving cessation, b) enabling new journeys for drivers, c) enabling/ replacing journeys that are difficult by other modes beyond the car, d) accessing social activities and networks, e) improving mobility for people with mobility constraints.

7.4.1. A solution to barriers posed by driving cessation

This category includes benefits envisaged by interviewees for themselves in the future or the older population. Participants, particularly drivers, appeared to perceive AVs as a solution to the barriers commonly experienced after driving cessation.

> *"For older people, the loss of their license is a big factor to them getting out and about. But if then you can just get in a car, and that took you where you wanted it to, that could be really good." (Tony, 55, driver)*

The sense of independence attributed to car driving was evident in the narratives of interviewees. Lifts from others or other modes of transport were perceived as less desirable.

> *"I think it might be for people who had their own car and cannot drive anymore. They will miss it. I know I would miss that bit of independence. So, it would be able to keep your independence, rather than relying on other people, or waiting for a bus, or." (Lucy, 67, driver)*

Indicatively, Emily, who is not a driver, when asked whether she would be interested in buying a driverless car, she made a distinction between her and her husband's sense of independence. As she noted, her husband depends on his car due to mobility issues.

There was also the perception among participants that driving at an older age is risky, due to slower reaction times and difficulties with eyesight.

> *"My mother and my wife's elderly father are still driving, and I worry about them and their safety. Their eyesight is not as good, and the reaction time is maybe not so good. The technology would be an excellent way to stop worrying about them. They would still have their independence and do the things they need to do. As I am moving towards that generation, absolutely, the benefits are there." (Ben, 58, driver)*

When reflecting about their circumstances, most of the drivers (ten out of seventeen) also envisaged that this could help them ensure that they continue being mobile and keeping up with their activities, if and when driving becomes difficult or impossible for them. Drivers of diverse ages discussed the prospect of driving cessation as a barrier for their mobility.

> *"I'm happy the way I am, but I will reach a certain age, it may not be far. I am 77. You won't appreciate this. When you reach 77 there is a clock ticking, and it is*

> *getting faster. You can't think long-term anymore. If I were 87, which is unlikely, I doubt I will drive. My eyesight will fail. I took a lady last night who is 82 and has a car, but she can't drive at night. At some point, I will need to resort to an alternative form of transport. And this is possibly way far the best. Just to be able to ring and in five minutes the car is there." (Nick, 77, driver)*

Many of the participants who perceived driverless cars as a satisfactory solution after giving up driving had also narrated the importance of driving for their ability to choose and access any places they want.

> *"Unless you are really, if you went out you would have to just go to certain things, you couldn't just say "Oh, I must go to such a place". You couldn't please yourself. Not at all. To be able to get in a car and drive is just the ultimate really at the moment." (Helen, 84, driver)*

Ahern and Hine (2012) found that the mobility of women can be impacted after their spouses stop driving. In this study, Anna who is not a driver and Sally who does not drive often stated that their decision to buy or not a driverless car would be influenced by the circumstances of their husbands who tend to give them lifts.

> *"Then if anything happened to my husband and he couldn't drive, we would be totally reliant on public transport which would have an even more major impact on our life." (Anna, 58, non-driver)*

The mobility implications of driving cessation (or self-regulation) can be contextual, mediated by experience and availability of alternative transport options (Musselwhite and Shergold, 2013; Nordbakke, 2013), and possibly experienced differently by men and women (Ahern and Hine, 2012; Murray and Musselwhite, 2019). Nevertheless, the loss of a driving license can lead to reduced mobility and unmet accessibility needs (Haustein and Siren, 2014; Nordbakke and Schwanen, 2014). Beyond the impact on accessibility needs, individuals who cease driving report unmet affective needs, such as a loss of status and independence (Musselwhite and Haddad, 2010b).

Overall, participants who thought that driving cessation could restrict their out-of-home mobility, their ability to choose activities they take part in, and their sense of independence were also more likely to perceive driverless technology as useful. Losing access to a car and, consequently, out-of-home mobility is something that individuals tend to be aware of, although not necessarily planning on how to cope with it (Yen et al., 2012). Siren and Haustein (2013), in a Danish study of "baby-boomers" found that women were more likely to believe that they would have ceased driving by the age of 80. In this study, driving cessation appeared to concern drivers, regardless of their age, gender, health

situation, possibly because the topic of investigation was a “techno-solution” to the problem. As such, participants reflected on their later lives without considering a specific time horizon. Notwithstanding that, some drivers did not express concerns about driving cessation and were not interested in AVs.

7.4.2. Immediate benefits

7.4.2.1. Enabling new journeys for drivers

Driving cessation is not always an abrupt event. In many cases, older drivers reduce their activity in environments and conditions where they feel confident and safe (Musselwhite and Haddad, 2010a). Five of the interviewees, Lucy, Robin, Olivia, Elena, and Sally, had already regulated their driving activity as a result of health issues (e.g., eyesight problems), or lack of confidence and comfort with the driving task under specific circumstances. They reported avoiding driving at night, on motorways, and restricting their car travel horizons to local places. A woman also brought up personal safety concerns as a reason to avoid driving at night. Among them, Lucy and Sally thought about journeys they would like to make if AVs were available and safe. The two women referred to night-time and longer-distance journeys that they have restricted.

> *“I wouldn’t have to worry about concentrating on driving. And seeing as well. My eyesight is all right in the daylight. But I wouldn’t drive at night at all.” (Sally, 75, driver)*

> *“I might go further. [laughs] Go to places I wouldn’t drive on my own. Because if it was in the traffic it would know where it was going, but I wouldn’t like being in too much traffic by myself.” (Lucy, 67, driver)*

7.4.2.2. Enabling/ Replacing journeys that are difficult by other modes beyond the car

Some of the women who do not hold a driving license imagined that the use of driverless cars or on-demand shared cars would be a more convenient and reliable means of transport, comparing to using public transport. For Grace, who relies on buses, taxis, and lifts from friends to get to places, an automated car would give her the freedom to go out “on any encountered weather”. Anna perceived that this could offer a good solution for her as long as she is in full-time employment, after narrating

her difficulties with commuting by bus. Both Grace and Anna referred to bus journeys that they would substitute with AVs if they could.

> *"To get here, because it is two buses, I leave the house at seven in the morning; I get here by 08:15. But, beyond a couple of minutes to get to a bus stop, the rest of the time is waiting for buses and travelling in the bus. Sometimes it can bypass some bus stop; sometimes it stops to every single bus stop. For me, I'm thinking if that technology existed and if I could use that technology on the road, and now having to stop and start and wait for the buses, you know I could go from A to B in probably 15 minutes. Traffic conditions permitting that, that would be a big advantage to me, because that would give me extra time in the house in the morning to do a couple more jobs before I have to leave. That would be beneficial to me, yes." (Anna, 58, non-driver)*

Three women, one driver and two non-drivers, imagined that an AV (either a shared car from a car club or a private car) would allow them to get to places that are difficult to reach by public transport.

> *"Or go further afield, to visit relatives that are not on bus routes. I can see they would be very good." (Grace, 73, non-driver)*
>
> *Lamprini: Relatives around Greater Manchester but not close to bus routes?*
>
> *"It would be impossible to get there; you just keep in touch by phone. But, if you have that car, it will take you anywhere, all around the Greater Manchester area. I could see my sister-in-law that lives in Bolton and things like that." (Grace, 73, non-driver)*

Emily was the only participant who mentioned issues about complementarity and competition between public transport and any types of on-demand shared driverless cars. For her, on-demand shared cars should be used to increase the availability of transport in areas that are poorly served by public transport. However, her concern was if these substituted conventional public transport, some older people could be excluded either because they could not or did not want to use driverless vehicles.

7.4.2.3. Accessing social activities and networks

In general, references to specific activities in which participants would be able to engage with AVs,

were not many. Most of these references included journeys for social activities and particularly to meet friends and family members. Both drivers and non-drivers mentioned these types of activities. These benefits were imagined by women. The only exception was Ben that mentioned socialising with people at a distance, although the issue in this case related to the inability to return safely after drinking.

Some of the women that brought up social activities described lack of suitable transport options as a barrier to meeting their friends or family, or a factor leading to reduced activity participation.

> *"I used to do more. But you still have to walk quite a bit. If you go to town for an activity, you got to go to the stop, and then you got to walk, and you got to research it. Sometimes mobility is a problem. My husband is not mobile, that's why he has the car." (Emily, 73, non-driver)*

Four women emphasised the potential of AVs (shared or private cars) to allow getting out and meeting with other people, doing hobbies or getting to discretionary destinations.

> *"Well, yes, because when I'm older. If you can't get out, if you can get in a driverless car and it takes you where you want to go, to get out of the house, only if it was a local thing here or to a club you go to, to get you out of the house and be with other people, I can see the benefits of it for that." (Lucy, 67, driver)*

> *"If you can go that far, it would be lovely, wouldn't it? Because me and my friends, three or four of us, go on a quiz on Tuesday nights, and we have to take an older person than us with us. That kind of thing, that would be good, because it is a regular trip. I also go dancing, and we always get a lift for that from other people. So yes, a local thing, sounds good." (Grace, 73, non-driver)*

Going to places at night or getting to touristic destinations were other discretionary activities mentioned by a few female participants. For instance, Zoe, who drives her Motability car, referred to long-distance travel as a reason to prefer a transport future with driverless cars (final scenario).

> *"I think probably I'd go for B. Because if I want to go on long journeys, I've been going to Blackpool and other places during the summer. I'd prefer to drive there. A minibus or taxi wouldn't take me to Wales. There would also be the cost to get a taxi or a minibus; it would depend on that." (Zoe, 71, driver)*

Overall, participants who imagined immediate benefits for their out-of-home mobility and access to places were mostly women of diverse ages, drivers and non-drivers. The female drivers (Lucy and

Sally) who reported these benefits had already self-regulated the use of cars and had some unmet needs, mostly concerning meeting relatives. Non-drivers with (Anna, Emily) or without access to a car (Grace), also imagined benefits in getting to places difficult to reach by public transport or going out at night. In terms of access to particular activities, participants thought about mainly leisure activities, visiting friends and family at a distance, and to a lesser extent hospital appointment, or commuting to work (for those participants still in employment). Older adults who do not drive, have been found to have significant unmet needs in terms of visiting their friends and family or doing their hobbies (Siren and Hakamies-Blomqvist, 2004; Haustein and Siren, 2014; Luiu et al., 2018b), although there is counter-evidence showing that those without access to a car can be more connected to their social networks in certain rural contexts (Shergold, 2019b). Similarly to this study, participants that participated in workshops and trials of AVs in the Flourish project when asked to think about specific destinations they would like to visit they mentioned more frequently cultural destinations and the countryside (Shergold, 2019a). In any case, the interviewees' accounts indicate that people who experience difficulties in getting to destinations because of lack of transport may hope to use AVs in the future.

The gender effect (in perceived immediate mobility and access benefits) may be partly explained by the small sample (particularly of non-drivers). There was only one male driver who mentioned regulating his driving activity, but he was concerned about the lack of control in driverless cars and did not report reduced engagement with activities. Similarly, the male non-driver participants seemed to be coping well with getting to the places they need by non-car modes. Beyond this, though, older women are considered as one of the main beneficiary groups of driverless vehicles due to their unmet access needs (Shergold et al., 2016). The unmet needs appear to be related to transport factors, such as their lower rates of driving license ownership (DfT, 2019g) or ceasing driving prematurely (Adler and Rottunda, 2006; Siren and Hakamies-Blomqvist, 2006).

7.4.3. Improving mobility for disabled people and people with mobility difficulties

Some of the participants mentioned benefits for older people who experience mobility issues, as well as disabled people of all ages. They further referred to potential suitable driverless services to assist those with mobility constraints. These included driverless cars offered as free public transport, driverless dial-a-ride, and private cars. A few of them also made the point that people who use volunteer driver schemes or dial-a-ride would be benefitted if they had the option of driverless cars.

> *"You could have multiple of these people that use the volunteer driver service saying, 'I no longer have need of these services because I can purchase a driverless vehicle, which then may come at cost or whatever." (Anna, 58, non-driver)*

Among the interviewees, six had long-standing mobility difficulties (from milder problems to physical disability), of which five are drivers. Among them, three were using "Motability" cars (David, Helen, Zoe), whereas the first two also used a mobility scooter and the latter one was a wheelchair user. Linda, who is not a driver, also uses a mobility scooter, while James and Elena (drivers) also reported issues with walking and getting to bus stops. These participants did not seem to share the same views on driverless technology. In fact, their attitudes and perceived usefulness ranged from strongly positive (Helen and Zoe) to strongly negative (David, Linda, Elena). Their trust in driverless technology (safety and reliability aspects), the extent to which they are reliant on cars, the degree of mobility difficulty/disability and requirement of assistive devices, their expectations of driving cessation, and to a lesser extent, their attitudes towards new technologies, seemed to influence their views.

7.5. Perceived barriers to adoption of AVs by the older population

Participants discussed concerns and potential barriers to adoption for the older population and, particularly, certain sub-groups. In this section, I outline the overarching themes around barriers. Barriers specifically associated with different use cases of AVs are discussed in the next chapter.

7.5.1. Age as a factor influencing future adoption of AVs

This theme relates to other following themes falling under the category of barriers. It is worth examining it first, as it shows how interviewees themselves narrate the potential age differences in the adoption of AVs. Twelve participants mentioned older age as a factor underlying willingness and ability to use AVs (either reflecting on their own perceived abilities and habits or for older people, in general). From the participants' point of view, the age barrier relates, first, to the broader digital technological divide. Some commented that younger people would adapt more easily to this transition, as they are more used to multiple digital technologies and devices. In their view, for older people adjusting to AVs would require a significant learning curve.

> "Given that, at the moment we have an old generation that struggles with IT, never mind with cars, it is not going to be this generation. Just like IT, as more are using

> it in their daily lives, they will accept it as they get older. It is a transitional thing; it might take 50 years, I don't know. There will be some early adopters and some people that will always struggle with it." *(Kate, 66, driver)*
>
> "Another thing is generational. A technology you are not familiar with. For a child that has always used an iPad, Apple technology or whatever company later on, it is not an issue. For someone who has never used it, it is like black magic.*" (Tony, 55, driver)*

When participants referred to their personal experiences with digital technologies, it was clear that these can be quite heterogeneous within the older population. Helen, 84, said that she 'loves the technology' and thinks into the future. She described the use of various other 'smart' technologies, smartphones, smartwatches, and her excitement about technological progress. In contrast, the narratives of some interviewees (for instance, Elena, David) point towards the lack of training to learn how to use modern technologies and their lack of confidence that they can manage to learn how to operate upcoming transport technologies. Lack of experience in digital technologies (e.g. smartphones or applications) was also evident in questions around booking and payment of AV services.

> *"Not lots of my generation are computer literate; we were not taught computers like you are. They baffle me. And I still have my marbles. A lot of people have dementia..The people where I live they are all my generation, the place was built for people who needed extra care. I can see only two people who could use it. The majority I would say no. You have to wait until that generation disappears." (David, 86, driver)*
>
> *"You would have to get used to it, wouldn't you? I could go on a driverless bus, I don't think I would go on a driverless car. If it seems to be working and it was safe, I would go on it.*
>
> *Lamprini: It makes you feel safer if it is not your car?*
>
> *Yes, it is hard to learn new technology in my age, I think, isn't it? I'm old, that is what I feel." (Elena, 70, driver)*

Accounts such as that of Emily and David suggest that some older people feel that AVs would exclude people with cognitive decline or impairments. Some participants associated older age with phenomena of cognitive or physiological decline. This belief influenced how they responded to the idea of AV adoption by older people.

> *"By the time it gets to me, I would be so old I wouldn't know where I am going." (Emily, 73, non-driver)*

Age was also associated with psychological barriers, such as lack of trust in new technology. One participant, Victoria, felt that older people would be anxious about whether they will be taken to the right destination. Victoria, as other people interviewed in this study, is a volunteer driver in a community transport scheme. She was sceptical about whether AVs would be useful for older people who need assistance from others.

> *"Buses, yes, I can understand. I can imagine it with putting something on the bus stops. But, to go pick someone up and taking them whenever they are going, like I'm doing this afternoon. I can't imagine how a person, an older person is going to get on with it.*
>
> *Lamprini: What do you think will be the difficulty, to get in and out?*
>
> *That and a lot of them don't like modern technology. They might be frightened of not getting where they want to go, being stuck somewhere. There are people struggling to get in the car. That could be another thing. I have to help some people I take regularly. I don't know, it is weird. I can't imagine it all." (Victoria, 69, driver)*

For Robin, his age means that he may be less willing to trust the technology and adjust to this change in the mobility system. Robin narrates the introduction of AVs as something to which older citizens need to adapt. He does not, though, perceive it as a positive change for his mobility.

> *"But, whether I could get in one and travel on the main road, I'd have to be blindfolded so that I don't see what is happening! [laughs] Tell me when we are there! A bit scary. I suppose the youngsters today, the young teenagers, they won't be scared because this is something that they grew up with. You can't teach an old dog new tricks they say." (Robin* 72, driver*)*

Finally, seven participants said that one of the reasons they are not so interested in AVs is that they believe it will take a long time until these can be used on public roads. Except for Olivia, who held positive attitudes towards AVs, most of those who shared this belief seemed to be somewhat sceptical about their usefulness.

> *"I think this won't happen in my lifetime. If I was 50 years younger, I'd be looking to new avenues, technologies. And I would be more acceptant to new technologies." (James, 76, driver)*

> *"I think because we are not seeing it moving quickly, we think it doesn't matter to me because it's not coming at the minute. I think it is something I would look forward to seeing it and trying it." (Olivia, 85, driver)*

Participants often refer to older age as a barrier either for themselves or older people. Previous research has shown that older people tend to feel less confident than younger population groups that they will be able to learn how to operate driverless cars (Lee, C. et al., 2017). This was, indeed, reflected in the accounts of interviewees. Nevertheless, participants suggested additional reasons why older people will not be equally willing or able to use AVs as younger generations. Trust barriers, beliefs about the level of technological development achieved, and perceptions of how AVs will interact with older people's capabilities seem to influence their opinion about potential age differences.

7.5.2. Suitability for people with severe physical and cognitive disabilities

As mentioned in the previous section, some appeared concerned about the extent to which AVs can be useful for older people with severe mobility impairments and disabilities. For a few interviewees, these barriers seemed to be quite critical concerns that influence their (negative) attitudes towards AVs. By contrast, others seem to perceive it as something that needs to be considered, for instance, to ensure that some human-driven services are maintained.

Ensuring that the vehicles are wheelchair-accessible was one point raised. Beyond this, others who had experience as volunteer drivers or giving lifts to friends mentioned the need of some older people for assistance from someone else to get in the vehicle. Anna narrates her experience from her close involvement in a community transport scheme.

> *"As with the volunteer drivers, we will get people bringing in their mothers and fathers. They say they are prone to falls, they need an arm for support from the driver, just open the car door for them and walk with them. In that scenario, those people would still need someone to assist them. For people who are more able-bodied, [they] wouldn't need assistance to the walk in or inside the vehicle." (Anna, 58, non-driver)*

For some disabled people who use wheelchairs, assistance from others can be necessary for some specific journeys. Zoe was quite enthusiastic about the prospect of driverless cars. However, she explained that for some of her journeys (for instance, shopping) she uses a taxi and not her Motability

car, as the driver can help with her shopping.

Five participants also felt that the technology might not be appropriate for people with cognitive impairments, particularly those with dementia and Alzheimer's disease. They pointed out that individuals with severe cognitive problems may be confused about booking a journey or their destination.

7.5.3. Perceived lack of usefulness

The analysis showed clearly that not all older people share the same beliefs about the potential mobility and accessibility benefits of AVs. Although some interviewees believed that AVs would improve their ability to get to places, either now or in the future, others felt that they would not gain any substantial benefits from this technology. The next chapter illustrates how participants' mobility could or could not change due to different forms of AVs. Nevertheless, for some of them, AVs were not an attractive future mobility option, regardless of the hypothetical use case. For many of these individuals, the perceived lack of usefulness coincided with concerns about the safety capabilities and reliability of AVs, lack of control, and other potential negative implications of AVs (e.g., unemployment of drivers).

The non-drivers who felt that they could manage their mobility and access needs without much trouble by public transport and with the help of their families and friends were not very interested, as expected. The cases of Brian and Linda are illustrative of this. Brian explained that the bus allows him to meet his needs because he knows how to "time it". Although he felt that he might not maintain the same mobility and activity participation level in the future, automated taxis or cars would not be attractive travel options for him. Linda, who was quite anxious about the safety capabilities of AVs, explained to me that she felt other options exist for those who cannot drive because of mobility or health issues.

> *"Lamprini: Some people believe they may be beneficial for people who don't have a license or cannot drive because of a mobility or health issue. Do you think it may be beneficial for these people?*
>
> *No, because I still think they have trams, taxis, and family members. I know not everyone has family, but you also have ring-and-ride and local support, or ambulances to pick you up if you are unable. I don't see any benefits, that's all." (Linda, 63, non-driver)*

Some drivers also saw little relevance for their own lives either now or in the future. They did not mention concerns about potential driving cessation, and they explained that they prefer driving and being in control of the vehicle. This was seen even in cases of individuals who report some difficulties with driving, for instance, not being able to drive at night because of eyesight problems (Elena) or in motorways (Robin).

7.5.4. Affordability of automated (private or shared/public) transport

Participants raised many questions about the cost of driverless cars. Although some male interviewees mentioned a potential reduction in the cost of insurance for private cars as they could become safer, others explained that the cost of purchase might obstruct them from buying a driverless car, even if they may want to. Some also raised the prospect for authorities to develop schemes, for instance, within the Motability scheme through which disabled drivers currently get accessible cars or schemes to replace conventional cars.

It is of note that participants did not only think about the absolute cost of the various types of AVs but also how their introduction will affect the transport expenses of older people in the long-term. Few participants also made the point that the choice to buy a car, either for themselves or in general the older population, would depend on how often they choose to go out. If the number of trips is low, on-demand transport solutions would be preferred on the grounds of lower transport costs.

> *"Yes, I think so, you know I am reaching the age when I may not be happy with owning a car, when driving reduces somewhat. If there was a club that allowed me to use a car occasionally, it would presumably reduce my running costs. I could just use them to pick me up from wherever and go to wherever I wanted to. The other four or five days home I could relax home. If I had stopped the volunteering driving. That would be an excellent idea." (John, 72, driver)*

Other participants brought up the lack of affordability for private cars as a social issue, not necessarily affecting them. They suggested that those who cannot afford a private car, they might use on-demand shared cars or taxis.

> *"That is only for rich people I think who can afford to buy their own car. I would see the majority wouldn't be able to access that. Maybe they will be lumped together with car share." (Emily, 73, non-driver)*

In general, the types of models (private cars or shared cars/taxis owned by the public sector or private

companies) was a question raised by some participants. An interesting point raised by one interviewee was that on-demand models would entail higher transport costs for older people, who can use concessionary fares for buses.

> *"Nobody will own a car in the end. As for the cost, it will cost less than owning a car, but possibly more than public transport for the elderly. [….] There are a lot of people here that have to count pennies, they can't afford it. This is why I give people lifts. Most of them are able to go for free by public transport, if there is a local bus stop – which is not always the case. It may be that the driverless car for the person over 70s." (Nick, 77, driver)*

The introduction of AVs also raises critical questions for the future of concessionary public transport policy for a few participants. While Nick and Emily thought about the provision of free on-demand services, Alice questioned if the policy of concessionary bus fares would continue in a transition to AVs.

7.5.5. Safety, reliability and the sense of control

Aspects of safety and the related issues of reliability and control over the driving task were among the most discussed within the interviews. It should be noted that the scenarios described the driverless vehicles as 'safe to use both for the persons inside the vehicles as well as for pedestrians, cyclists and users of other vehicles'. Despite that, interviewees expressed their safety concerns both in the initial phases of the interview and during scenario exercises.

Overall, the anticipation of safety benefits was low among participants within this study. As mentioned in section 7.2.2, seven participants were aware of accidents that had taken place with AVs in the US, and this might have had affected their perception of safety. Five participants emphasised the potential for driverless vehicles to be safer than human drivers or to become safe as the technology progresses. In contrast, 18 of the interviewees raised concerns and questions relating to the safety features and the levels of human control over critical situations. In any case, reducing the number of accidents or eliminating road rage and risky driving behaviours, was perceived as a significant potential benefit of the technology.

> *"If you could work out the no crashing thing, then you'd hope they would be safer. On my way to work today, I saw a crash. You would hope that these would eliminate these sorts of accidents. We are human beings, prone to distraction,*

making errors. I'd hope that if you can eliminate the human aspect, you could reduce accidents." (Tony, 55, driver)

Some of those who showed trust in the safety capabilities stated that they had heard about the technical and safety features of the technology (for instance, their sensors). This also illustrates that information about the technology and how it works may increase confidence in its safety aspects. Lack of knowledge about the mechanisms of technology seemed to lead to more scepticism about AVs. Participants, on many occasions, asked for information, for instance, about how the traffic lights are regulated with driverless technology or how the driverless vehicle recognises pedestrians and cyclists.

In addition, regulations and controls by authorities were also perceived by some participants as a reassuring process about their safety potential.

"The authorities will make sure before they are released. And I'd be happy with that if the authorities made the checks." (John, 72, driver)

"I don't think they would put them on the road if they weren't safe. If they were safe and they were working, yes, I would feel safe." (Helen, 84, driver)

"I am hoping they will be safer, so you wouldn't have drunk drivers, road rage. I would hope they will be tested before they are allowed on the roads. I am pretty sure they will be. We are all scared of new things, aren't we?" (Zoe, 71, driver)

7.5.5.1. Limitations and failures of the technology

Linda was the most concerned participant about the safety of AVs, perceiving them as less capable of navigating the road space safely in comparison with human drivers. Beyond her, many participants showed scepticism about the extent to which driverless vehicles can cope with complex driving tasks, from driving on a congested city centre road to dealing with near misses. Participants also described empty vehicle running for parking or charging as possible limitations of AVs.

"I think it will be harder in a city centre like Manchester, because it is so busy. Motorway I can see because you go straight on." (Natalie, 69, non-driver)

"And if you couldn't park, that would be a problem. If you are going to hospital appointments, it is a nightmare with parking. […] No space, you have to go around and around. If it dropped you off to an outpatients appointment, it would then have

> *to go and park itself. How would a driverless car cope with that? The practicalities are overwhelming." (Emily, 73, non-driver)*

Many participants discussed the likelihood of failures. Participants reflected on negative experiences with current technologies to imagine and argue for these potential failures. Lack of reliability in certain environments ('rural roads' or 'foggy days') was another cause of concern. Other issues related to the reliability in specific applications of the technology, for instance, being taken to the right destination by a taxi or being sure that the bus will stop at the correct location.

> *"I would like more reassurance on the accuracy and reliability of it. One thing that springs to mind is that at the moment SatNavs are not always accurate in town centres. SatNav ability needs to be finetuned to be absolutely foolproofed. That's the main thing really. If you think the practicality of getting by your vehicle from A to B. It is the reliability, certainly in this country, how it would find locations. I would want the SatNav to be better." (Kate, 66, driver)*

> *"The SatNav would need something to pick up the signal? And what about grey areas, like in the hills in the Pennines, when the reception is poor? And what about foggy days will they be able to operate with their sensors, or will they think there is an obstacle there and they don't move?" (Robin* 72, driver*)*

A common issue brought up was also what they could do in case of an emergency, whether there would be a call or control centre that could assist the public.

> *"I was just thinking that when that happens or when technology breaks down. They do break down, computers, from time to time. What happens then? That is my concern? Is there somebody to ring, is there a centre or something telling you what to do how to program it or something?" (Natalie, 69, non-driver)*

Four participants also proposed that training and, possibly even a driving license, would be essential to allow the public to use them. Emily, who does not drive, said that she would not be as able to 'understand' the car and ready to deal with emergencies as a driver would. Similarly, Alex believes that technology cannot be perfect, and people should be trained and alert to react in emergencies, possibly by taking over control of the vehicle.

The interaction with cyclists, pedestrians and conventional vehicles was less frequently mentioned than other safety limitations of AVs. Most of the participants focused on imagining themselves as adopters of the technology and discussed safety and reliability as potential users. Therefore, the references on the safety of cyclists and pedestrians were few (including the well-known accident in

the US involving a “driverless” car and a cyclist). The transition period when conventional and driverless cars may co-exist, though, received some attention from participants. Tony described this as an “uneasy period” where two different cultures will collide. For others, it was important to know if they will be on dedicated lanes or roads, as they perceived it impractical or unsafe to have a mixed fleet on the roads.

> *“Because a human in a car that is not driverless and a bus that is driverless. The human in that will take advantage of that bus. If he thinks that he can proceed at speed, try to overtake or outmanoeuvre that bus, a driverless bus must be accompanied by a driverless car. So that both will have the sensitivity built in them, computer chips or computer systems within the cars to be able to coordinate with each other. You know how drivers are going to take advantage of that driverless bus?” (Alex, 61, non-driver)*

Most of the studies on older people’s acceptance towards AVs suggest that reliability and safety are significant concerns (Nielsen and Haustein, 2018; Huff et al., 2019; Faber and van Lierop, 2020), beyond few exceptions that show overall high levels of trust on the safety aspects of the technology (Rahman et al., 2019). Quantitative studies from the UK also show that a large part of the public (regardless of age) is worried about technical failures and driverless vehicles' interaction with other road users (Acheampong and Cugurullo, 2019; DfT, 2019h).

This study illustrates the need for citizens to know both about safety benefits in the long run and how any new safety risks stemming from the technology are addressed. The communication of the safety features and the procedures for safe testing and operation by public authorities are likely to be critical for the adoption by the older population. Training and clear guidelines on what is expected from the users when they are in the vehicle would also be reassuring for older people.

7.5.5.2. Lack of control and preferences for a steering wheel

Participants raised the related issue of (lack of) control over the driving task. Giving up control appeared as a troubling idea, particularly for drivers who pointed out their long-term driving experience. Discomfort with the idea of losing control was further illustrated throughout the first scenario conversation. The first scenario was discussed with 17 participants, 16 out of 17 drivers and Natalie, who had recently lost access to her car but still had an active driving license.

Nine out of the 17 participants preferred the option to have a steering wheel in the "driverless vehicle". Also, four participants would prefer a vehicle with a wheel either in the transition period to fully driverless or as long as they were capable of driving. Finally, four of them showed a stronger preference for fully driverless vehicles.

The most frequent reason for choosing a 'semi-driverless' mode was the need to retain a sense of control in case of an incident.

> *"I would prefer to have the driving wheel. I think for people who have been driving for many years, like myself, we feel that we want to retain some control of the vehicle in case the systems do not work as we expect. And I know there are many reliability tests you can do to show how good a software is. But there is this feeling inside that I want to have something that I can do." (Ben, 58, driver)*

The interviewees described using the wheel in emergencies. In some cases, their preference over a wheel stems from a resistance to the idea that AVs could deal with complex, real-world situations.

> *"You are limited by my imagination on how the technology could advance. There are things like parking, you need to park and there are no allocated spaces. Or you need to drop somebody off and then go to park. How can you do that? All the nuances of driving. Like I said this might be limited by my imagination, rather than the practicalities of it." (Tony, 55, driver)*

Having the ability to change your mind, for instance, about the route someone wants to follow, was raised both in the context of this scenario and, in general, throughout some interviews. A level of manual control was also considered as necessary on the grounds of security by one participant.

> *"I would prefer it to have a wheel. If you are driving in an area where it is particularly prone to burglaries or car-jacking and stuff like that, you must have the option to take over the car manually and drive off. An automated car wouldn't have that feature, or it wouldn't know. Or the criminals could find a way to circumvent that. So you must have the ability to manually take over." (George, 55, driver)*

Two participants mentioned that they would like to have the option to drive on certain occasions as a reason to prefer a semi-driverless against a fully driverless car. The enjoyment of driving was raised by five drivers (three men and two women) as a barrier to accepting driverless cars. The participants, though, associated the enjoyment with a sense of being in control in most cases.

> *"Like I said, in America, there is fantastic scenery and it is pleasurable. There is an element of freedom, that you are in control of where you are going. It is you, if you get me. You are not being taken somewhere by machines. It is your decision and choices. 'Actually, today I want to go here, and I will go this way, or I will try to return from this way'. I suppose the technology may allow you do that, but again limited by current technology." (Tony, 55, driver)*

The need to control aspects of the driving task affected how participants imagined using their travel time in a driverless vehicle. Some of the interviewees expressed inconvenience with the idea of doing activities while in the car. For people who preferred having a wheel, beyond motion sickness, the main argument was that people should still be alert and concentrated on the road environment.

> *"I'd prefer the second one, perhaps. The steering wheel could be used as an accelerator pedal, to make it go faster or slower, that will give you something to do. And how would you put it in reverse? I suppose there would have to be a program in them." (Robin*,72, driver*)*

In contrast, two of the four individuals that preferred a fully driverless capacity, gave as a reason the willingness to engage with other activities (e.g. sleeping, reading a book). For the participants who preferred a fully driverless mode, this option was perceived as safer. Two made the point that a steering wheel would be a distraction or risky if people engaged with other activities. Nick also made the point that the driving skills of people would degrade if highly automated, semi-driverless vehicles were used. For Olivia, who has begun considering driving cessation, a semi-driverless vehicle seemed like an inappropriate option if she decides to give up on driving. Other arguments made against the semi-driverless is that they would not allow everyone to use them, reducing their potential benefit for society.

> *"If I am at somebody else's car, I do question the driving. I wouldn't want to do that at all. I think younger people or young people would want to do that. I can see my grandchildren would want to do that. I do enjoy driving, but I've driven for a very long time, and I couldn't do without it because of where I live. But, once I decide to give up, then it has to be wholly." (Olivia, 85, driver)*

Nevertheless, even among drivers who would prefer a fully driverless capability, some individuals mentioned the fear of not being able to exercise any control. For instance, Nick said he would prefer a fully driverless mode, but he would not be among the first adopters within the transition period.

> *"This question of who is in control. Well, I think literally everybody will be nervous about not being in control of it. It will just develop steadily. Apart from some courageous who will abandon control earlier. I'd like to wait." (Nick, 77, driver)*

> *"I just think it is the responsibility for something automatic. You don't know if someone is going to step in front of you, or cars are going to change lanes, how fast it goes, how slow it goes when it is raining when it is foggy. It is just a lot of things to think to put your trust on something and not to want to just use your hands, do it yourself." (Zoe, 71, driver)*

It should be noted that having some sense of control was also a requirement for non-drivers. For instance, Linda said that she would feel safer on the road (either in another conventional car or as a pedestrian) if a driver could take over control of the cars in some cases.

The lack of control over the driving task appears to be an important issue that developers and policymakers need to consider in the design of automated technology. In the study of Shergold (2019a), participants in pilots expressed the wish to maintain some control, for instance, through an emergency stop button. Li, S. et al. (2019b) found that most participants would prefer a partially (level 3) versus a fully (level 4/5) automated vehicle (SAE International, 2018), although many specified this would be different for themselves in the future, if and when cognitive and health impairments made driving difficult for them. In this study, the driverless vehicle with the steering wheel was not described as what SAE International (2018) names a highly automated (level 3) vehicle; an automated system that requires from the user to respond promptly and take over the driving task safely. The conditions under which the manual takeover would take place were left open to the imagination of participants. The manual takeover seems important for them to compensate for the limitations of the technology, for any malfunctions and unprecedented risks. The way control is turned from the driverless system to older people in AVs, though, has implications for their safety. Current research with conditionally AVs (level 3) suggests that older people have poorer manual take-over response in comparison to younger people, particularly when they are completely disengaged and focused on secondary activities (Li, S. et al., 2019a).

The tension between retaining a sense of control and being able to use it in the future was apparent in the responses of many participants. As discussed in section 7.4.1, many driver participants attributed high values to driverless technology because of the role it could play after potential driving cessation. There may be diverse needs, particularly among drivers, ex-drivers, and people who have never driven, in terms of controlling the driving task. In any case, it will be essential that researchers,

policymakers, and the industry consider these needs in the development of these innovations, engaging with older people.

7.5.6. Wider societal concerns

The interview data suggest that the acceptance of older people is dependent on the broader transport and social implications of AVs.

Better traffic conditions were imagined by some as a result of traffic management. Others, though, believed that the number of cars would be equal or higher and assumed worsened traffic conditions. Empty vehicle running and rules about the number of cars allowed per household were other points raised by participants as critical for future congestion conditions.

> *"But, I think it is going to have to be something completely different than this [shows image]. It is just too much traffic. Going to Radcliffe from here is like sitting in a car park really. If it was driverless.Perhaps you would be able to move a bit quicker with them being driverless, the sensors would move them all along. But, you would be on a chain." (Helen, 84, driver)*

Whether they would be electric or not was another commonly raised question. A few of the participants expressed hopes about improved air quality and reduced fuel consumption, while others were concerned about the lack of noise in electric vehicles.

Finally, five participants were concerned about the unemployment effects of a transition to driverless transport. Most of them talked about putting drivers across the transport sector out of jobs. One of them also perceived further unemployment risks if the number of cars bought and used is lower, due to a transition to on-demand models and fewer accidents.

7.6. Discussion and conclusion

Most of the participants in this study, overall, imagine that the technology would have benefits for their later lives or for older people in general. At the same time, participants mentioned factors that could exclude or discourage older people from the use of AVs.

Participants confirmed AVs' potential to reduce some barriers to out-of-home mobility for older people. AVs could reduce the following accessibility barriers (under many preconditions as discussed in the next paragraphs), according to the participants:

a) **Driving cessation or self-regulation** (either experienced by older people themselves or within a household, specifically relevant to older women);
b) **The lack of or poor-quality public transport and door-to-door connections** (particularly in connection to social networks and leisure destinations);
c) **The difficulty or inability to use private cars and other public transport forms due to physiological impairments or health issues.**

Participants mentioned that they would like to use AVs for leisure and social purposes, which is in line with results from other relevant studies (Musselwhite, 2019; Shergold, 2019a; Faber and van Lierop, 2020). It is also possibly associated with difficulties to meet discretionary needs for older people without access to a car (Siren and Hakamies-Blomqvist, 2004; Haustein and Siren, 2014; Luiu et al., 2018b).

In this study, older women (drivers or non-drivers) reported the necessity for AVs because they are more likely to experience barriers in getting to places. Older men who had access to a driving license perceived AVs as a potential solution if they had to stop driving, allowing for the same sense of independence and mobility as cars do nowadays. Men that do not drive did not perceive any personal benefit from the introduction of AVs, as they were satisfied with their current mobility and activity participation levels. These gender differences are possibly partly explained by the qualitative nature of the study and its small sample. Nevertheless, studies also suggest that women have more unmet accessibility needs than men (Hjorthol, 2012; Kim, S., 2011; Luiu et al., 2018b).

The views of participants that reported long-standing mobility difficulties/disabilities were quite polarised. Many of them are heavily dependent on their (conventional or Motability) car to get to places. For some of the disabled drivers (for instance, based on the accounts of Zoe), AVs would allow them to keep up with their out-of-home mobility and activity level and choices if they had to stop driving. However, for others (for example, based on the narratives of David), AVs did not appear as an attractive transport option due to various barriers and concerns, for instance, lack of trust in AVs.

The study found several factors that may exclude or discourage older people from the use of AVs. Some factors affect the ability of older people to adopt AVs:

a) **Suitability for people with cognitive and severe forms of mobility impairments:** Participants in this study doubted about the usefulness and safety of this technology for people with dementia, Alzheimer’s disease and certain forms of mobility impairments. Services with

human assistance may still be required in the future to cover some mobility needs and journeys.

b) **The cost of private and shared AVs:** The findings of this study also suggest that if shared AVs are proposed as a new form of public transport, older people may consider their cost in relation to the policy of concessionary fares.

Other factors are associated with the ability and the willingness of older people to be users of the technology:

a) **The pre-existing experience with digital technologies and the perceived ability and opportunities to learn how to use AVs:** The narratives of interviewees show that this is not a universal issue across the whole older population, with some interviewees having more experience and confidence with the use of digital technologies.

b) **Concerns about safety and reliability:** These appear as significant barriers in older people's willingness to use AVs. As a result, some older people may show a strong preference for an automated system that allows human drivers or licensed users to retain a control level in the driving task. The extent to which this would be safe and inclusive of the needs of different groups of older people (e.g., driving experience, confidence, and ability) would depend on the shape the technological development takes.

c) **Wider societal concerns**, including the impact of AVs on traffic congestion, potential unemployment effects and air pollution.

It is worth noting that the benefits perceived by policymakers and experts are broadly in line with those perceived by the participants in this study. There are certainly some new issues raised in this chapter, for instance, the gender element and the willingness to use AVs for leisure and social needs. With regard to the perceived barriers to AV adoption analysed in this chapter, some transport policymakers and experts mentioned some of these. However, barriers related to trust in the capabilities of AV technology, and the influence of wider social effects on public perceptions are possibly less anticipated by policymakers and experts. The affordability of AVs also seemed to be more prevalent in the discussions with older people comparing to the documents and the interviews with transport professionals.

8. Findings from the interviews with older people related to different automated transport services

8.1. Introduction

In this chapter, I also draw from the qualitative interview study in Greater Manchester. I present the findings related to the acceptance of older people to use AVs in various forms, as examined with the use of scenarios during the interviews. The scenarios explore the final research question of this thesis:

- What is the willingness of current and future cohorts of older people to adopt different types of automated vehicles & services, and what are the factors (benefits, barriers) appearing to influence this?

I asked interviewees to express their opinions about and intention to adopt the following automated transport services:

1. Automated buses: These refer to fully driverless fixed-route and timetable buses, same as conventional buses but without the use of a driver. The cost was described as similar to that of current buses.
2. Automated taxis: The hypothetical service refers to a fully driverless taxi service that requires the use of smartphone applications. The service is one plausible scenario of on-demand asynchronous sharing of AVs. The cost was described as similar to that of current taxis.
3. Automated shared taxi: The scenario describes a fully driverless taxi service that requires the use of smartphone applications and involves the sharing of a ride with another passenger who books a journey from and to nearby places. It portrays a plausible application of on-demand synchronous sharing of AVs, a form of ride-sharing. The cost of automated ride-sharing was described as cheaper than that of taxi services.
4. Automated neighbourhood car club: The hypothetical driverless car club service refers to a car rental scheme. The shared cars can be accessed from a designed parking spot within one's neighbourhood. The hypothetical service deviates from the 'automated taxi' scenario, as it deliberately does not describe a door-to-door capability. The scenario is similar to automated taxis but possibly less 'realistic' as a future service offered by operators and local authorities.
5. Automated private cars: The scenario describes fully driverless private cars. Their cost was described as similar to that of a 'good brand new car'.

Following these, I presented to participants two alternative transport future scenarios, one suggesting improvements for active travel and public transport availability, and the other the introduction of automated private cars.

As discussed in the methodology chapter, I analysed the data using a qualitative content analysis (Hsieh and Shannon, 2005). I used a deductive approach to analyse interviewees' responses regarding their willingness to adopt different services. The primary category, 'willingness to adopt different services', was divided into three sub-categories for each service. The first category reflects a somewhat positive attitude to adopt the service. The second category was applied in the cases of participants that were quite unsure about whether they would use a specific automated vehicle or service. The third category was used to label responses that expressed a quite negative attitude to adopt the service. Table 8.1 shows the criteria I used to categorise these responses systematically across the interview data and the findings for each interviewee. The table in Appendix D is an extended version of this table and includes examples of quotes labelled under these sub-categories/codes.

Beyond their level of willingness to adopt AVs, I analysed the particular factors influencing or restricting the interviewees' intention to use AVs. I looked across the data for factors that constitute benefits from the use of these services and barriers or preconditions that would influence adoption. The coding approach was data-driven. I derived the codes from the data with some insights from relevant studies. I developed categories and themes by organising and grouping codes with similar content or meaning.

8.2. Overview of findings

Twenty-one out of twenty-four interviewees discussed all the scenarios. Time restrictions and a prolonged discussion during the first stage of the interview did not allow me to get the responses of three interviewees. David took part only in the initial part of the interview and held quite negative attitudes towards AVs. For one participant, Olivia, only data related to buses were collected, while Alex gave responses for buses, taxis, and shared taxis.

The acceptance of AVs across older people is quite varied and dependent on the operational characteristics of the hypothetical vehicle or service. Although most interviewees appeared as willing to use at least some of the proposed services, a few participants showed strong reluctance to use AVs, regardless of the type of service and vehicle. For these individuals, particularly non-drivers (e.g., Linda and Brian), mobility barriers could emerge in a scenario in which AVs reduce their options to use non-

automated buses or taxis. It is also of note that on many occasions, interviewees suggest that they might use an AV, in its various forms, without necessarily referring to any benefits from these.

Table 8.1: Categorisation of participants' responses about their willingness to use different automated transport vehicles and services

Category	Criteria	Responses	
		Drivers	**Non-drivers**
Automated bus			
Might use an automated bus	Interviewee gives a neutral or positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	11 (Alice, Ben, Elena, James, John, Kate, Lucy, Olivia, Sally, Tony, Victoria)	4 (Anna, Emily, Grace, Natalie)
Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	1 (Robin)	1 (Alex)
Would not probably use an automated bus	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	4 (George, Helen, Nick, Zoe)	2 (Brian, Linda)
Automated taxis			
Might use an automated taxi	Interviewee gives a positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	9 (Alice, Ben, Helen, John, Kate, Nick, Sally, Tony, Victoria)	3 (Alex, Anna, Natalie)
Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	2 (Lucy, Zoe)	1 (Emily)
Would not probably use an automated taxi	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	4 (Elena, George, James, Robin)	3 (Brian, Grace, Linda)
Automated shared taxis			
Might use an automated shared taxi	Interviewee gives a positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	4 (Ben, John, Lucy, Sally)	1 (Natalie)
Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	1 (Victoria)	1 (Anna)

Category	Criteria	Responses	
		Drivers	**Non-drivers**
Would not probably use an automated shared taxi	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	10 (Alice, Helen, Elena, George, James, Kate, Nick, Robin, Tony, Zoe)	5 (Alex, Brian, Emily, Grace, Linda)
Automated neighbourhood car clubs			
Might use an automated shared car	Interviewee gives a positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	9 (Ben, Elena, George, John, Kate, Lucy, Sally, Tony, Zoe)	4 (Anna, Emily, Grace, Natalie)
Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	4 (Alice, Helen, Nick, Victoria)	0
Would not probably use an automated shared car	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	2 (James, Robin)	2 (Brian, Linda)
Automated private cars			
Might be interested in buying an automated car	Interviewee gives a positive response to questions "would you be interested in buying a driverless car?", "would something change in the way you move around?", even when she/he mentions cost or wish to override	5 (Helen, James, Lucy, Tony, Zoe)	2 (Anna, Grace)
Unsure	Interviewee states that she/he is unsure about buying a driverless car or does not provide a clear response.	6 (Alice, Ben, George, Kate, Nick, Sally)	1 (Natalie)
Would not probably be interested in buying an automated car	Interviewee gives a negative response to questions about "would you be interested in buying?", "would something change in the way you move around?"	4 (Elena, John, Robin, Victoria)	3 (Brian, Emily, Linda)

8.2.1. Automated buses

Automated buses appeared to be the most acceptable use case of driverless technology among all those presented to participants (fifteen participants stated that they might use it, two respondents were very unsure, and six held quite negative attitudes towards this service).

The interviewees did not associate this service with significant benefits for their current or future mobility. Many interviewees specified that they would be willing to use a driverless bus, but it might not change their mobility patterns or mode choices. The automated bus scenario described a conventional fixed-route bus that one catches in bus stops, as with conventional buses. Therefore, it comes as no surprise that benefits in terms of reduced barriers to mobility, for instance, after driving cessation or because of mobility impairments, were not envisaged.

Although many interviewees did not anticipate benefits from this hypothetical service, they still expressed a willingness to use an automated bus in the future. Possibly the fact that a bus would be something that they could easily try out and accept or reject prompted this reaction. Also, it might be perceived as easier to get used to and less demanding to learn how to operate. For a few interviewees, the benefits would be a more reliable service as a result of better traffic flow or door-to-door transport for the few that imagined this capability. One younger interviewee, Tony, mentioned not having to interact with a driver, for instance, to ask for information or to pay.

As far as barriers to potential adoption are concerned, safety and reliability factors that were discussed in the previous chapter at length were also prevalent in this use case. Some participants were more positive towards the possibility to use a driverless bus if they were assured about its safety and trustworthiness (e.g., that it will stop at the bus stop following a request to do so or that it will perform the driving task safely). Others showed mistrust about its capabilities, and this influenced their lack of intention to use it in the future. Interviewees referred to technical and practical issues about the operation of automated buses that would make them anxious in their travel. Indicatively, Brian, who uses buses daily, showed his discomfort with the idea of driverless buses. However, this response is also possibly influenced by how the scenario describes automated buses (like conventional ones and without dedicated lane with no specific details about the use of the service).

> *"I can't imagine driverless buses. Not in Manchester. Because there is so much traffic in Manchester now. We were held up on the bus going home this morning. [analyses the incident] But a driverless. I couldn't imagine that there was so much technology in these buses to try and stop these buses, waving to them. No, I can't imagine it." (Brian, 84, non-driver)*

Two further barriers were identified in the case of automated buses. The first is related to public transport accessibility (frequency of services, distances to bus stop) and the preference to drive instead of using a bus for those who can. The second is related to a sense of security and vulnerability within automated buses.

Table 8.2: Frequency of interviewees who mentioned different benefits, barriers/preconditions related to driverless buses

Factors affecting the willingness to use automated buses	I might use an automated bus	Unsure about the use of bus	I would not probably use an automated bus
Benefits			
The bus service would be improved - ticketless, reliability, speed, flexible routes	5	0	0
Barriers/preconditions			
Availability of buses (frequency)	1	0	0
Distance to the bus stop and getting in the bus	1	0	2
Preference to use own conventional car	1	0	2
Anti-social behaviour	9	2	3
Not feeling insecure in a driverless bus about anti-social behaviour	2	0	0
Emergencies (e.g. illnesses, problems with the boarding of passengers)	3	1	1
Would get used to it	3	0	0
Safety, reliability, control concerns	6	1	2
Questions about practicalities of driverless buses (payment, stopping at bus stops/boarding)	3	1	1
Questions about sharing space with conventional cars/being on dedicated lanes	0	2	0

For interviewees who stated that they probably would not be interested in such a service, the more commonly reported reasons were, among drivers, preference to use their cars, either because of convenience or difficulty to get to a bus stop. However, distance to a bus stop and preference to use the car for certain trips (e.g., shopping) was also raised by interviewees who showed some intention to use a driverless bus in the future. These factors relate to commonly recognised barriers to public transport use for older people (Zeitler and Buys, 2014; Nordbakke and Schwanen, 2014; Shergold and Parkhurst, 2012).

The most significant issue for all interviewees (drivers and non-drivers) was security, regardless of whether they stated they would use the hypothetical service or not. The majority of them were worried about either a) antisocial behaviour (fourteen participants) or b) the lack of human assistance/intervention in case of an emergency (five participants). The concerns were raised by both male and female participants, across all age groups. Anti-social behaviour was described as people not paying their tickets, 'causing trouble', fighting, being aggressive, and robbing others.

"There is no safety inside the bus for passengers. There is definitely no safety, someone could start an argument, and there is no one saying stop, you need to get

> *out of the bus. There is no policing of bus passengers. That is the word." (Robin,* 72, driver*)*

> *"Because whether I like it or not, there are some passengers at night or daytime who are drunk or disorderly, you will make being in the bus extremely dangerous." (Alex, 61, non-driver)*

Some women said that they would avoid using this service at night or on specific routes. One of them, Helen, explained that she did not perceive personal security as an issue, because "*older people don't go out at night*". Helen was among the oldest interviewees. Her quote possibly reflects commonly reported temporal barriers to older people's out-of-home mobility due to non-transport factors (e.g. criminal activity, fear of falling) (Nordbakke, 2013; Office for National Statistics, 2018).

Some suggested that there might be new types of security and emergency systems but questioned whether these would be equally capable as humans to deal with any issues. CCTV cameras could be in place, but maybe intervention following these could be too late, or perpetrators could find new ways to escape the vehicle.

> *"That is something you need to think about for the safety and security of all passengers. You get some undesirable passengers sometimes that causes some trouble. A driver can call the centre and dispatch the police and can pull to the side. Would that driverless bus detect that there is a fight inside the bus and do that? I don't know." (Anna, 58, non-driver)*

> *"Because with the cameras it is a bit late when someone is bashed over their heads for something. They can't intervene straightaway. That would be one concern about it." (Alice, 68, driver)*

> *"Not having anybody on a bus at all, a bus has 50 people in theory. In a double-decker. Anything could happen upstairs. You are not going to have a driver, but you will have someone to watch the CCTV. Maybe it will be like an Alexa that will shout to people "Get out!". [….] Presumably, a driverless bus when something happens it opens all the doors, so the perpetrator knows that." (Emily, 73, non-driver)*

These concerns were echoed in the case of other emergencies, for instance, when a medical emergency occurs. Some were worried about whether the bus would be capable of 'sensing' when all passengers have got in/off the bus. Alice perceived this as an essential risk of driverless buses, as older people or children could get in or out of the buses without their carers or parents.

> *"Yes, someone has a heart attack. Anything like that. How do you have a bus that not only drives, but it can also sense every passenger and check on their wellbeing? Whereas in a bus now, if the passenger next to you collapses and has a seizure, you can inform the driver. The bus driver can take action, can stop the bus, can perform CPR; they have control. In a driverless vehicle, what do you do? Do you ring a telephone number?" (George, 55, driver)*

When the issue of a human supervisor or inspector within the bus came up, there were conflicting positions among the interviewees. In the study of Dong et al. (2017), transit users' willingness to use an automated bus increased in scenarios with the presence of an employee to monitor the vehicle or provide assistance to passengers. For many interviewees here, placing a supervisor within the automated bus seemed a rational idea and necessary, particularly during the night or for routes passing through the city centre, which is possibly associated with more incidents of anti-social behaviour. However, others questioned this option because 'it defeats the purpose'.

8.2.2. Automated taxis

As with automated buses, the taxis were a relatively acceptable use case for participants (twelve interviewees showed some willingness to use an automated taxi, three were quite unsure, and seven held quite negative views about automated taxis).

Only three of the participants reported significant benefits for themselves. The responses of other participants who showed some willingness to use the service suggested that they would not 'mind' using it in some conditions and if assured of its safety. Interviewees often said that there would not be substantial changes in their travel behaviour following the introduction of such a service. For a few, more commonly male participants, it might be preferable than conventional taxis due to the replacement of the driver. Others, though, mentioned that they rarely use taxis. In general, the automated taxi was not perceived as a substitute for car or public transport journeys, more as a one-to-one replacement of conventional taxis. Only Nick, who had heard of automated taxis as the most likely application of the technology, discussed this as a solution after his potential driving cessation. This also highlights that familiarity with applications of the technology through media not only affects attitudes towards AVs (Rahman et al., 2019; Robertson et al., 2019) but also expectations about how it will be used in the future.

Table 8.3: Frequency of interviewees who mentioned different benefits, barriers/preconditions related to automated taxis

Factors affecting the willingness to use automated taxis	I might use an automated taxi	Unsure about the use of taxis	I would not probably use an automated taxi
Benefits			
Easy to book	0	1	0
Feeling safer in a driverless taxi comparing to a conventional taxi	1	0	0
Indifference - negative emotions about the interaction with the (taxi) driver	2	1	0
A transport solution after potential driving cessation	1	0	0
Barriers/preconditions			
Getting used to it	0	1	0
Lack of assistance from a (taxi) driver	1	0	0
Missing conversation with a (taxi) driver	0	0	2
Safety, reliability, control concerns	3	0	5
Taxi firms can be profiteering	0	1	0
Use dependent on the cost of the service - taxi	3	1	0

Safety, reliability, and lack of human control were again key factors influencing acceptance of this use case. Among the seven participants that stated they would not probably like to use an automated taxi, safety was the most frequent concern. Their comments showed a lack of trust that the technology will operate as it should, fear of being alone in a driverless taxi and anxiety about what to do if there is a failure of the system.

There were two opposing views among interviewees concerning the replacement of the taxi driver with driverless technology. Therefore, this played a role both as a benefit and a barrier for different individuals. Beyond Zoe, a wheelchair user, who explained that she might need a taxi driver to help her with her shopping, others narrated pleasant experiences from the interaction with taxi drivers.

> *"I like a driver. And then we have a chat because I know most of the drivers. They pick me up from the train station, the Chorlton street. I know some of the drivers and some of them are very good. And it is quite nice." (Brian, 84, non-driver)*

> *"There is no one to talk to; you are on your own. Another way to stop the act of conversation, you know?" (Robin* 72, driver*)*

It is difficult to say if there are gender differences in how social interaction in various transport modes is discussed. Male interviewees discussed more eloquently their personal interaction with taxi or bus

drivers (either positively or negatively). Women referred more frequently to the social implications of automated transport and the potential for increasing loneliness. The following quote is from Kate's interview, and she refers to the adoption of AVs (that allow for individual use) by older people.

> *"For anybody who lives alone and is lonely, it is a very cold way of getting your transport from A to B, because you don't speak to a single person. And it would all be done by technology. Because technology would tell you that the car is there and you would get into it, and you would never speak to anybody. Somebody who wanted to work alone in a journey, they would like that..but.." (Kate, 66, driver)*

In contrast to those who seemed to believe that taxi drivers were helpful, others perceived the interaction with a taxi driver as redundant or burdensome in some cases. Being in a driverless taxi was associated with a sense of privacy and less worrying about starting a conversation with a driver. One participant, Ben, recalled unpleasant experiences with taxi drivers due to unsafe driving. For him, such a service would mean he might be more willing to meet friends for drinks at night.

> *"It would be quite nice to have your little area, to be sat in your driverless little pod and it would take you where you need to go, without having to talk to a driver, saying this way or that way. Because presumably, you pay upfront. I can see the advantages. At the same time, you haven't got anyone to talk to. If that's what you want." (Emily, 73, non-driver)*

> *"When you get a taxi now, it is always difficult for me, I am never sure if I should converse with the driver and talk about things. With the driverless taxi that wouldn't apply. I would get exactly what I wanted there, if it picked me up wherever I wanted it from, and it was going to take me wherever I was going to." (John, 72, driver)*

These findings suggest that psychological factors, such as the preference for privacy and social interaction with the driver, would also influence the adoption of automated taxis.

8.2.2.1. Use of smartphones and app-based services

Although the scenario presented an app-based taxi service, there was not a clear influence of smartphone use on respondents' answers. Some participants who do not own a smartphone or do not use applications said that they might use a driverless taxi in the future. This can be because their thoughts and responses were more focused on the transport experience (being inside a driverless

taxi), instead of using a smartphone to book or pay for it. It should be noted that the use of smartphones and mobile applications was not discussed across all interviews. The sub-sample is small to make any inferences for the older population.

In total equal numbers of participants stated that they own, and they do not own a smartphone, (seven in each category). Among the owners of smartphones, three of them said that they would not use them to call a taxi or that they use limited smartphone applications. Elena said "I have a smartphone, but I wouldn't, I have limited apps on my phone. I don't need to know; I feel that I know enough." Similarly, participants said they do not have a smartphone because they do not feel like they need one. Two of the younger participants said that they have begun using some applications for taxi services (either Uber or others offered by local companies). Another participant also brought up Uber, but in this case, to explain why he did not use it. For Robin, beyond the fact that he does not have "the facilities to ring them" – a smartphone – local companies are preferable.

> *"Because it's a bit more personal. You can pay the driver. With the smartphone, they have different charge rates. I wouldn't like to use it, no." (Robin* 72, driver*)*

Overall, smartphone ownership did not play a role in participants' responses in the context of the scenario. Some younger old participants are already familiar with the use of app-based taxi services, showing again that the future cohort of older people may be more "open" to the idea of digitalised transport. The experiences of older people with app-based taxi services in the UK and abroad are under-explored. The accounts of some participants suggest that they may not be interested in learning how to use app-based transport services as other options exist (for instance, to call a company). The dynamic charging rate was only mentioned by one participant, but it may reflect wider concerns, given that taxis can be perceived as an expensive transport mode (Ahern and Hine, 2012).

8.2.3. Automated shared taxis

The scenario of automated shared taxis received the least positive responses compared to all use cases (fifteen of the participants said that they would not probably use automated taxis, five said that they might use it, and two were very unsure). The study adds to current evidence suggesting that older people have concerns about sharing a ride with strangers (Shergold, 2019a), identifying factors playing an important role in this decision. The resistance towards ride-sharing, though, seems to be an issue across age groups (Clayton et al., 2020).

Table 8.4: Frequency of interviewees who mentioned different benefits, barriers/preconditions related to automated shared taxis

Factors affecting the willingness to use automated shared taxis	I might use an automated shared taxi	Unsure about the use of shared taxis	I would not probably use an automated shared taxi
Benefits			
Benefits of ridesharing (reduced cost, interaction with other passengers, reduced congestion)	2	1	2
Barriers/preconditions			
Preference to use own conventional car	0	0	1
Inconvenience in sharing transport space with others	0	0	3
Emergencies - illnesses	0	0	2
Anti-social behaviour	0	1	12
Not feeling insecure in a shared taxi about anti-social behaviour	2	0	0
Waiting time and trip purpose	1	0	0

During the interview, many participants mentioned the benefits of sharing a ride with others and giving people a lift by car. These practices were commonplace for many participants. From having a conversation and sharing the transport costs to reducing traffic congestion, participants observed that sharing a car or taxi ride with others has benefits. For a minority among those who showed some willingness to use this hypothetical service, the reduced transport cost and the social interaction with others were perceived as incentives.

Nevertheless, the majority of interviewees showed high inconvenience with the idea of sharing a taxi ride with a stranger, primarily due to security concerns. These concerns were recognised even by those who showed a positive intention to adopt taxi-sharing in the future. Ben, for instance, reflected on the gender aspect and emphasised that a woman might not be comfortable with this service. For Sally, it would depend on the time of the day.

Almost all the participants who showed low acceptance towards automated shared taxis were concerned about security. The concerns were similar to those raised for automated buses. In some cases, people thought about possible incidents of violence (e.g., physical, sexual attacks). Few interviewees implied rejection of individuals based on subjective criteria, such as the health or

appearance of a person. The following quote from Nick's interview exemplifies these points. Nick narrates an event from a past journey with his daughter.

> *"We were going to Blackpool and there were traffic jams everywhere around. And she said "everybody should share, and she was looking around and saying everybody is one person in one car, why don't people share". And I said I don't want to share with an idiot or someone who smells or has a disease. There are many reasons people can object to it. And if you volunteered to share, can you say I volunteered, but I don't want you! [laughs]." (Nick, 77, driver)*

Some women mentioned it would depend on who they would be sharing with, suggesting they may feel safer with other women or people of the same age group.

> *"If it was during the day or maybe sharing with a female, maybe, but if it was an evening and you were going out or coming home late at night, you don't know who, maybe not." (Anna, 58, non-driver)*

Emily suggested that she would use a driverless taxi only if she had mobility issues, which would make her vulnerable.

> *"Well, if I was doing it, it would mean that my mobility is worse than what it is. Depending on who I would be sharing with, I would feel vulnerable. I wouldn't want to feel vulnerable in my little pod." (Emily,73, non-driver)*

Beyond anti-social behaviour concerns, some participants showed inconvenience with sharing transport space with others. George explained his discomfort by narrating his current preference to drive instead of using public transport, feeling that people can misbehave in the specific geographical and cultural context. For Alice, the issue does not apply to all shared modes, only taxis that entail sharing a smaller and more "private" space.

One participant said that the use of a shared taxi would depend on the journey purpose and the extent to which shared taxis were reliable. This comment echoed other negative comments about long journeys and waiting times in dial-a-ride and similar community transport services offered to older people around Greater Manchester.

8.2.4. Automated neighbourhood car clubs

The service was relatively acceptable by interviewees (thirteen expressed a positive attitude to adopt it in the future, four seemed quite unsure, and four showed that they probably would not use it).

In comparison to the earlier hypothetical scenarios examined, this service was associated more commonly with benefits for mobility and accessibility either now or in the future among the themes discussed in 7.3.2. Six interviewees, drivers, and non-drivers, mentioned that the service would replace or enable journeys that are difficult to make, with references to discretionary journeys among them. For Ben and Tony, who are younger drivers and have satisfactory access to places, this service would enable journeys to social activities that involve drinking. For women who feel restricted in their travel horizons, this service would allow getting to places difficult to reach by bus (Emily and Sally), and it would replace journeys by bus (Anna). In addition, it would allow going out in the evenings (Grace and Sally). Lucy and John referred more to future benefits in a situation where they would give up on their car or driving.

Table 8.5: Frequency of interviewees who mentioned different benefits, barriers/preconditions related to automated neighbourhood car clubs

Factors affecting the willingness to use automated neighbourhood car clubs	I might use a car from a car club	Unsure about the use of car clubs	I would not probably use a car from a car club
Benefits			
Good solution after giving up on car/driving	2	0	0
Enabling/replacing difficult journeys	6	0	0
Returning home after drinking safely	2	0	0
Getting to discretionary activities	1	0	0
Not worrying about maintenance, insurance, costs	4	0	0
Sharing the car with friends/family	3	0	0
Useful as an initial experience of driverless technology	1	0	0
Affordable for those who cannot afford a private one	1	0	0
Barriers/preconditions			
Availability and reliability of shared cars	3	3	0
Distance to get to car club station/ opportunity to make it door-to-door service	4	0	1
Preference to use own conventional car	0	0	1

Factors affecting the willingness to use automated neighbourhood car clubs	I might use a car from a car club	Unsure about the use of car clubs	I would not probably use a car from a car club
Relationship with neighbours	1	1	0
Safety, reliability, control concerns	2	0	1
Use dependent on the cost of the service	0	1	0

Another benefit of this service discussed by four participants - drivers, is that the users do not have to arrange or pay for the maintenance, insurance, any cleaning or repair needs. Less often reported benefits of the hypothetical service were that it could make automated technology more accessible to older people by providing an affordable service for those who cannot buy a private one.

Using this service to share a ride with others also appeared to influence the responses of some women positively. The advantage of having the company of friends or relatives seemed to increase their confidence in using this transport mode and being safe in the vehicle.

The most significant barriers and preconditions underlying the acceptance of all participants were related to a) the availability and reliability of the service, b) the distance required to access it, and to a lesser extent c) the safety and control aspects of the vehicle. These were reasons/barriers mentioned by some participants regardless of whether they showed a positive or negative attitude towards the service.

Availability and reliability of the service was the most discussed theme across all the conversations on neighbourhood car clubs. An important conclusion from these discussions is that participants would appreciate an on-demand, reliable service that allows travelling beyond the local area. Given that the service was described as a neighbourhood car club, participants imagined that the demand for the service might exceed the supply of the cars, particularly on high peak hours. In effect, some women described it as something that you would have to pre-plan for its use.

> *"Well, that could cause a lot of problems I would have thought. It sounds very good idea, but I would have thought that someone should have set up a system by where the people have the car at specific time. In the face of it, it sounds quite good, but then everybody would be clashing, wouldn't they? Depends on how big the neighbourhood is, how many people are involved in it." (Alice, 68, driver)*

> *"It would depend on whether you can get it. Someone has already booked it for three o'clock, and this is when you want it. If it is shopping, it wouldn't matter if I*

> *am thirty minutes earlier or later. But if it's a doctor's appointment or work and you have to be there at a certain time. And everyone would want the same slots at ten o'clock in the morning, wouldn't they?" (Zoe, 71, driver)*

Victoria thought about clashing with her neighbours. She held negative attitudes towards sharing a vehicle with individuals from her neighbourhood. Alice thought that reliance on this service might be problematic in urgent situations when transport is needed. She discussed the possible need for regulations about the ownership and use of driverless vehicles and in this case, she raised the question if some groups would have exclusive rights to use it (e.g., retired people, or disabled individuals).

Some participants commented that the neighbourhood car club - if it was implemented as a door-to-door service – resembles the hypothetical taxi service. Overall, the neighbourhood car club, though, was perceived as more beneficial in terms of reducing barriers with out-of-home mobility and getting to places. Possibly how participants perceive conventional taxi services and how they imagined the relative cost and reliability of the two services played a role.

8.2.5. Automated private cars

The participants were overall less interested in buying an automated car, comparing to using an automated taxi, bus, or shared car. The interviewees' answers were less straightforward in terms of willingness to buy an automated car, as they referred to how their attitude might change if their circumstances change or depending on other external factors (e.g., the cost of purchase). Seven of the interviewees stated that they were willing to buy an automated car, either reflecting on their current or future circumstances, seven seemed quite uncertain or referred to several preconditions. The responses of seven interviewees suggested that it would be highly unlikely for them to buy a car (see Appendix D for examples of how these responses were categorised). The response of one participant who stated he would like to buy an automated car, but only one that he can override (semi-driverless), was placed under the positive attitudes.

Some drivers said that they might be interested in buying an automated car because of a concern about driving cessation. All of the drivers who mentioned the potential for driving cessation were positive towards buying a driverless car (although James would want to buy one that allows him to maintain some control aspects). Other benefits mentioned had to do with increased convenience comparing to a conventional car, for instance, not having to park the vehicle, a task that can be burdensome for some older people, and being more relaxed and engaging with other activities when in the car.

Non-drivers who gave positive responses (Grace and Anna) gave elaborate descriptions of journeys and activities which an automated car would enable. For Natalie, who had only recently lost her car because of damages incurred in an accident, a decision to buy either a conventional or a driverless car, would depend on whether she manages her mobility needs without a car in her life or not and the cost of the latter one. In contrast, non-drivers who were not interested explained that they are able to cope with the current transport modes, and they do not feel that they need a private car.

Table 8.6: Frequency of interviewees who mentioned different benefits, barriers/preconditions related to automated private cars

Factors affecting the willingness to buy an automated private car	I might be interested in buying an automated car	Unsure about buying a car	I would probably not like to buy an automated car
Benefits			
Enabling - replacing difficult journeys	3	1	1
Increased convenience comparing to driving (e.g. doing other activities, no need to park it)	2	0	0
Getting to discretionary activities	2	0	0
After potential driving cessation	4	4	0
Beneficial for me when I have difficulty to walk and use public transport	0	1	0
Barriers/preconditions			
Cost of purchase	1	2	1
Not good investment if the cost is low	0	1	0
Safety, reliability, control concerns	1	1	3
Enjoying driving	0	1	1
Fine with my current transport options	0	0	2
Vandalism, theft risk	0	0	1
Difficulty to learn at my age to use it	0	0	1

Looking into the barriers or preconditions brought up by the participants, the cost of purchase was one of the most frequent concerns, brought by four participants with different responses in terms of willingness to buy. In some cases, it was phrased as a precondition, as 'I would buy if it was in my price range' and in other cases as a prohibitive factor. In addition, the majority of people in the lowest income bracket showed a lack of interest in buying a driverless car.

Safety and control aspects were found mainly in participants who showed a very low willingness to buy an automated car and to a lesser extent among some of the more sceptical/unsure individuals. Enjoying driving was another issue brought up by participants in the above-mentioned categories. Ben, for instance, said that he would prefer using an on-demand automated car once in a while and

keep driving when he feels like it. He lives in a rural area and described driving in this area as pleasurable.

I further looked into and compared the participants' responses regarding the neighbourhood car club service and the private car, to explore which factors might influence choices between ownership and on-demand use of automated or conventional vehicles. First, the extent to which different individuals want to engage in activities and the level of mobility they aspire to have influence these preferences. These needs would then influence the transport costs and the final decisions about ownership of an AV. For instance, John imagined that he will restrict his out-of-home mobility in the future. For him an automated car would be a luxury that he would not be able or like to pay for, whereas summoning an automated car once in a while would help him meet his needs. Other drivers also commented that they would prefer using on-demand services (either car clubs or taxis) until they were capable of driving. Following the driving cessation process, they "might be tempted to buy their own car". The previous arguments suggest that for current drivers, the choice between a private car over a shared one appears to be influenced by how people imagine their mobility and access needs in the future and the transport costs these would entail.

> *"If I became incapable of driving, I'd be tempted to buy a car rather than use one from a taxi company. That would be totally dependent on costs and then this would depend on how much the car is used. If I was using taxis for everywhere..This week I went to Blackpool, Hebden Bridge, Heywood, Radcliffe. Tomorrow I am going to Southport. Within the week I'd probably have done several hundred miles. If I was doing that all the time, it would be much cheaper to buy a driverless car. If I am doing big distances too." (Nick, 77, driver)*

Preference to own a car over using neighbourhood car clubs was expressed only by drivers. Other factors that seem to play a role in individuals' preference over private cars is that they are available at any time, and they offer the freedom to carry whatever one wants. The culture of automobility also appeared as likely to influence decisions between summoning and owning a vehicle for older people who are able to exercise this choice.

> *"Culturally that is what we always had; we always owned the car. That might be more appealing. I can understand the car club, though." (Tony, 55, driver)*

8.3. Alternative transport future scenarios

This scenario task was used, first, as an opportunity for interviewees to discuss alternative transport futures, beyond car-based solutions. Second, the intention was to capture their attitudes towards AVs and triangulate the data elicited throughout the earlier stages of the interviews. Therefore, the first scenario described a less car dependent future with better active travel and public transport options. For most participants, the comparison between the scenarios came down to a comparison between a highly reliable and well connected public transport network in combination with good quality pedestrian environments (option A) against more or less affordable driverless cars that can move freely in dedicated driverless car lanes (option B). Some participants reflected more holistically on aspects of the scenario, while others chose to focus on particular aspects.

Overall, the participants showed a good understanding of the scenarios. Nevertheless, in some cases, participants appeared confused about some aspects of the scenario (for instance, some believed that option A also entailed automated cars). In these cases, I read along again the scenarios to ensure participants had understood their content. Two responses were rejected at the end of the analysis as it was considered that the participants had misunderstood the scenarios to the extent that their answers did not represent the content of the scenarios. Beyond these, interviewees' choices were consistent with attitudes and experiences discussed in earlier stages of the interview.

Among the 19 participants who responded in this scenario, twelve expressed a preference over scenario B, four over scenario A and three were quite unsure or would like a combination of the two. For people who preferred scenario A, improvements in walking conditions and public transport services are necessary and would support them in their later lives. The individuals (all female, two drivers, two non-drivers) who chose this option were somewhat restrained in their assumptions about the individual and collective benefits of AVs.

> *"I'd prefer for everything to be designed better, the pavements and roads. So that everybody could use them, rather that these driverless vehicles. I wouldn't like them no." (Elena, 70, driver)*

> *"It is very difficult to say, because as you get older and you can't do things like you used to do, sometimes it comes to the point where you can no longer drive. It depends on your health and things like that. I think the first option would be better, because it is easier if you can't drive, the bus stops and everything will be more relevant. I do think that public transport is the main thing that needs to be improved. And as I said it is probably fine in big cities, Manchester, London,*

> *Birmingham. As you spread out then it becomes harder, smaller towns are left out, rural communities sometimes there is nothing there at all. Rather than worrying about driverless cars, I do think they should more focused on public transport." (Alice, 68, driver)*

Some interviewees compared the scenarios in plausibility. For most of them, option A was more "idealistic". One of the elements criticised was, for instance, giving priority in traffic lights to pedestrians and improving the quality of pavements. This was considered as difficult and possibly not publicly acceptable, even among participants who perceived these interventions as useful.

> *"That is very good, but would it ever happen? [reads along each line and makes comments like: traffic lights give priority to pedestrians], that would drive the drivers mad, you can't do that! – It is idealistic, very idealistic. But if it was so nobody would need a driverless car, nobody would need a car. If you have a mobility scooter, there are places where you can't negotiate the sidewalk because of the state of the pavement or where people are parking. As it is at the moment, this isn't how it is. It's a good idea." (Emily, 73, non-driver)*

Similarly, geographical, built environment and economic barriers would not allow for public transport to be as convenient as described in scenario A, according to some participants.

> *"Will they be more frequent; run on time I don't know (the buses). Are they going to put on tram or train lines through ten centres to accommodate everybody? I don't think so. I think they will still have to divert around. In Heywood there is a train station so you can catch a train to Bury, but it is from the opposite side from where I live, so I need to take two buses or walk 20 to 30 minutes. I don't see them putting a tram line there." (Anna, 58, non-driver)*

Among the people who preferred scenario B, the most frequently reported reasons were mobility difficulties (either current or expected in the future), enjoying the freedom of owning or using a car and concerns about future driving cessation. For some people, driverless cars, particularly if they were on driverless lanes as described in the scenario, would reduce traffic congestion and improve journey reliability. Some people, though, expressed doubts about the plausibility of this hypothesis, thinking that traffic congestion would continue even with the dedicated lanes. The extent to which these would be affordable was also debated by two individuals. Despite the fact that the scenario focused on driverless cars, some participants imagined the technology to be applied in outpatient services and dial-a-ride, buses, or shared cars.

This scenario exercise was a useful tool to triangulate data – given the high consistency of responses within the context of the final scenario and the earlier phases of the interviews. What the scenario confirms is that in the current conditions, the car is perceived as essential by many older people, particularly older drivers, to meet their mobility needs with the most comfort. Therefore, a future with driverless car technology is anticipated as it would enable older people to maintain their level of mobility. At the same time, though, for some older people, interventions in active travel and public transport should be prioritised.

8.4. Discussion

Overall, the findings suggest that acceptance of AVs across older people is quite varied and dependent on the transport service. Although most interviewees appeared as willing to use at least some of the proposed services, some participants were not interested in the hypothetical AV scenarios, regardless of the type of service and vehicle.

The scenario of automated buses followed by neighbourhood car clubs appeared as the most acceptable service for the interviewees (looking at positive intention to adopt). Neighbourhood car clubs also received the least negative responses when interviewees were asked about the possibility to use these services in the future. Shared taxis, a form of ridesharing with strangers, was the least acceptable scenario due to personal safety and privacy concerns. Whilst participants imagined that they could make occasional use of the automated taxi service, they did not express substantial benefits for their mobility and ability to get to places. By contrast, they envisaged that automated cars or car clubs would reduce current or future mobility and accessibility barriers. The neighbourhood car club possibly ranks as the best option if both the willingness to use and imagined benefits for mobility and access to places are taken into account.

Recent studies exploring the willingness of older people to use automated transport services have found a higher willingness to use hypothetical on-demand options (taxi, shared car, shuttles, and community transport) than a private car (Faber and van Lierop, 2020; Rahman et al., 2020). Similarly, in this study, some participants associated automated cars with substantial benefits for older people's out-of-home mobility, but overall intention or capability to buy is low. It is of note that interviewees who expressed dissatisfaction with their accessibility levels expressed the view that car clubs would improve their ability to get to places. However, participants overall did not think about the automated taxi as a service that would make a substantial change in the way they travel. Given that my description did not refer to the potential reduction in the cost of these services as a result of automation (Bösch

et al., 2018), the study can make limited inferences about the influence of possibly more affordable taxi services on older people's accessibility. Moreover, the fact that automated taxis can be imagined as a substitution of conventional taxis, while automated car clubs may be thought as a new type of service possibly influences the responses about the two scenarios.

The scenario exercises allowed to identify social and psychological factors influencing the acceptance of different use cases of AVs. There is currently limited qualitative research on acceptability barriers to automated buses. Concerns about personal safety in automated transport vehicles that will involve shared use with others have been identified by other researchers (Dong et al., 2017). Security concerns can restrict older people's travel by public transport at night or at times when trains and buses are not full (Luiu et al., 2018a; Musselwhite, 2017c). Concerns about antisocial behaviour and other emergencies (e.g., health incidents, problems with boarding on/off the vehicle) are likely to discourage the adoption of automated buses, shuttles, and ridesharing. Security systems, such as cameras, were considered as less likely to be effective in dealing with criminal actions or medical and other emergencies. Based on these, for buses to feel safe travel options regardless of time and location, it is likely that an operator will still be required in some services so that these are accepted by older people. Given that the replacement of drivers is what drives the reduction in the operational cost of AVs in advanced economies (Becker, H. et al., 2020), policymakers will have to consider and demonstrate how personal security is safeguarded in automated public transport.

As far as shared taxis are concerned, some participants perceived the potential reduction in the cost as an incentive to adopt this transport service. Nevertheless, the majority had substantial personal security concerns about sharing a taxi ride with strangers. Issues of sharing the transport space can also be an issue for some because of privacy concerns or negative attitudes towards current public transport services expressed by some drivers. As Kovacs et al. (2020) and McLoughlin et al. (2018) argue, the development of demand-responsive services where users will be matched with others of the same age group, or gender in combination with reduced fares could incentivise ridesharing among older people. The narratives of some participants, particularly women, point to this direction. Offering the possibility to choose who to share with can be perceived as an incentive for some individuals. However, there should be caution in the way such services and "matching" criteria are implemented to avoid discriminatory behaviours against groups or individuals.

In contrast to older people's perceptions of automated shared taxis, several interviewees from local authorities emphasised opportunities from shared taxis and, in general, automated ride-sharing services (e.g. MKC, TfWM, CCC, TfGM officials). Transport professionals held the view that automated ride-sharing services could be affordable and sustainable transport options. In their view, they could facilitate traffic demand and congestion reduction provided that the public accepts and adopts these

new modes. Hence, they perceived shared taxis and similar services as more preferable applications of driverless technology than private cars or shared vehicles that allow for single occupancy.

Previous studies have illustrated that (shared) transport can serve as a space for interaction with others for older people, for instance, within buses (Musselwhite, 2017b), community transport, or when they get a lift from members of their family and friends (Musselwhite, 2017a). The accounts of participants point to two different directions with respect to how social interaction is perceived and experienced in different transport modes and by different individuals. For instance, interaction with a taxi or bus driver can be burdensome for some (particularly younger old drivers) who appreciate privacy and control over their journey. In contrast, for others, it would be something missed if taxi drivers were replaced by automated taxis or if the use of individualised automated transport became the norm for older people. The latter may reflect a wider discomfort with increasing technology use that can be perceived as anti-social (Marston et al., 2019). Moreover, a full substitution of human-assisted taxi services would disadvantage disabled older people who use these for certain activities (e.g., shopping).

Sharing a car journey with friends and family members is a widespread practice for many older people, who receive or give lifts to others. In this study, women (drivers and non-drivers) imagined that they would share a service (particularly the neighbourhood car club) with others. Sharing a vehicle with others would serve the practical purpose of getting to the same destination. It was also described as a practice that would improve their confidence and sense of safety. Therefore, developing vehicle space and pricing of services that enables sharing with others from their social network might serve better the transport needs of older people, particularly women. Given that some local authority officials hold high expectations around ride-sharing (e.g. the officials from TfGM mentioned plans for automated shuttles around Greater Manchester), understanding factors underlying acceptance towards these services appears as a priority for researchers and policymakers. There may be opportunities to innovate and create shared services that allow synchronous use with individuals from the same community or social networks.

Another aspect that was identified as key precondition to ensure adoption and accessibility benefits for older people, related to the extent to which transport services offer door-to-door capacity. In effect, AVs, either as private vehicles or shared vehicles, could offer a door-to-door service. Participants' responses in the neighbourhood car club and bus scenarios (both described as requiring to walk for a distance to get these services) show that enabling door-to-door transport would be a key advantage for individuals who experience mobility difficulty and those who are used to travel by car. In the current conditions, distance to a public transport stop (actual or subjective) can prevent older people from using public transport or getting to activities of value when other alternatives are not

available (Davey, 2006; Nordbakke and Schwanen, 2014). Ensuring that automated (shared) services are on-demand and offer a stable, reliable service would also be critical for older people to feel that they can rely on such services. It could also affect their attitudes towards car ownership. Currently, one of the main advantages of the car, is that it is available anytime, as the narratives of participants denote. In contrast, participants who rely on buses explained that the lack of frequent services means that they have to schedule their activities carefully or leave their home early, with some of them feeling it more as a burden than others.

Although some of the participants show strong interest in owning a fully or highly automated vehicle, they express concerns about their inability to afford a private car. If AVs are used primarily as private modes, there could be widened economic inequalities in private car access and use within this age group. In a scenario where AVs are offered both as private cars and on-demand options, choices among the two will be influenced by the level of activities older people want to engage in, the relative cost of these options, and their income. For the cohorts of individuals approaching older ages, who currently own cars and will be able to afford an AV in the future, it is likely that a drive for private ownership would continue without substantial changes in the transport system.

9. Conclusions

The overall aim of this thesis was to explore the potential accessibility implications of AVs for older population groups in England, UK. It employed a multi-method research design and focused on a) the perspective of AV policy and governance, and b) the perceptions of older people themselves.

In this chapter, I present the key findings in relation to the research questions and the overarching contributions of the research in respect of the relevant literatures. I also discuss the limitations of this study, and I outline future research directions. Finally, I make recommendations for UK policymakers based on the research findings.

9.1. Revisiting the research questions

9.1.1. Question 1: How do transport authorities and key transport professionals perceive the impacts of AVs on the accessibility of older people and other socially/ transport disadvantaged groups?

The findings suggest that transport authorities and professionals perceive that AVs could potentially improve older and disabled people's accessibility. The impacts on lower-income groups are either not analysed (e.g. as in the strategy documents) or perceived as quite uncertain (as in the interviews). The key governance actors observe some potential risks for older people's ability and willingness to adopt AVs, such as ownership and use of digital technologies, and lack of acceptance. The findings suggest that, at this stage, these actors have begun considering the ability of older people to access AVs and less how AVs will influence, at a broader level, their ability to access opportunities.

Overall, the outputs of the document analysis and the interviews suggest that transport authorities and key governance actors in AV development are somewhat optimistic about the impacts of AVs on transport and society. The interview findings suggest that this optimism, at the regional and local levels of government, stems from the anticipation that AVs could improve shared/public transport provision, reduce the current accessibility gaps, and provide an alternative to car ownership. Notwithstanding that, the research identified significant differences in the positions of various authorities and professionals. For instance, the documents from DfT, TfL, TfGM and WECA appear to emphasise the uncertainty around AVs, while TfWM mentioned only benefits around AVs.

The interviews were further illustrative of potential differences comparing to the documents examined. Based on the interview findings, it appears that actors (from public authorities and third-sector organisations) who are less closely involved in AV-related research projects are more sceptical about the scale and direction of the social impacts of AVs.

The strategy documents do not include a thorough assessment of the potential distributional impacts of AVs, suggesting that the equity impacts of AVs have been overlooked within the policy framing of transport authorities to date. The only social groups mentioned by some authorities are older and disabled people. Both groups are perceived either as certainly or potentially beneficiaries. Only the recent strategy documents of DfT mention some potential barriers to the adoption of AVs for older people (e.g., accessible design and lack of assistance for older and disabled people, use of smartphones).

Moreover, the interview findings partly support and add to those of the document analysis concerning older people's accessibility. The majority referred to the potential benefits of AVs to reduce barriers associated with a decline in mobility capabilities and car access at older ages. Overall, the interview findings, though, suggest a greater emphasis on barriers to accessing AVs (acceptance, technological familiarity, the potential of AVs to cater for all needs and impairments) comparing to the document analysis. Low income and affordability barriers that may hinder access to AVs among lower-income older groups seem to be often overlooked by transport professionals.

The research has also identified that governmental actors appear to be thinking about accessibility in a narrower sense than the ease of older people to reach essential activities and services. The findings from the document analysis and the interviews indicate an emphasis on accessibility to AVs. There seems to be a gap in understanding how older people's access to destinations could be affected as a result of changes in the land-use system and the conditions for pedestrians, cyclists, and users of conventional public transport. That is not to say that policymakers do not have an interest in improving the accessibility conditions (the ease to access destinations) for older population groups. It is simply illustrative of the complexity of making assumptions about the distributional impacts of AVs.

These findings highlight the need for more research on this domain to inform the development of future policies. The impacts of AVs on the accessibility of older people will not be evident until and if these start operating on public roads and influencing mobility behaviour and everyday practices. Nevertheless, researchers and policymakers have a responsibility to anticipate a range of plausible impacts on socially and transport disadvantaged groups. Lack of anticipation of the broader impacts of AVs may entail missed opportunities for public authorities to act and shape the pathway of AV

development (Cohen and Cavoli, 2018; Fitt et al., 2019). The repercussions can be increasing transport disadvantage and exclusion experienced by segments of the older population.

9.1.2. Question 2: What is the emerging policy response towards AVs, and how is this likely to affect the accessibility of older people and other socially/ transport disadvantaged groups?

The findings from the document analysis and interviews suggest that currently, transport authorities in England have mainly played a facilitating role in the development of AVs through research and development and plans to adapt infrastructures, similar to what other studies have also observed (Hopkins and Schwanen, 2018). Indicative of that is that only a few authorities and strategy documents (mainly from DfT, TfL, WECA and TfGM) discuss the need to steer the development of AVs in line with wider strategic objectives. Additionally, transport authorities to date have not created plans that outline specific policies or regulations that could be implemented to manage the social implications of AVs.

Nevertheless, there are some positive signs that some public authorities may choose more proactive styles of governance in the future. Within their strategy documents, TfL and DfT have developed principle-based frameworks for all emerging mobility services and technologies, including AVs. The principles could be used to guide future actions without prescribing the policy, planning and regulatory instruments to achieve these. These authorities have included equity-related principles, suggesting that they recognise their role in managing the distributional outcomes of AVs.

A majority of interviewees recognised that a level of public sector intervention will be required to achieve any opportunities envisaged and avoid undesirable consequences from the deployment of AVs. Some interviewees from transport authorities also indicated a consideration of policies to prevent inequalities and exclusion of older people and other groups. For instance, some mentioned mobility credits for lower-income groups, the continuation of human-assisted services for older people and others who may need it, marketing and training for older people to ensure they can adopt AVs.

In conclusion, this research suggests that limited steps have been taken so far to integrate AVs with broader strategic objectives, such as reduced accessibility inequalities and motorised travel demand. Furthermore, transport authorities have not created plans with possible actions to ensure that older people and other socially/transport disadvantaged groups will gain accessibility benefits from AVs.

9.1.3. Question 3: Do older people perceive benefits for their mobility and accessibility from AVs, and if so, what are these?

As it is argued in the background literature, the study confirmed that AVs are perceived as beneficial by some older adults as they may counteract the effects of:

a) Driving cessation or self-regulation (either experienced by older people themselves or within a household, specifically relevant to older women);
b) The lack of or poor-quality public transport and door-to-door connections (particularly in connection to social networks and leisure destinations);
c) The difficulty or inability to use private cars and other forms of public transport due to physiological impairments or health issues.

The findings suggest that older people anticipate that AVs will support them in undertaking more leisure and social journeys. Other researchers have also found evidence of these expectations (Musselwhite, 2019; Shergold, 2019a; Faber and van Lierop, 2020).

AVs would compensate for health barriers, the loss of a driving license and barriers posed by the transport system (i.e. the long distances to public transport, long waiting times at bus stops) and the location of activities across space (i.e. social networks living in different locations). From this perspective, the expectations of the potential user group match these of the experts and policymakers.

The study found a gender dimension to these perceived benefits, associated with the current mobility and accessibility barriers older women face. Some of the women that were interviewed (drivers and non-drivers, of various ages) expressed the immediate need for such an innovation. Older men that had access to a driving license perceived AVs as a potential solution if they had to stop driving, allowing for the same sense of independence and mobility as cars do nowadays. These gender differences can be partly explained by the qualitative nature of the study and the small sample (non-driver men who were also able and used to public transport). Nevertheless, older women often have more unmet accessibility needs than men and might find AVs more relevant for their circumstances.

The evidence from this study confirms that older people who face transport barriers and unmet activity participation needs may be interested in adopting AV services (either as private or shared solutions).

9.1.4. Question 4: What are the barriers possibly inhibiting older people's adoption of AVs from their perspectives?

The interview study provides an in-depth account of barriers to AV adoption by the older population. The factors that may exclude or discourage older people from AV adoption stem from the interplay of personal and socio-economic characteristics and the technology itself. These factors relate both to the ability and willingness to adopt AVs and appear to affect differently different groups of older people.

Unwillingness to adopt AVs in many cases stems from the perceived lack of need for the transport innovation (e.g. not having ceased driving, having access to car lifts from own social network, using public transport). Nevertheless, low willingness to adopt AVs can also stem from a negative perception of its safety capabilities or, in general, negative attitudes and concerns, among other barriers that will inhibit the ability of older individuals to use AVs.

The issue of trust about the safety capabilities and the reliability of AVs appears to be critical for the acceptance of older people. Beyond scepticism about the capability of AVs to cope with complex driving environments and behaviours of other road users, older people appear to be concerned about malfunctions. The barrier of trust on AV technology was mentioned only by few interviewees from local authorities and other stakeholder organisations.

The cost barriers to adopt AVs were an important concern of participants. Particularly in a scenario in which AVs are offered as private forms of transport, inequalities among income groups, and exclusion issues among the most disadvantaged could widen. If on-demand shared AVs are proposed as a new form of public transport, older people may consider their cost in relation to the policy of universal concessionary fares.

Additionally, some older people are concerned about the extent to which AVs will be able to cater for all the journeys and individuals with more severe mobility and cognitive impairments, such as dementia and Alzheimer. Although AVs can be assistive to older people who experience mobility and mild cognitive impairments (with less certainty about severe age-related cognitive issues), older citizens do not expect these transport solutions to satisfy all needs, particularly of the most vulnerable groups.

Older adults themselves refer to a potential age gap in the uptake of digital technologies and possibly in AVs. Lack of experiences with digital technologies among older people and the difficulty to learn how to use them were issues raised by the interviewees. Older age was also associated with psychological barriers and higher difficulty to trust technology. Opportunities to try out and learn how to use AVs and any other technologies required for access to them will be critical to avoid exclusion

of those who have less experience with the use of the latest technologies. This will not be a universal issue across the older population, as previous experiences and confidence with learning new technologies are likely to affect this issue.

Wider societal concerns will also affect acceptance towards AVs among older citizens. For instance, the impact on traffic congestion, increased ownership and policies to curtail it and potential unemployment effects are some of the concerns of older people**.** Strongly negative attitudes towards AVs among older people may be partly related to scepticism about their wider implications for society (e.g. unemployment effects).

Finally, some interviewees expressed a preference for alternative solutions to reduce accessibility gaps due to driving cessation or barriers to walking and using public transport. Improving the frequency, density and reliability of public transport, the walkability of places or using cars with advanced in-vehicle technologies that can assist older drivers with driving difficulties were some of them. This finding highlights the need for policymakers to consider the different preferences and needs of older people to gain access to places, beyond AVs.

9.1.5. Question 5: What is older people's willingness to adopt different types of automated vehicles & services, and what are the factors (benefits, barriers) appearing to influence this?

The research also explored perceptions of and acceptance towards different use cases of AVs. The use cases explored were five: a) fixed-route and timetable automated public transport (without a driver), b) automated taxi (ride-hailing - similar to what is envisaged by transportation network companies, like Uber, summoned with the use of smartphones), c) automated shared taxis (ride-sharing in a taxi space), d) "neighbourhood car clubs" (rented automated cars that would be accessed through hubs in residential areas, not prescribed way to access it), and e) automated private cars.

The acceptance of AVs across older people is quite varied and dependent on the operational characteristics of the hypothetical vehicle or service. Although most interviewees appeared as willing to use at least some of the proposed services, some showed strong reluctance to use AVs, regardless of the proposed service. In line with the few previous studies of willingness towards AV adoption, overall stated interest or capability to buy AVs is low, although private cars are often associated with substantial benefits for older people's out-of-home mobility.

The scenario of automated buses followed by neighbourhood car clubs appeared, overall, as the most acceptable service for the participants (looking at positive intention to adopt). Neighbourhood car clubs also received the least negative responses from participants. Shared taxis, a form of ride-sharing with strangers, was the least acceptable scenario. Automated private cars and neighbourhood car clubs were associated more commonly with reduced barriers to mobility and access to places. The neighbourhood car club possibly ranks as the best option if the willingness to use and benefits for mobility and access to places are taken into account.

Three other key findings appear here in connection to the visions of many transport authorities to support the development of on-demand AV systems.

First, personal security is a key issue in any sort of automated shared service, shared taxis and buses. Discriminatory behaviours could also emerge if individuals are prompted to choose with whom they can share a taxi. It is unclear what types of security systems and vehicles are considered by policymakers and industry actors to alleviate these concerns and whether they would be acceptable by older citizens. Further research could explore this issue.

Second, it is of note that on-demand automated taxis received quite polarised responses regarding the replacement of a driver. For some, substituting a driver with automated technology is preferred on the grounds of privacy or reduced risk of an accident. However, for others, the use of taxi satisfies social and practical needs; having a discussion or getting help with shopping for individuals with mobility impairments.

Third, the comparison between automated taxis and neighbourhood car clubs also illustrates some interesting but challenging to interpret findings. The neighbourhood car clubs were often perceived as a service that could be unreliable or unavailable at peak times. However, it was more commonly associated with mobility and accessibility benefits than taxis. It is likely that how interviewees imagined the relative pricing of the services played a role. From the accounts of some women, the ability to travel with friends and family was also a factor motivating them to accept the service, showing again that the social interaction aspects are important for some older individuals.

9.2. Original contributions of the research

The first contribution of this research is the critical synthesis of the literature on the accessibility implications of AVs, and the factors influencing the mobility and accessibility of older people. The research has contributed to the development of a framework that shows the key accessibility

implications for older people (see figure 9.1). The framework could be used as a guiding instrument to create some qualitative and quantitative indicators to assess the impact of AVs on older people.

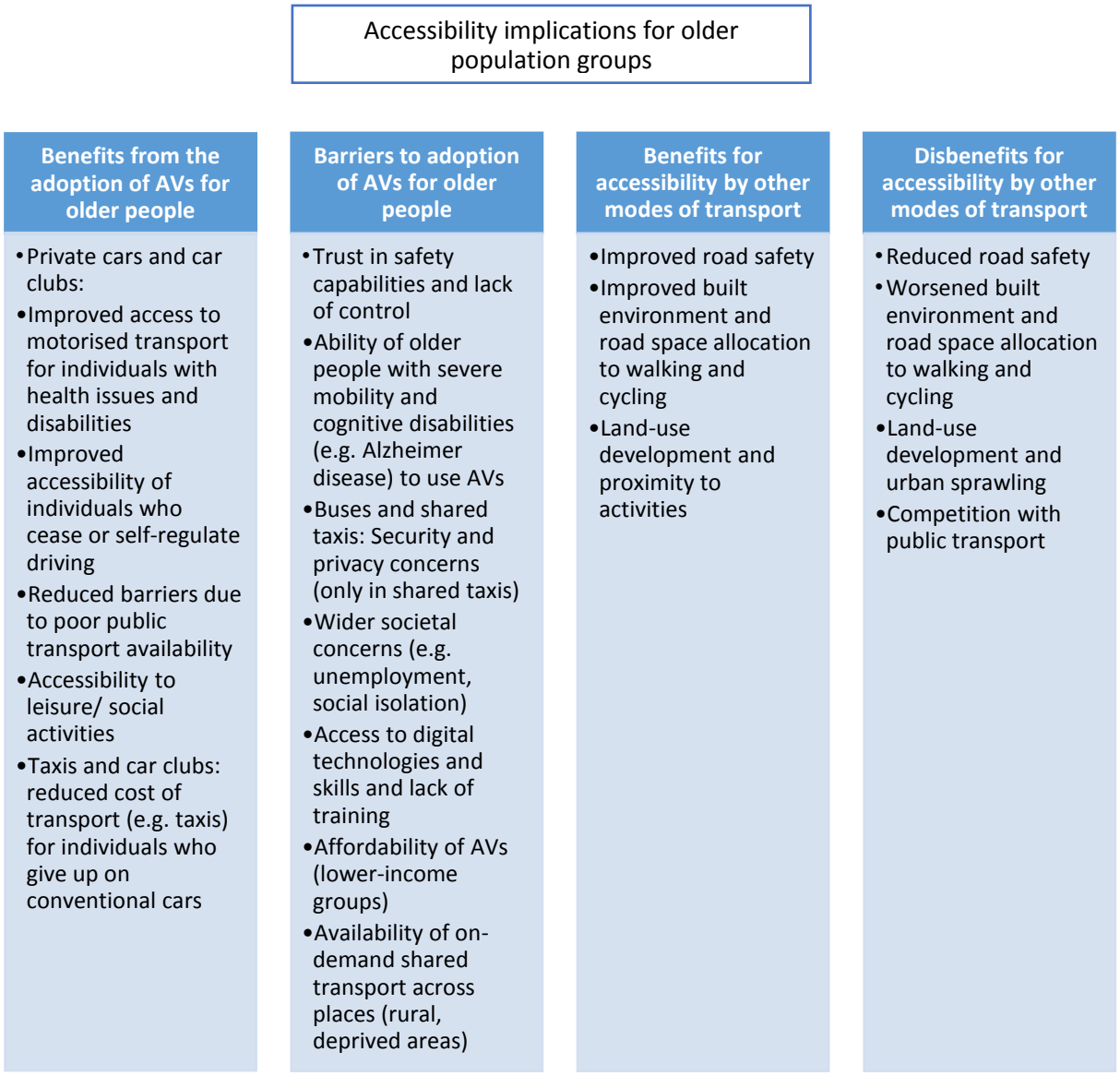

Figure 9.1: Updated framework of key accessibility implications for older people

The framework was developed based on a comprehensive literature review linking the factors that can lead to inaccessibility of older people with the implications of AVs (figure 3.1) and it was updated to capture the findings from interviews with older people (figure 9.1). Drawing from these research findings, some new insights about the potential benefits from and barriers to adoption of AVs have emerged. Older citizens anticipated potential benefits for their accessibility from automated private

cars and neighbourhood car clubs. Moreover, the participants expressed an interest in undertaking social and leisure journeys by these modes. The research also adds to our knowledge of potential barriers to adoption of AVs. The updated framework includes barriers identified through the interview study with older people (i.e. the ability of older people with severe mobility and cognitive disabilities to use AVs, wider societal concerns that may affect willingness to adopt AVs, trust in the safety capabilities and lack of control).

The research has also provided new insights into the relationships between transport authorities/professionals and the potential accessibility implications for older people, as illustrated in the broader conceptual framework (figure 3.2). The emphasis of key transport stakeholders is on the impacts illustrated on the left side of the conceptual framework and specifically, on the potential accessibility by and to AVs for older people (see figure 3.2) – the categories of benefits from and barriers to adoption of AVs by older people. Hence, the second contribution of this research is that it adds to our understanding of how governance actors in England perceive the impacts of AVs, as a whole, and their specific accessibility implications for older population groups. The research shows that transport professionals have an interest in ensuring the access of older people to AVs. However, there seems to be a narrow perception of the accessibility implications of older people in many cases. Indicative of this is the identification of the limited attention to the indirect effects of AVs on the ability of older people to access places by walking, cycling and conventional public transport. The finding is important as it illustrates the need to develop frameworks for the evaluation of AVs' distributional impacts.

The third contribution to knowledge stems from the focus of the research on policy responses of transport authorities in England. The research supports the findings of others that among the UK stakeholders there is a level of awareness that proactive planning will be necessary to ensure any socially desirable outcomes sought from AVs (Cohen et al., 2018). However, it has also shown that within the various levels of government, there is a lack of consideration about specific policies that may be required to manage the outcomes of AVs in line with older people's accessibility.

Methodologically, the interview study with members of the public over the age of 55 has used an original method (interviews in a UK setting, scenarios of different automated transport services) and provided original insights about the perceived accessibility benefits from and barriers to AV adoption. It has provided novel evidence about the compensatory role of AVs due to accessibility gaps that relate to personal (e.g. holding a driving license) and contextual factors (e.g. access to public transport, the transition to a single-person household). There is some existing research from the UK context that has argued that older people themselves perceive some opportunities from AVs for their out-of-home

mobility (Musselwhite, 2019; Shergold, 2019a). The research has additionally found some gender differences in the perceived benefits of AVs.

The study with older people also provides a detailed account of barriers to adoption, as observed by older people themselves. It adds to previous studies by identifying some additional factors that are perceived as barriers to adoption by older people themselves (e.g. having dementia, or severe mobility problems that require assistance).

Finally, the research is one among the few that has explored perception of older age groups towards different automated transport modes and services. Beyond the security concerns in shared vehicles that have been discussed by others (Dong et al., 2017), it identified other factors that could influence future attitudes towards different types on automated vehicles and services (e.g. personal income, aspirations for activity participation, past experiences of ownership, preference for social interaction).

9.3. Limitations of the research

One of the challenges experienced while carrying out this research was the difficulty in identifying and ensuring the participation of planners and other civil servants within transport government bodies closely with the experience in AV projects who had many other pressures on their time. One limitation, therefore, is that I did not manage to get access to interviewees from organisations that were part of the sample for the document analysis (Transport for London, Highways England, CCAV).

Although the interviews allowed detailed discussions with a range of stakeholders from public authorities, public/private organisations and non-governmental organisations, the research design allows for limited generalisability. The transport authorities chosen were some of the most likely advanced in terms of AV-related activities in the UK. Local authorities that have not taken part in AV-related projects were not included in the sample. In fact, I contacted transport practitioners from three other authorities not known to have taken part in AV experimentation at the time of the study (two members of NEXUS – the Tyne and Wear Passenger Transport Executive, one from Merseytravel for the Liverpool City Region and two from the West Yorkshire Combined Authority (WYCA)). However, I did not receive responses from these organisations. In the case of WYCA, a transport officer responded to my initial call for participation, suggesting a later date for the interview. Eventually, the officer did not respond to further emails. The non-response by these authorities cannot be interpreted as a clear sign of lack of interest in AVs. Nevertheless, it can be hypothesised that local authorities that have not taken part in AV experimentation are more sceptical about the potential of AVs to improve the accessibility of older people or, in general, transport inequalities. Moreover, it may be that they

are equally, more or less advanced in their understanding and identification of necessary policy interventions comparing to the authorities examined here. Future studies could explore the positions of smaller authorities that have not taken part in AV research and development activities, in or outside England.

Another limitation stems from the fact that I did not ask for the transport professionals' personal characteristics, educational and professional background. Some of these issues were brought up during discussions with the interviewees about how their training and professional experiences affect their expectations from AVs. Given that I had not asked for the interviewees' consent to link this information with their pseudonyms and organisations, I have not included these details in my analysis. It is likely that transport practitioners' training and professional experiences would influence how they perceive the implications of AVs. For instance, there could be differences in the relevant opinions of engineers, economists and social scientists who work in the transport sector. The personal characteristics of transport professionals could affect the types of questions they perceive as pertinent to AV experimentation (e.g. purely technical or broader social questions), the tools and methods of enquiry they choose to analyse the implications of innovations. Moreover, the inclusion of such characteristics could help understand the diversity (or lack of) in the sample of transport professionals – even though it is unknown whether the particular field of future mobility is diverse, for instance, in terms of gender, age, stage of career development, subjects of academic degrees and qualifications.

The research explored what policy actions are taken or considered by key governance actors to steer the development of AVs in a way that improves the accessibility of older people. These policy responses were critically evaluated based on the conceptual framework that I constructed through the literature review. Reflecting on the extent to which the interview structure allowed to investigate the second research question (see section 9.1.2), I recognise that my approach had some strengths and limitations. Asking interviewees how they think AVs will impact on the accessibility of older people and other transport/socially disadvantaged groups allowed them to reflect on relevant policies (e.g. the interviewees who mentioned mobility credits for low-income groups) or projects (e.g. involvement of older and disabled individuals in the design of AVs). Other open-ended questions about the necessary policies and regulations at the national/local level also allowed interviewees to reflect how the public sector has approached the governance of AVs. Nevertheless, I did not ask interviewees directly about policies they advocate to achieve any opportunities for improved accessibility of older people in a transition to AVs. Questions about policies tightly linked to older people's accessibility could have produced new data relevant to the second research question.

The research involving older people used a qualitative methodology and, therefore, had a small sample of interviewees. The aim was variation in terms of age, driving ability and gender. However, a

small number of non-drivers participated in the research which poses challenges for comparisons between drivers and non-drivers. Given the heterogeneity of older people in their current mobility and accessibility (as discussed in chapter 2), and the various factors that seem to influence the opinions of older citizens regarding AVs, further qualitative studies and quantitative methods may offer more in-depth insights about the distributional impacts of AVs within the older population.

Another limitation could stem from the way current accessibility gaps were explored in the interview study with citizens. People from disadvantaged backgrounds could have adapted their preferences on their (low) mobility and (poor) access levels. This is a common limitation in research that addresses equity questions (e.g. Ryan et al., 2019). In this study, individuals with strongly negative attitudes towards AVs did not express any unmet accessibility needs. In some occasions, it was clear that these individuals had coping strategies to maintain good levels of mobility (e.g. using a Motability car). However, it could also be that these individuals avoided any discussion about mobility problems to make a case about AVs and their (lack of) usefulness for their circumstances.

This research should only be interpreted as a partial snapshot in time. The positions of transport authorities and older citizens concerning AVs are likely to change in the future. In fact, they may already be quite different from the period when the data was collected before the pandemic. It remains unknown if the same interviewees and authorities examined here still hold the same beliefs about the opportunities of AVs for transport and older people. It also remains unknown how the COVID Pandemic will influence the mobility practices of different segments of older people, their attitudes towards different modes of transport and the extent to which access to goods, services and social networks is enabled through physical mobility. Beyond the particular major disruptive event, many others can take place (e.g. climate emergency), making the findings of this research obsolete. Finally, the cohorts of the older population that may be the first adopters of AVs may have quite different experiences, needs, and capabilities from the current generations.

9.4. Recommendations for policymakers

Despite these technical limitations, the research has helped to highlight some key recommendations that would assist national/local policymakers in the development of policies to take better account of the needs of older people in the transition to AVs:

1. Direct engagement with older people should be a priority for research and experimentation projects. Engagement and research involving diverse groups of older people will be critical to understand the conditions under which AVs can or cannot compensate for mobility, sensory

and cognitive impairments that typically affect the use of other modes of transport. Beyond allowing developers and policymakers to create accessible vehicles, though, engagement processes should aim to understand perceptions around AVs and improve future mobility offers in line with local transport needs. They should be used as an opportunity to understand the needs and concerns of those who do not want to or cannot use AVs and other transport innovations.

2. It is critical that policymakers consider the safety, reliability and lack of control concerns of older people surrounding AVs. Explaining any safety protocols and standards that are followed in the trials of AVs might improve the trust of the public that these can operate safely. Demonstrating that AVs bring about substantial safety benefits appears as essential for older people's trust in AVs.
3. The models of vehicle access and related costs should be taken into consideration to understand the extent to which lower-income older adults can access AVs. Income could play a more significant role in future inequalities in mobility and access to places among older adults when AVs are available to be used. Current policies have focused on providing (universal) concessionary fares for anyone over the state pension age in the UK. Income inequalities in the access of AVs among older people might require changes in this policy (e.g. introduction of criteria based on income and need).
4. Shared taxis and synchronous shared use of vehicles are commonly proposed by policymakers as affordable and sustainable use cases of automation. However, the lack of willingness among older people to use shared taxis and the underlying barriers (e.g. security, privacy concerns) should be taken into consideration in the development of future trials and services.
5. Researchers and policymakers need to critically assess the direct and indirect effects of AVs on the ability of older people to reach opportunities by walking. Trials and demonstration projects may be well placed to explore how older pedestrians interact with AVs. Scenario exercises could allow transport professionals and planners to explore whether/ how changes in the built environment and land-uses (e.g. the higher density in city-centres as suggested by other researchers and professionals in this study) would affect the ability of older people to access services and opportunities by non-motorised modes.
6. Practical tools exist that allow imagining the multiple futures that may envelop and constructing an action plan. As other researchers have argued (Shergold et al., 2015; Lyons and Davidson, 2016; Banister and Hickman, 2013), exploratory scenario planning and normative visioning/backcasting exercises would offer policymakers the opportunity to consider various plausible futures, their desirability and how their policies need to adapt to

support desirable social outcomes. Given the current mobility and access barriers experienced by segments within the older population and the ageing rate of society, future scenarios need to consider solutions within and outside technological innovation. Policy agendas need to be robust and adaptable, prioritising policy actions that can be beneficial under various futures examined – with or without AVs or with varying degrees of adoption (Banister and Hickman, 2013).

9.5. Directions for future research

In addition to the key findings and contributions to knowledge outlined in this chapter, a number of opportunities for further research can also be identified.

New studies could explore the positions of other stakeholders influencing AV governance. Researchers could explore the views and actions of private companies from the automotive industry, public transport, ride-hailing providers and organisations that provide community transport. This would help understand better if/how industry actors and transport providers perceive the needs of the older population in the design of their products and services. It could also help untangle the visions of these actors and the influence they may exert in the trajectory of AVs.

Moreover, studies could investigate the viewpoints of professionals from the field of ageing concerning policy development needs. These experts may be better positioned to understand the heterogeneity within the older population than transport professionals with expertise and interests outside ageing and mobility.

It is unknown whether and how the personal characteristics (e.g. gender), educational and professional background (e.g. qualifications) of transport professionals influence their knowledge and opinions regarding AVs, their accessibility and equity impacts. Future qualitative and quantitative studies could explore the effects of these personal characteristics on transport professionals' viewpoints around AVs.

More research is required to explore the acceptance of older people. This research has provided insights about perceived benefits from AVs and barriers to adoption. The sample of non-drivers was relatively small, though. New studies should aim to include a larger and diverse group of non-drivers (males and females and of diverse ages) to understand any potential differences between drivers and non-drivers.

Further quantitative research could allow us to explore differences among older population groups in terms of perceived benefits from AVs for their mobility and accessibility, barriers to adoption, and

wider concerns from the transition to AVs. These should include questions around the current mobility behaviour, the socio-economic characteristics and the ownership and use of digital technologies (e.g. smartphones) to capture potential inequalities within the older population. In this way, researchers can assist policymakers in considering older people as a heterogeneous group and developing policies based on specific needs.

Qualitative researchers could develop and test more scenarios of alternative AV services with older people at a range of settings across the UK (e.g. urban/rural) to understand if and how these can be designed to meet their mobility needs. The scenarios could focus on other types of synchronously shared vehicles that were not included in this study (for example, community transport services or car-sharing with people from the same social network). They could also include pricing structures to explore potential mode-shift effects (e.g. from car or buses to new services) among older people.

References

Abbott, P. and Sapsford, R. 2005. Living on the Margins. Older people, place and social exclusion. *Policy Studies.* **26**(1), pp.29-46.

Acheampong, R.A. and Cugurullo, F. 2019. Capturing the behavioural determinants behind the adoption of autonomous vehicles: Conceptual frameworks and measurement models to predict public transport, sharing and ownership trends of self-driving cars. *Transportation Research Part F: Traffic Psychology and Behaviour.* **62**, pp.349-375.

Adler, G. and Rottunda, S. 2006. Older adults' perspectives on driving cessation. *Journal of Aging Studies.* **20**(3), pp.227-235.

Ahern, A. and Hine, J. 2012. Rural transport – Valuing the mobility of older people. *Research in Transportation Economics.* **34**(1), pp.27-34.

Ahern, A. and Hine, J. 2014. Accessibility of Health Services for Aged People in Rural Ireland. *International Journal of Sustainable Transportation.* **9**(5), pp.389-395.

Alessandrini, A., Campagna, A., Site, P.D., Filippi, F. and Persia, L. 2015. Automated Vehicles and the Rethinking of Mobility and Cities. *Transportation Research Procedia.* **5**, pp.145-160.

Alsnih, R. and Hensher, D.A. 2003. The mobility and accessibility expectations of seniors in an aging population. *Transportation Research Part A: Policy and Practice.* **37**(10), pp.903-916.

American Public Transportation Association. 2016. *Shared mobility and the transformation of public transit.* [Online]. [Accessed 29/10/2018]. Available from: https://www.apta.com/

Anderson, J., Kalra, N., Stanley, K., Sorensen, P., Samaras, C. and Oluwatola, O. 2016. *Autonomous Vehicle Technology. A Guide for Policymakers.* [Online]. Santa Monica, California: RAND Corporation. [Accessed 10/05/2017]. Available from: https://www.rand.org

Anderson, K., Kalra, N., Stanley, K., Sorensen, P., Samaras, C. and Oluwatola, O. 2014. *Autonomous Vehicle Technology. How to best realize its social benefits.* [Online]. [Accessed 10/05/2017]. Available from: http://www.rand.org

Asher, L., Aresu, M., Falaschetti, E. and Mindell, J. 2012. Most older pedestrians are unable to cross the road in time: a cross-sectional study. *Age Ageing.* **41**(5), pp.690-694.

Atkins. 2017. *West of England Joint Transport Study. Final Report.* [Online]. [Accessed 05/11/2019]. Available from: https://www.bristol.gov.uk/documents/20182/33167/Joint+transport+study/a34b16f2-821f-cc04-51f5-7e030c328c3d

Atkins. 2018. *Transport for the North. Strategic Transport Plan. Integrated Sustainability Appraisal Report.* [Online]. [Accessed 05/09/2019]. Available from: https://transportforthenorth.com/wp-content/uploads/STP-ISA-Full-Report-Final.pdf

Atkinson-Palombo, C., Varone, L. and Garrick, N.W. 2019. Understanding the Surprising and Oversized Use of Ridesourcing Services in Poor Neighborhoods in New York City. *Transportation Research Record: Journal of the Transportation Research Board.* **2673**(11), pp.185-194.

Banister, D. and Hickman, R. 2013. Transport futures: Thinking the unthinkable. *Transport Policy.* **29**, pp.283-293.

Becker, F. and Axhausen, K.W. 2017. Literature review on surveys investigating the acceptance of automated vehicles. *Transportation.* **44**(6), pp.1293-1306.

Becker, H., Becker, F., Abe, R., Bekhor, S., Belgiawan, P.F., Compostella, J., Frazzoli, E., Fulton, L.M., Guggisberg Bicudo, D., Murthy Gurumurthy, K., Hensher, D.A., Joubert, J.W., Kockelman, K.M., Kröger, L., Le Vine, S., Malik, J., Marczuk, K., Ashari Nasution, R., Rich, J., Papu Carrone, A., Shen, D., Shiftan, Y., Tirachini, A., Wong, Y.Z., Zhang, M., Bösch, P.M. and Axhausen, K.W. 2020. Impact of vehicle automation and electric propulsion on production costs for mobility services worldwide. *Transportation Research Part A: Policy and Practice.* **138**, pp.105-126.

Bissell, D., Birtchnell, T., Elliott, A. and Hsu, E.L. 2018. Autonomous automobilities: The social impacts of driverless vehicles. *Current Sociology.* **68**(1), pp.116-134.

Bösch, P.M., Becker, F., Becker, H. and Axhausen, K.W. 2018. Cost-based analysis of autonomous mobility services. *Transport Policy.* **64**, pp.76-91.

Bowen, G. 2009. Document Analysis as a Qualitative Research Method. *Qualitative Research Journal.* **9**(2), pp.27-40.

Braun, V. and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology.* **3**(2), pp.77-101.

Bristol City Council. 2019. *Bristol Transport Strategy.* [Online]. [Accessed 03/11/2019]. Available from: https://www.bristol.gov.uk/documents/20182/3641895/Bristol+Transport+Strategy+-+adopted+2019.pdf/383a996e-2219-dbbb-dc75-3a270bfce26c

Broome, K., Worrall, L., McKenna, K. and Boldy, D. 2010. Priorities for an age-friendly bus system. *Canadian Journal on Aging.* **29**(3), pp.435-444.

Campaign for Better Transport. 2018. *Buses in Crisis.A report on bus funding across England and Wales 2010 – 2018.* [Online]. [Accessed 09/10/2019]. Available from: https://bettertransport.org.uk/

Cavoli, C., Phillips, B., Cohen, T. and Jones, P. 2017. *Social and behavioural questions associated with Automated Vehicles. A Literature Review.* [Online]. London. [Accessed 09/03/2017]. Available from: https://www.ucl.ac.uk/

CCAV. 2018. *UK Connected & Autonomous Vehicle Research & Development Projects 2018.* [Online]. [Accessed 23/12/2019]. Available from: https://www.gov.uk/government/publications/connected-and-autonomous-vehicle-research-and-development-projects

CCAV. 2019. *Code of practice: Automated vehicle trialling.* [Online]. London: DfT. [Accessed 06/07/2019]. Available from: https://assets.publishing.service.gov.uk/

CCAV. unknown. *About us.* [Online]. [Accessed 07/08/2020]. Available from: https://www.gov.uk/government/organisations/centre-for-connected-and-autonomous-vehicles

Centre for Ageing Better. 2018. *Age is just a number: Views among people aged 50 and over in the English Longitudinal Study of Ageing.* [Online]. [Accessed 10/04/2020]. Available from: https://www.ageing-better.org.uk/

Centre for Ageing Better. 2019. *The State of Ageing 2019. Adding life to our years.* [Online]. [Accessed 10/04/2020]. Available from: https://www.ageing-better.org.uk/

Cheyne, C. and Imran, M. 2016. Shared transport: Reducing energy demand and enhancing transport options for residents of small towns. *Energy Research & Social Science.* **18**, pp.139-150.

Chihuri, S., Mielenz, T.J., DiMaggio, C.J., Betz, M.E., DiGuiseppi, C., Jones, V.C. and Li, G. 2016. Driving Cessation and Health Outcomes in Older Adults. *J Am Geriatr Soc.* **64**(2), pp.332-341.

Circella, G. and Alemi, F. 2018. Transport Policy in the Era of Ridehailing and Other Disruptive Transportation Technologies. **1**, pp.119-144.

Clark, J. and Curl, A. 2016. Bicycle and Car Share Schemes as Inclusive Modes of Travel? A Socio-Spatial Analysis in Glasgow, UK. *Social Inclusion.* **4**(4), pp.83-99.

Clayton, W., Paddeu, D., Parkhurst, G. and Parkin, J. 2020. Autonomous vehicles: who will use them, and will they share? *Transportation Planning and Technology.* **43**(4), pp.343-364.

Clewlow, R.R. and Mishra, G.S. 2017. *Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States. Research Report.* [Online]. Institute for Transportation Studies, University of California, Davis. [Accessed 29/10/2018]. Available from: https://its.ucdavis.edu/

Cohen, T. and Cavoli, C. 2018. Automated vehicles: exploring possible consequences of government (non)intervention for congestion and accessibility. *Transport Reviews.* **39**(1), pp.129-151.

Cohen, T. and Jones, P. 2020. Technological advances relevant to transport – understanding what drives them. *Transportation Research Part A: Policy and Practice.* **135**, pp.80-95.

Cohen, T., Jones, P. and Cavoli, C. 2017. *Social and-behavioural questions associated with automated vehicles. Scoping study by UCL Transport Institute. Final report - January 2017.* [Online]. London. [Accessed 10/03/2017]. Available from: https://www.gov.uk/

Cohen, T., Stilgoe, J. and Cavoli, C. 2018. Reframing the governance of automotive automation: insights from UK stakeholder workshops. *Journal of Responsible Innovation.* **5**(3), pp.257-279.

Cohen, T., Stilgoe, J., Stares, S., Akyelken, N., Cavoli, C., Day, J., Dickinson, J., Fors, V., Hopkins, D., Lyons, G., Marres, N., Newman, J., Reardon, L., Sipe, N., Tennant, C., Wadud, Z. and Wigley, E. 2020. A constructive role for social science in the development of automated vehicles. *Transportation Research Interdisciplinary Perspectives.* **6**, p100133.

Curtis, C., Stone, J., Legacy, C. and Ashmore, D. 2019. Governance of Future Urban Mobility: A Research Agenda. *Urban Policy and Research.* **37**(3), pp.393-404.

Cyganski, R., Fraedrich, E. and Lenz, B. 2015. Travel-time valuation for automated driving: a use-casedriven study. In: *TRB 94th Annual Meeting*.

Davey, J.A. 2006. Older people and transport: coping without a car. *Ageing and Society.* **27**(1), pp.49-65.

DfT. 2015a. *The Pathway to Driverless Cars. A Code of Practice for testing.* [Online]. [Accessed 07/08/2020]. Available from: https://www.gov.uk/

DfT. 2015b. *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies.*

DfT. 2017a. *Evaluation of Concessionary Bus Travel The impacts of the free bus pass.* [Online]. [Accessed 20/09/2018]. Available from: https://assets.publishing.service.gov.uk/

DfT. 2017b. *National Travel Survey: England 2016. Statistical release.* [Online]. [Accessed 14/08/2017]. Available from: https://www.gov.uk/

DfT. 2018a. *Annual bus statistics: England 2017/18.* [Online]. [Accessed 10/10/2019]. Available from: https://assets.publishing.service.gov.uk/

DfT. 2018b. *The Inclusive Transport Strategy: Achieving Equal Access for Disabled People.* [Online]. [Accessed 29/11/2019]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728547/inclusive-transport-strategy.pdf

DfT. 2018c. *Transport and technology: public attitudes tracker. Waves 1 and 2 Summary.* [Online]. [Accessed 10/05/2019]. Available from: https://www.gov.uk/

DfT. 2019a. *Future of Mobility. Urban Strategy. Moving Britain Ahead.* [Online]. [Accessed 04/04/2019]. Available from: https://assets.publishing.service.gov.uk/

DfT. 2019b. *National Travel Survey: England 2018.* [Online]. Available from: https://www.gov.uk/

DfT. 2019c. *NTS0611: Average number of trips (trip rates) by age, gender and purpose: England, 2018.* [Online]. Available from: https://www.gov.uk/government/statistical-data-sets/nts04-purpose-of-trips#travel-purpose-by-age-and-gender

DfT. 2019d. *NTS0612. Average distance travelled by age, gender and purpose: England, 2018.* [Online]. [Accessed 12/11/2019]. Available from: https://www.gov.uk/government/collections/national-travel-survey-statistics

DfT. 2019e. NTS0702: Travel by personal car access, gender and main mode or mode: England. [Online]. [Accessed 07/11/2019]. Available from: https://www.gov.uk/government/statistical-data-sets/nts07-car-ownership-and-access#history

DfT. 2019f. NTS06001. Average number of trips (trip rates) by age, gender and main mode: England , from 2002. [Online]. [Accessed 15/11/2019]. Available from: https://www.gov.uk/government/statistical-data-sets/nts03-modal-comparisons#mode-by-age-and-gender

DfT. 2019g. Table NTS0201. Full car driving licence holders by age and gender: England, 1975/76 onwards. [Online]. [Accessed 20/11/2019]. Available from: https://www.gov.uk/government/statistical-data-sets/nts02-driving-licence-holders

DfT. 2019h. *Transport and Technology: Public Attitudes Tracker. Wave 3 Summary Report.* [Online]. [Accessed 01/02/2020]. Available from: https://www.gov.uk

Docherty, I., Marsden, G. and Anable, J. 2018. The governance of smart mobility. *Transportation Research Part A: Policy and Practice.* **115**, pp.114-125.

Dong, X., DiScenna, M. and Guerra, E. 2017. Transit user perceptions of driverless buses. *Transportation.* **46**(1), pp.35-50.

Dowling, R. and Kent, J. 2015. Practice and public–private partnerships in sustainable transport governance: The case of car sharing in Sydney, Australia. *Transport Policy.* **40**, pp.58-64.

Duarte, F. and Ratti, C. 2018. The Impact of Autonomous Vehicles on Cities: A Review. *Journal of Urban Technology.* **25**(4), pp.3-18.

Duncan, M., Charness, N., Chapin, T., Horner, M., Stevens, L., Richard, A., Souders, D., Crute, J., Riemondy, A. and Morgan, D. 2015. *Enhanced mobility for aging populations using automated vehicles.* [Online]. [Accessed 11/05/2020]. Available from: https://ftp.fdot.gov

Eby, D.W., Molnar, L.J., Zhang, L., St Louis, R.M., Zanier, N. and Kostyniuk, L.P. 2015. *Keeping Older Adults Driving Safely: A Research Synthesis of Advanced In-Vehicle Technologies. A LongROAD Study.* [Online]. [Accessed 10/04/2020]. Available from: https://aaafoundation.org/

Eby, D.W., Molnar, L.J., Zhang, L., St Louis, R.M., Zanier, N., Kostyniuk, L.P. and Stanciu, S. 2016. Use, perceptions, and benefits of automotive technologies among aging drivers. *Injury Epidemiology.* **3**(1), p28.

Elo, S. and Kyngas, H. 2008. The qualitative content analysis process. *Journal of Advanced Nursing.* **62**(1), pp.107-115.

Faber, K. and van Lierop, D. 2020. How will older adults use automated vehicles? Assessing the role of AVs in overcoming perceived mobility barriers. *Transportation Research Part A: Policy and Practice.* **133**, pp.353-363.

Fagnant, D.J. and Kockelman, K. 2015. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice.* **77**, pp.167-181.

Figueroa, M.J., Nielsen, T.A.S. and Siren, A. 2014. Comparing urban form correlations of the travel patterns of older and younger adults. *Transport Policy.* **35**, pp.10-20.

Fitt, H., Curl, A., Dionisio, M.R., Ahuriri-Driscoll, A. and Pawson, E. 2019. Considering the wellbeing implications for an ageing population of a transition to automated vehicles. *Research in Transportation Business & Management.* **30**, p100382.

Flourish mobility. unknown. *Flourish.* [Online]. [Accessed 10/05/2019]. Available from: http://www.flourishmobility.com/

Fraedrich, E., Heinrichs, D., Bahamonde-Birke, F.J. and Cyganski, R. 2018. Autonomous driving, the built environment and policy implications. *Transportation Research Part A: Policy and Practice.*

Freemark, Y., Hudson, A. and Zhao, J. 2019. Are Cities Prepared for Autonomous Vehicles? *Journal of the American Planning Association.* pp.1-19.

Geurs, K.T. and van Wee, B. 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography.* **12**(2), pp.127-140.

González-González, E., Nogués, S. and Stead, D. 2019. Automated vehicles and the city of tomorrow: A backcasting approach. *Cities.* **94**, pp.153-160.

González-González, E., Nogués, S. and Stead, D. 2020. Parking futures: Preparing European cities for the advent of automated vehicles. *Land Use Policy.* **91**, p104010.

Goodman, A. and Aldred, R. 2018. Inequalities in utility and leisure cycling in England, and variation by local cycling prevalence. *Transportation Research Part F: Traffic Psychology and Behaviour.* **56**, pp.381-391.

Government Office for Science. 2019. *The future of mobility. A time of unprecedented change in the transport system.* [Online]. [Accessed 23/02/2019]. Available from: https://assets.publishing.service.gov.uk/

Greater Manchester Combined Authority. 2018. *Greater Manchester Age-friendly Strategy.* [Online]. [Accessed 08/12/2019]. Available from: https://www.greatermanchester-ca.gov.uk/

Guerra, E. 2015. Planning for Cars That Drive Themselves. *Journal of Planning Education and Research.* **36**(2), pp.210-224.

Harper, C.D., Hendrickson, C.T., Mangones, S. and Samaras, C. 2016. Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions. *Transportation Research Part C: Emerging Technologies.* **72**, pp.1-9.

Harvey, J., Guo, W. and Edwards, S. 2019. Increasing mobility for older travellers through engagement with technology. *Transportation Research Part F: Traffic Psychology and Behaviour.* **60**, pp.172-184.

Hassan, H.M., Ferguson, M.R., Razavi, S. and Vrkljan, B. 2019. Factors That Influence Older Canadians' Preferences for using Autonomous Vehicle Technology: A Structural Equation Analysis. *Transportation Research Record: Journal of the Transportation Research Board.* **2673**(1), pp.469-480.

Haustein, S. and Siren, A. 2014. Seniors' unmet mobility needs – how important is a driving licence? *Journal of Transport Geography.* **41**, pp.45-52.

Haustein, S. and Siren, A. 2015. Older People's Mobility: Segments, Factors, Trends. *Transport Reviews.* **35**(4), pp.466-487.

Highways England. 2017a. *Connecting the Country. Planning for the long term.* [Online]. [Accessed 05/09/2019]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/666876/Connecting_the_country_Planning_for_the_long_term.pdf

Highways England. 2017b. *Strategic Road Network Initial Report.* [Online]. [Accessed 05/09/2019]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/666884/Highways_England_Strategic_Road_Network_Initial_Report_-_WEB.pdf

Hjorthol, R. 2012. Transport resources, mobility and unmet transport needs in old age. *Ageing and Society.* **33**(7), pp.1190-1211.

Hjorthol, R., Levin, L. and Sirén, A. 2010. Mobility in different generations of older persons. *Journal of Transport Geography.* **18**(5), pp.624-633.

HM Government. 2017. *Industrial Strategy. Building a Britain fit for the future.* [Online]. [Accessed 05/05/2018]. Available from: https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

HM Government. 2018a. *Automated and Electric Vehicles Act 2018.* [Online]. [Accessed 12-08-2019]. Available from: https://www.legislation.gov.uk/ukpga/2018/18/contents/enacted

HM Government. 2018b. *The Key Principles of Cyber Security for Connected and Automated Vehicles.* [Online]. [Accessed 20/08/2019]. Available from: https://www.gov.uk/

Holley-Moore, G. and Creighton, H. 2015. *The future of transport in an ageing society.* [Online]. [Accessed 10/05/2019]. Available from: https://www.ageuk.org.uk/

Hopkins, D. and Schwanen, T. 2018. Automated Mobility Transitions: Governing Processes in the UK. *Sustainability.* **10**(4), p956.

Hsieh, H.F. and Shannon, S.E. 2005. Three approaches to qualitative content analysis. *Qualitative Health Research.* **15**(9), pp.1277-1288.

Huff, E.W., DellaMaria, N., Posadas, B. and Brinkley, J. 2019. Am I Too Old to Drive?: Opinions of Older Adults on Self-Driving Vehicles. In: *The 21st International ACM SIGACCESS Conference on Computers and Accessibility*. pp.500-509.

Hulse, L.M., Xie, H. and Galea, E.R. 2018. Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Safety Science.* **102**, pp.1-13.

International Transport Forum. 2017. *Urban Mobility System Upgrade. How shared self-driving cars could change city traffic.* [Online]. [Accessed 18/08/2017]. Available from: https://www.itf-oecd.org/

Ipsos MORI. 2014. *Only 18 per cent of Britons believe driverless cars to be an important development for the car industry to focus on* [Online]. [Accessed 13/05/2019]. Available from: https://www.ipsos.com/

Jin, S.T., Kong, H. and Sui, D.Z. 2019. Uber, Public Transit, and Urban Transportation Equity: A Case Study in New York City. *The Professional Geographer.* **71**(2), pp.315-330.

Jin, S.T., Kong, H., Wu, R. and Sui, D.Z. 2018. Ridesourcing, the sharing economy, and the future of cities. *Cities.* **76**, pp.96-104.

Jones, P. and Lucas, K. 2012. The social consequences of transport decision-making: clarifying concepts, synthesising knowledge and assessing implications. *Journal of Transport Geography.* **21**, pp.4-16.

Kenyon, S. 2011. Transport and social exclusion: access to higher education in the UK policy context. *Journal of Transport Geography.* **19**(4), pp.763-771.

Kim, S. 2011. Assessing mobility in an aging society: Personal and built environment factors associated with older people's subjective transportation deficiency in the US. *Transportation Research Part F: Traffic Psychology and Behaviour.* **14**(5), pp.422-429.

Kim, S.H., Mokhtarian, P.L. and Circella, G. 2020a. How, and for whom, will activity patterns be modified by self-driving cars? Expectations from the state of Georgia. *Transportation Research Part F: Traffic Psychology and Behaviour.* **70**, pp.68-80.

Kim, S.H., Mokhtarian, P.L. and Circella, G. 2020b. Will autonomous vehicles change residential location and vehicle ownership? Glimpses from Georgia. *Transportation Research Part D: Transport and Environment.* **82**, p102291.

Kostyniuk, L.P. and Molnar, L.J. 2008. Self-regulatory driving practices among older adults: health, age and sex effects. *Accident Analysis and Prevention.* **40**(4), pp.1576-1580.

Kovacs, F.S., McLeod, S. and Curtis, C. 2020. Aged mobility in the era of transportation disruption: Will autonomous vehicles address impediments to the mobility of ageing populations? *Travel Behaviour and Society.* **20**, pp.122-132.

Krueger, R., Rashidi, T.H. and Rose, J.M. 2016. Preferences for shared autonomous vehicles. *Transportation Research Part C: Emerging Technologies.* **69**, pp.343-355.

Kyriakidis, M., Happee, R. and de Winter, J.C.F. 2015. Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transportation Research Part F: Traffic Psychology and Behaviour.* **32**, pp.127-140.

Law Commission. 2017. *Automated Vehicles.* [Online]. [Accessed 10/08/2019]. Available from: https://www.lawcom.gov.uk/project/automated-vehicles/

Law Commission. 2019. *Automated Vehicles: Analysis of Responses to the Preliminary Consultation Paper.*

Lee, C., Ward, C., Raue, M., D'Ambrosio, L. and Coughlin, J.F. 2017. Age Differences in Acceptance of Self-driving Cars: A Survey of Perceptions and Attitudes. [Online]. Cham: Springer International Publishing, pp.3-13.

Lee, R.J., Sener, I.N. and Jones, S.N. 2016. Understanding the role of equity in active transportation planning in the United States. *Transport Reviews.* **37**(2), pp.211-226.

Legacy, C., Ashmore, D., Scheurer, J., Stone, J. and Curtis, C. 2018. Planning the driverless city. *Transport Reviews.* **39**(1), pp.84-102.

Li, H., Raeside, R., Chen, T. and McQuaid, R.W. 2012. Population ageing, gender and the transportation system. *Research in Transportation Economics.* **34**(1), pp.39-47.

Li, S., Blythe, P., Guo, W. and Namdeo, A. 2019a. Investigating the effects of age and disengagement in driving on driver's takeover control performance in highly automated vehicles. *Transportation Planning and Technology.* **42**(5), pp.470-497.

Li, S., Blythe, P., Guo, W. and Namdeo, A. 2019b. Investigation of older drivers' requirements of the human-machine interaction in highly automated vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour.* **62**, pp.546-563.

Litman, T. 2017. *Autonomous Vehicle Implementation Predictions. Implications for Transport Planning.* [Online]. [Accessed 27/02/2017]. Available from: https://www.vtpi.org/avip.pdf

Liu, P., Zhang, Y. and He, Z. 2019. The effect of population age on the acceptable safety of self-driving vehicles. *Reliability Engineering & System Safety.* **185**, pp.341-347.

Local Democracy, Economic Development and Construction Act 2009. 2009. Available from: https://www.legislation.gov.uk/

London Assembly. 2018. *Future transport. How is London responding to tehnological innovation?* [Online]. London, UK. [Accessed 15/03/2018]. Available from: https://www.london.gov.uk/

Lucas, K. 2012. Transport and social exclusion: Where are we now? *Transport Policy.* **20**, pp.105-113.

Lucas, K., Bates, J., Moore, J. and Carrasco, J.A. 2016. Modelling the relationship between travel behaviours and social disadvantage. *Transportation Research Part A: Policy and Practice.* **85**, pp.157-173.

Lucas, K., Stokes, G., Bastiaanssen, J. and Burkinshaw, J. 2019. *Inequalities in Mobility and Access in the UK Transport System.* [Online]. [Accessed 16/04/2019]. Available from: https://assets.publishing.service.gov.uk/

Lucas, K., Tyler, S. and Christodoulou, G. 2009. Assessing the 'value' of new transport initiatives in deprived neighbourhoods in the UK. *Transport Policy.* **16**(3), pp.115-122.

Luiu, C., Tight, M. and Burrow, M. 2017. The unmet travel needs of the older population: a review of the literature. *Transport Reviews.* **37**(4), pp.488-506.

Luiu, C., Tight, M. and Burrow, M. 2018a. Factors Preventing the Use of Alternative Transport Modes to the Car in Later Life. *Sustainability.* **10**(6).

Luiu, C., Tight, M. and Burrow, M. 2018b. An investigation into the factors influencing travel needs during later life. *Journal of Transport & Health.* **11**, pp.86-99.

Lyons, G. and Davidson, C. 2016. Guidance for transport planning and policymaking in the face of an uncertain future. *Transportation Research Part A: Policy and Practice.* **88**, pp.104-116.

Lyons, G., Hammond, P. and Mackay, K. 2019. The importance of user perspective in the evolution of MaaS. *Transportation Research Part A: Policy and Practice.* **121**, pp.22-36.

Manaugh, K., Badami, M.G. and El-Geneidy, A.M. 2015. Integrating social equity into urban transportation planning: A critical evaluation of equity objectives and measures in transportation plans in North America. *Transport Policy.* **37**, pp.167-176.

Marin-Lamellet, C. and Haustein, S. 2015. Managing the safe mobility of older road users: How to cope with their diversity? *Journal of Transport & Health.* **2**(1), pp.22-31.

Marottoli, R.A., Mendes de Leon, C.F., Glass, T.A., Williams, C.S., Cooney, L.M. and Berkman, L.F. 2000. Consequences of Driving Cessation: Decreased Out-of-Home Activity Levels. *Journal of Gerontology: SOCIAL SCIENCES.* **55B**(6), pp.S334–S340.

Marsden, G., Anable, J., Bray, J., Seagriff, E. and Spurling, N. 2019. *Shared mobility – where now, where next?* [Online]. Oxford. Available from: https://www.creds.ac.uk/

Marsden, G. and Docherty, I. 2019. *Governance of UK Transport Infrastructures. Future of Mobility Evidence Review.* [Online]. [Accessed 20/04/2019]. Available from: https://www.gov.uk/

Marsden, G., Ferreira, A., Bache, I., Flinders, M. and Bartle, I. 2014. Muddling through with climate change targets: a multi-level governance perspective on the transport sector. *Climate Policy.* **14**(5), pp.617-636.

Marston, H.R., Genoe, R., Freeman, S., Kulczycki, C. and Musselwhite, C. 2019. Older Adults' Perceptions of ICT: Main Findings from the Technology In Later Life (TILL) Study. *Healthcare (Basel).* **7**(3).

Martens, K. 2011. Substance precedes methodology: on cost–benefit analysis and equity. *Transportation.* **38**(6), pp.959-974.

Martens, K. 2015. Accessibility and Potential Mobility as a Guide for Policy Action. *Transportation Research Record: Journal of the Transportation Research Board.* **2499**(1), pp.18-24.

Mason, J. 2002. *Qualitative Researching.* SAGE publications

Mason, M. 2010. Sample Size and Saturation in PhD Studies Using Qualitative Interviews. *Forum: Qualitative Social Research.* **11**(3).

Matthews, K., Nazroo, J. and Marshall, A. 2018. Digital inclusion in later life: cohort changes in internet use over a ten-year period in England. *Ageing and Society.* **39**(9), pp.1914-1932.

Mattioli, G. 2014. Where Sustainable Transport and Social Exclusion Meet: Households Without Cars and Car Dependence in Great Britain. *Journal of Environmental Policy & Planning.* **16**(3), pp.379-400.

Mattioli, G., Lucas, K. and Marsden, G. 2018a. Reprint of Transport poverty and fuel poverty in the UK: From analogy to comparison. *Transport Policy.* **65**, pp.114-125.

Mattioli, G., Wadud, Z. and Lucas, K. 2018b. Vulnerability to fuel price increases in the UK: A household level analysis. *Transportation Research Part A: Policy and Practice.* **113**, pp.227-242.

Mayring, P. 2000. Qualitative Content Analysis. *Forum: Qualitative Social Research.* **20**(2).

McCool, S. 2019. *CAV public acceptability dialogue. Engagement report.* [Online]. [Accessed 03/03/2020]. Available from: https://assets.publishing.service.gov.uk/

McLoughlin, S., Prendergast, D. and Donnellan, B. 2018. Autonomous Vehicles for Independent Living of Older Adults. Insights and Directions for a Cross-European Qualitative Study. In: *Proceedings of the 7th International Conference on Smart Cities and Green ICT Systems Funchal, Madeira, Portugal*. pp. 294-303.

Metz, D. 2010. Transport policy for an ageing population. *Transport Reviews.* **23**(4), pp.375-386.

Meyer, J., Becker, H., Bösch, P.M. and Axhausen, K.W. 2017. Autonomous vehicles: The next jump in accessibilities? *Research in Transportation Economics.* **62**, pp.80-91.

Midlands Future Mobility. 2019. *Webpage of Midlands Future Mobility.* [Online]. [Accessed 02/01/2020]. Available from: https://midlandsfuturemobility.co.uk/

Milakis, D., Kroesen, M. and van Wee, B. 2018. Implications of automated vehicles for accessibility and location choices: Evidence from an expert-based experiment. *Journal of Transport Geography.* **68**, pp.142-148.

Milakis, D., Snelder, M., van Arem, B., van Wee, B. and Correia, G. 2017a. Development and transport implications of automated vehicles in the Netherlands: scenarios for 2030 and 2050. *European Journal of Transport and Infrastructure Research.* (17 (1)), pp.63-85.

Milakis, D., van Arem, B. and van Wee, B. 2017b. Policy and society related implications of automated driving: A review of literature and directions for future research. *Journal of Intelligent Transportation Systems.* **21**(4), pp.324-348.

Milakis, D. and van Wee, B. 2020. Implications of vehicle automation for accessibility and social inclusion of people on low income, people with physical and sensory disabilities, and older people. In: Antoniou, E., et al. eds. *Demand for Emerging Transportation Systems.* The Netherlands: Elsevier, pp.61-73.

Millard-Ball, A. 2016. Pedestrians, Autonomous Vehicles, and Cities. *Journal of Planning Education and Research.* **38**(1), pp.6-12.

Milton Keynes Council. 2018a. *Mobility Strategy for Milton Keynes 2018 - 2036 LTP4.* [Online]. [Accessed 09/06/2019]. Available from: https://www.milton-keynes.gov.uk/highways-and-transport-hub/policy-and-strategy-hub/transport-policy

Milton Keynes Council. 2018b. *Mobility Strategy for Milton Keynes 2018 - 2036. Detailed context and evidence base.* [Online]. [Accessed 09/06/2019]. Available from: https://www.milton-keynes.gov.uk/highways-and-transport-hub/policy-and-strategy-hub/transport-policy

Milton Keynes Council. 2018c. *Mobility Strategy for Milton Keynes 2018 - 2036. Transport Infrastructure Delivery Plan.* [Online]. [Accessed 09/06/2019]. Available from: https://www.milton-keynes.gov.uk/highways-and-transport-hub/policy-and-strategy-hub/transport-policy

Milton Keynes Council. 2020. *MK Council starts innovative ride sharing trial*. [Press release]. Available from: https://www.milton-keynes.gov.uk/

Mladenović, M.N., Stead, D., Milakis, D., Pangbourne, K. and Givoni, M. 2020. Governance cultures and sociotechnical imaginaries of self-driving vehicle technology: Comparative analysis of Finland, UK and Germany. In: Milakis, D., et al. eds. *Policy Implications of Autonomous Vehicles* [Online]. Advances in Transport Policy and Planning, Elsevier. [Accessed 03/07/2020]. Available from: https://www.sciencedirect.com/

Mott Macdonald. 2018. *Greater Manchester Spatial Framework Transport Study Addressing the Issues.* [Online]. Available from: https://assets.ctfassets.net/nv7y93idf4jq/1TkPi8nuLzR5lNtMhc5M7g/075920a1c330a87cf11522cbeb3f5401/181213_GMSF_Transport_Study_Addressing_the_Issues_Report_RevB_ISSUE.PDF

Mulley, C. 2017. Mobility as a Services (MaaS) – does it have critical mass? *Transport Reviews.* **37**(3), pp.247-251.

Murray, A. and Musselwhite, C. 2019. Older peoples' experiences of informal support after giving up driving. *Research in Transportation Business & Management.* **30**.

Musselwhite, C. 2014. Environment–person interactions enabling walking in later life. *Transportation Planning and Technology.* **38**(1), pp.44-61.

Musselwhite, C. 2017a. Exploring the importance of discretionary mobility in later life. *Working with Older People.* **21**(1), pp.49-58.

Musselwhite, C. 2017b. *Mobilities for an Ageing Population: Is the car necessary for successful ageing?* [Online]. Oxford, UK. Available from: https://www.tsu.ox.ac.uk/

Musselwhite, C. 2017c. Public and Community Transport. In: Musselwhite, C. ed. *Transport, Travel and Later Life.* [Online]. Transport and Sustainability, Emerald Publishing, pp.117-128. [Accessed 08/05/2019]. Available from: https://www.emerald.com/

Musselwhite, C. 2019. Older People's Mobility, New Transport Technologies and User-Centred Innovation. In: Muller, B. and Meyer, G. eds. *Towards User-Centric Transport in Europe.* [Online]. Switzerland: Springer, pp.87-103. [Accessed 10/06/2019]. Available from: https://www.springer.com/

Musselwhite, C. and Haddad, H. 2007. *Prolonging the Safe Driving of Older People through Technology. Final Report.* [Online]. The Centre for Transport & Society. University of the West of England, Bristol. [Accessed 13/05/2019]. Available from: https://www.drcharliemuss.com/

Musselwhite, C. and Haddad, H. 2010a. *An exploration into the travel needs of older people.*

Musselwhite, C. and Haddad, H. 2010b. Mobility, accessibility and quality of later life. *Quality in Ageing and Older Adults.* **11**(1), pp.25-37.

Musselwhite, C. and Shergold, I. 2013. Examining the process of driving cessation in later life. *Eur J Ageing.* **10**(2), pp.89-100.

Neutens, T., Schwanen, T., Witlox, F. and De Maeyer, P. 2010. Equity of Urban Service Delivery: A Comparison of Different Accessibility Measures. *Environment and Planning A: Economy and Space.* **42**(7), pp.1613-1635.

Newman, P.W.G. and Kenworthy, J.R. 1996. The land use—transport connection. *Land Use Policy.* **13**(1), pp.1-22.

Nielsen, T.A.S. and Haustein, S. 2018. On sceptics and enthusiasts: What are the expectations towards self-driving cars? *Transport Policy.* **66**, pp.49-55.

Nogués, S., González-González, E. and Cordera, R. 2020. New urban planning challenges under emerging autonomous mobility: evaluating backcasting scenarios and policies through an expert survey. *Land Use Policy.* **95**, p104652.

Nordbakke, S. 2013. Capabilities for mobility among urban older women: barriers, strategies and options. *Journal of Transport Geography.* **26**, pp.166-174.

Nordbakke, S. 2019. Mobility, Out-of-Home Activity Participation and Needs Fulfilment in Later Life. *Int J Environ Res Public Health.* **16**(24), p5109.

Nordbakke, S. and Schwanen, T. 2014. Transport, unmet activity needs and wellbeing in later life: exploring the links. *Transportation.* **42**(6), pp.1129-1151.

Nordhoff, S., de Winter, J., Madigan, R., Merat, N., van Arem, B. and Happee, R. 2018. User acceptance of automated shuttles in Berlin-Schöneberg: A questionnaire study. *Transportation Research Part F: Traffic Psychology and Behaviour.* **58**, pp.843-854.

Ofcom. 2018. *Access and Inclusion report in 2018. Consumers' experiences in communications markets.* [Online]. [Accessed 30/01/2020]. Available from: https://www.ofcom.org.uk/

Office for National Statistics. 2018. *Living longer how our population is changing and why it matters. Overview of population ageing in the UK and some of the implications for the economy, public services, society and the individual.* [Online]. Available from: https://www.ons.gov.uk/

Office for National Statistics. 2019. *Health state life expectancies, UK: 2016 to 2018.* [Online]. Available from: https://www.ons.gov.uk/

Oxfordshire County Council. 2015. *Local Transport Plan 2015-2031. Volume 1: Policy & Overall Strategy.* [Online]. [Accessed 05/09/2019]. Available from: https://www2.oxfordshire.gov.uk/cms/sites/default/files/folders/documents/roadsandtransport/transportpoliciesandplans/localtransportplan/ConnectingOxfordshirevol1policyandoverallstrategy.pdf

Oxfordshire County Council. 2016. *Science Transit Strategy.* [Online]. Available from: https://mycouncil.oxfordshire.gov.uk/documents/s33709/Background%20CA_JUN2816R11%20Connecting%20Oxfordshire%20vol%206%20-%20Science%20Transit%20Strategy.pdf

Pangbourne, K., Mladenović, M.N., Stead, D. and Milakis, D. 2020. Questioning mobility as a service: Unanticipated implications for society and governance. *Transportation Research Part A: Policy and Practice.* **131**, pp.35-49.

Pangbourne, K., Stead, D., Mladenović, M. and Milakis, D. 2018. The Case of Mobility as a Service: A Critical Reflection on Challenges for Urban Transport and Mobility Governance. In: Marsden, G. and Reardon, L. eds. *Governance of the Smart Mobility Transition.* Emerald Publishing Limited, pp.33-48.

Papa, E. and Ferreira, A. 2018. Sustainable Accessibility and the Implementation of Automated Vehicles: Identifying Critical Decisions. *Urban Science.* **2**(1), p5.

Parkhurst, G., Galvin, K., Musselwhite, C., Phillips, J., Shergold, I. and Todres, L. 2013. A Continuum for Understanding the Mobility of Older People. In: *Urban Transport Studies Group 2013*, *January 2013, Oxford, UK*.

Parkhurst, G. and Lyons, G. 2018. The many assumptions about self-driving cars. In: *16th Annual Transport Practitioners Meeting, 5-6 July, 2018, Oxford*.

Patomäki, H. 2015. Realist Ontology for Futures Studies. *Journal of Critical Realism.* **5**(1), pp.1-31.

Payre, W., Cestac, J. and Delhomme, P. 2014. Intention to use a fully automated car: Attitudes and a priori acceptability. *Transportation Research Part F: Traffic Psychology and Behaviour.* **27**, pp.252-263.

Pereira, R.H.M., Schwanen, T. and Banister, D. 2016. Distributive justice and equity in transportation. *Transport Reviews.* **37**(2), pp.170-191.

Prattley, J., Buffel, T., Marshall, A. and Nazroo, J. 2020. Area effects on the level and development of social exclusion in later life. *Soc Sci Med.* **246**, p112722.

Pudāne, B., Rataj, M., Molin, E.J.E., Mouter, N., van Cranenburgh, S. and Chorus, C.G. 2019. How will automated vehicles shape users' daily activities? Insights from focus groups with commuters in the Netherlands. *Transportation Research Part D: Transport and Environment.* **71**, pp.222-235.

Rahman, M.M., Deb, S., Strawderman, L., Burch, R. and Smith, B. 2019. How the older population perceives self-driving vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour.* **65**, pp.242-257.

Rahman, M.M., Deb, S., Strawderman, L., Smith, B. and Burch, R. 2020. Evaluation of transportation alternatives for aging population in the era of self-driving vehicles. *IATSS Research.* **44**(1), pp.30-35.

Rayle, L., Dai, D., Chan, N., Cervero, R. and Shaheen, S. 2016. Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy.* **45**, pp.168-178.

Ritchie, J. and Lewis, J. 2003. *Qualitative research practice. A guide for social science students and researchers.* Sage Publications.

Robertson, R.D., Woods-Fry, H., Vanlaar, W.G.M. and Mainegra Hing, M. 2019. Automated vehicles and older drivers in Canada. *J Safety Res.* **70**, pp.193-199.

Robson, C. and McCartan, K. 2016. *Real World Research. A Resource for Users of Social Research Methods in Applied Settings.* 4th edition ed. Wiley.

Rosenbloom, S. 2001. Driving Cessation Among Older People: When Does It Happen and What Impact Does It Have? *Transportation Research Record: Journal of the Transportation Research Board.* **1779**(1), pp.93-99.

Rosenbloom, S. 2004. *Mobility of the elderly: good news and bad news.* [Online]. Washington, DC. [Accessed 10/03/2018]. Available from: http://onlinepubs.trb.org/

Rosenbloom, S. and Winsten-Bartlett, C. Asking the Right Question. Understanding the Travel Needs of Older Women Who Do Not Drive. *Transportation Research Record: Journal of the Transportation Research Board.* **1818**(02-3554), pp.78-82.

Rubin, H. and Rubin, I. 2005. *Qualitative Interviewing (2nd ed.): The Art of Hearing Data.* Sage Publications.

Ryan, J. 2020. Examining the Process of Modal Choice for Everyday Travel Among Older People. *Int J Environ Res Public Health.* **17**(3).

Ryan, J., Svensson, H., Rosenkvist, J., Schmidt, S.M. and Wretstrand, A. 2016. Cycling and cycling cessation in later life: Findings from the city of Malmö. *Journal of Transport & Health.* **3**(1), pp.38-47.

Ryan, J. and Wretstrand, A. 2019. What's mode got to do with it? Exploring the links between public transport and car access and opportunities for everyday activities among older people. *Travel Behaviour and Society.* **14**, pp.107-118.

Ryan, J., Wretstrand, A. and Schmidt, S.M. 2019. Disparities in mobility among older people: Findings from a capability-based travel survey. *Transport Policy.* **79**, pp.177-192.

SAE International. 2018. *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.* [Online]. SAE International. [Accessed 22/10/2018]. Available from: https://www.sae.org/

Scheiner, J. 2006. Does the car make elderly people happy and mobile. Settlement structures, car availability and leisure mobility of the elderly. *European Journal of Transport and Infrastructure Research.* **6**(2), pp.151-172.

Schoettle, B. and Sivak, M. 2014. *A survey of public opinion about autonomous and self-driving vehicles in the U.S., the U.K., and Australia.* [Online]. [Accessed 15/05/2019]. Available from: http://www.umtri.umich.edu/

Schoettle, B. and Sivak, M. 2016. *Motorists' preferences for different levels of vehicle automation: 2016.* [Online]. [Accessed 16/05/2019]. Available from: http://www.umich.edu/

Schreier, M. 2014. Qualitative Content Analysis. In: Flick, U. ed. *The SAGE Handbook of Qualitative Data Analysis.* [Online]. pp.170-183. Available from: https://methods.sagepub.com/

Schwanen, T., Banister, D. and Bowling, A. 2012. Independence and mobility in later life. *Geoforum.* **43**(6), pp.1313-1322.

Schwanen, T. and Páez, A. 2010. The mobility of older people – an introduction. *Journal of Transport Geography.* **18**(5), pp.591-595.

Shaheen, S. and Chan, N. 2016. Mobility and the Sharing Economy. Potential to Facilitate the First- and Last-Mile Public Transit Connections. *Built Environment.* **42**(4), pp.573-588.

Shaheen, S., Totte, H. and Stocker, A. 2018. *Future of Mobility. White paper.* [Online]. [Accessed 23/04/2018]. Available from: https://escholarship.org/

Shergold, I. 2019a. *Overall Findings from Research with Older People participating in Connected Autonomous Vehicle trials.* [Online]. [Accessed 19/02/2020]. Available from: http://www.flourishmobility.com/publications

Shergold, I. 2019b. Taking part in activities, an exploration of the role of discretionary travel in older people's wellbeing. *Journal of Transport & Health.* **12**, pp.195-205.

Shergold, I., Lyons, G. and Hubers, C. 2015. Future mobility in an ageing society – Where are we heading? *Journal of Transport & Health.* **2**(1), pp.86-94.

Shergold, I. and Parkhurst, G. 2012. Transport-related social exclusion amongst older people in rural Southwest England and Wales. *Journal of Rural Studies.* **28**(4), pp.412-421.

Shergold, I., Wilson, M., Parkhurts, G., Ashley, H. and Cockburn, M. 2016. *The mobility of older people, and the future role of Connected Autonomous Vehicles. A literature review.* [Online]. [Accessed 18/10/2019]. Available from: https://uwe-repository.worktribe.com/

Shope, J.T., Begg, D. and Brookland, R. 2019. Older former drivers' health, activity, and transport in New Zealand. *Journal of Transport & Health.* **14**, p100559.

Singleton, P.A. 2018. Discussing the "positive utilities" of autonomous vehicles: will travellers really use their time productively? *Transport Reviews.* **39**(1), pp.50-65.

Singleton, P.A., De Vos, J., Heinen, E. and Pudāne, B. 2020. Potential health and well-being implications of autonomous vehicles. In: Milakis, D., et al. eds. *Policy Implications of Autonomous Vehicles* [Online]. Advances in Transport Policy and Planning, Elsevier, pp.163-190. [Accessed 07/08/2020]. Available from: https://www.sciencedirect.com/

Siren, A. and Hakamies-Blomqvist, L. 2004. Private car as the grand equaliser? Demographic factors and mobility in Finnish men and women aged 65+. *Transportation Research Part F: Traffic Psychology and Behaviour.* **7**(2), pp.107-118.

Siren, A. and Hakamies-Blomqvist, L. 2006. Does gendered driving create gendered mobility? Community-related mobility in Finnish women and men aged 65+. *Transportation Research Part F* **9**, pp.374–382.

Siren, A. and Haustein, S. 2014. What are the impacts of giving up the driving licence? *Ageing and Society.* **35**(9), pp.1821-1838.

Siren, A. and Haustein, S. 2015. Driving licences and medical screening in old age: Review of literature and European licensing policies. *Journal of Transport & Health.* **2**(1), pp.68-78.

Siren, A., Hjorthol, R. and Levin, L. 2015. Different types of out-of-home activities and well-being amongst urban residing old persons with mobility impediments. *Journal of Transport & Health.* **2**, pp.14-21.

Smith, G., Sochor, J. and Karlsson, I.C.M. 2018. Mobility as a Service: Development scenarios and implications for public transport. *Research in Transportation Economics.* **69**, pp.592-599.

Social Exclusion Unit. 2003. *Making the Connections: Final Report on Transport and Social Exclusion.* [Online]. London, UK. [Accessed 09/08/2017]. Available from: http://www.ilo.org/

Soteropoulos, A., Berger, M. and Ciari, F. 2018. Impacts of automated vehicles on travel behaviour and land use: an international review of modelling studies. *Transport Reviews.* **39**(1), pp.29-49.

Spinney, J. and Lin, W.-I. 2018. Are you being shared? Mobility, data and social relations in Shanghai's Public Bike Sharing 2.0 sector. *Applied Mobilities.* **3**(1), pp.66-83.

Stayton, E. and Stilgoe, J. 2020. It's Time to Rethink Levels of Automation for Self-Driving Vehicles. *SSRN Electronic Journal.* [Online]. Available from: https://ssrn.com/

Stilgoe, J. 2017. Seeing like a Tesla: How can we anticipate self-driving worlds? *Glocalism.* **3**.

Stilgoe, J. 2018. Machine learning, social learning and the governance of self-driving cars. *Soc Stud Sci.* **48**(1), pp.25-56.

Stjernborg, V., Emilsson, U.M. and Ståhl, A. 2014. Changes in outdoor mobility when becoming alone in the household in old age. *Journal of Transport & Health.* **1**(1), pp.9-16.

Stokes, G. 2013. The Prospects for Future Levels of Car Access and Use. *Transport Reviews.* **33**(3), pp.360-375.

Stokes, G. and Lucas, K. 2011. *National Travel Survey Analysis. Working Paper N° 1053.* [Online]. [Accessed 10/11/2016]. Available from: http://www.tsu.ox.ac.uk/

Sustrans. 2018. Looking to the future of transport: investing to support mobility. *Sustrans.* [Online]. Available from: https://www.sustrans.org.uk/

Taeihagh, A. and Lim, H.S.M. 2018. Governing autonomous vehicles: emerging responses for safety, liability, privacy, cybersecurity, and industry risks. *Transport Reviews.* **39**(1), pp.103-128.

TfGM. 2017. *GM Transport Strategy 2040. A sustainable urban mobility plan for the future.* [Online]. Available from: https://downloads.ctfassets.net/nv7y93idf4jq/7FiejTsJ68eaa8wQw8MiWw/bc4f3a45f6685148eba2acb618c2424f/03._GM_2040_TS_Full.pdf

TfGM. 2018. *GM Transport Strategy 2040. Evidence Base 2018 Update.* [Online]. Available from: https://downloads.ctfassets.net/nv7y93idf4jq/3ryONeNzmuSAsPDzgtB3jt/489fbfefd35227ba4bad46c89f0e210a/2040_Evidence_Base_Update_Collated.pdf

TfGM. 2019. *GM Transport Strategy 2040. Draft Delivery Plan (2020-2025).* [Online]. Available from: https://assets.ctfassets.net/nv7y93idf4jq/2GBbEBM4hm68q9qqvdaI1T/97f7b3d51ef9b312b756cd15bd0b008c/190128_Delivery_Plan_2020-2025_Draft_MASTER_final.pdf

TfL. 2018. *Mayor's Transport Strategy.* [Online]. [Accessed 04/04/2018]. Available from: https://www.london.gov.uk/sites/default/files/mayors-transport-strategy-2018.pdf

TfL. 2019a. *Connected and Autonomous Vehicles statement.* [Online]. [Accessed 19/07/2019]. Available from: http://content.tfl.gov.uk/connected-and-autonomous-vehicle-statement.pdf

TfL. 2019b. *Connected and Autonomous Vehicles: guidance for London trials.* [Online]. [Accessed 20/07/2019]. Available from: http://content.tfl.gov.uk/connected-and-autonomous-vehicles-guidance-for-london-trials.pdf

TfN. 2019. *Strategic Transport Plan.* [Online]. [Accessed 05/09/2019]. Available from: https://transportforthenorth.com/wp-content/uploads/TfN-final-strategic-transport-plan-2019.pdf

TfWM. 2017. *Movement for Growth: 2026 Delivery Plan for Transport.* [Online]. Available from: https://www.tfwm.org.uk/media/2539/2026-delivery-plan-for-transport.pdf

TfWM. 2018. *Connected & Autonomous vehicles are the future - the West Midlands is leading the way.* [Online]. Available from: https://www.tfwm.org.uk/strategy/innovation-future-mobility/

TfWM. no date. *Movement for Growth: The West Midlands Strategic Transport Plan.* [Online]. Available from: https://www.tfwm.org.uk/media/1099/movement-for-growth.pdf

Tirachini, A. and Antoniou, C. 2020. The economics of automated public transport: Effects on operator cost, travel time, fare and subsidy. *Economics of Transportation.* **21**.

Tournier, I., Dommes, A. and Cavallo, V. 2016. Review of safety and mobility issues among older pedestrians. *Accident Analysis and Prevention.* **91**, pp.24-35.

Transport Committee. 2018. *Mobility as a Service. Eighth Report of Session 2017 - 2019.* [Online]. [Accessed 12/12/2018]. Available from: https://publications.parliament.uk/

Travelwest. 2020. *Joint Local Transport Plan 4 2020-2036.* [Online]. [Accessed 05/05/2020]. Available from: https://s3-eu-west-1.amazonaws.com/travelwest/wp-content/uploads/2020/04/Adopted-Joint-Local-Transport-Plan-4.pdf

U.S. Department of Transportation. 2018. *Preparing for the future of transportation. Automated vehicles 3.0.* [Online]. [Accessed 22/10/2018]. Available from: https://www.transportation.gov/AV

UITP. 2017. *Policy Brief. Autonomous vehicles: A potential game changer for urban mobility.* [Online]. Available from: https://www.uitp.org/

UK Autodrive. 2020. *Autodrive.* [Online]. [Accessed 10/01/2020]. Available from: http://www.ukautodrive.com/

Urban Transport Group. 2020. *Automatic for the people?* [Online]. [Accessed 26/03/2020]. Available from: http://www.urbantransportgroup.org/

van Schalkwyk, M.C.I. and Mindell, J.S. 2018. Current issues in the impacts of transport on health. *British Medical Bulletin.* **125**(1), pp.67-77.

Van Wee, B. and Banister, D. 2015. How to Write a Literature Review Paper? *Transport Reviews.* **36**(2), pp.278-288.

ViaVan. 2020. *Innovative transport pilot for Furzton, Emerson Valley, and Tattenhoe residents*. [Press release]. Available from: https://www.viavan.com/

Wadud, Z. 2017. Fully automated vehicles: A cost of ownership analysis to inform early adoption. *Transportation Research Part A: Policy and Practice.* **101**, pp.163-176.

Wadud, Z. and Huda, F.Y. 2019. Fully automated vehicles: the use of travel time and its association with intention to use. *Proceedings of the Institution of Civil Engineers - Transport.* pp.1-15.

Wadud, Z., MacKenzie, D. and Leiby, P. 2016. Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A: Policy and Practice.* **86**, pp.1-18.

WSP. 2019. *Infrastructure Plan. Stage 1 Evidence Review* [Online]. [Accessed 09/06/2019]. Available from: https://www.milton-keynes.gov.uk/highways-and-transport-hub/policy-and-strategy-hub/transport-policy

Yang, J. and Coughlin, J.F. 2014. In-vehicle technology for self-driving cars: advantages and challenges for aging drivers. *International Journal of Automotive Technology.* **15**(2), pp.333-340.

Yin, R. 2018. *Case study research and applications: design and methods.* Sixth ed. Los Angeles: Sage.

Zakharenko, R. 2016. Self-driving cars will change cities. *Regional Science and Urban Economics.* **61**, pp.26-37.

Zeitler, E. and Buys, L. 2014. Mobility and out-of-home activities of older people living in suburban environments: 'Because I'm a driver, I don't have a problem'. *Ageing and Society.* **35**(4), pp.785-808.

Zenzic. 2020. *Zenzic.* [Online]. Available from: https://zenzic.io/about/

Zhang, W. and Guhathakurta, S. 2017. Parking Spaces in the Age of Shared Autonomous Vehicles: How Much Parking Will We Need and Where? *Transportation Research Record: Journal of the Transportation Research Board.* **2651**(1), pp.80-91.

Zhang, W., Guhathakurta, S. and Khalil, E.B. 2018. The impact of private autonomous vehicles on vehicle ownership and unoccupied VMT generation. *Transportation Research Part C: Emerging Technologies.* **90**, pp.156-165.

Zhang, W. and Wang, K. 2020. Parking futures: Shared automated vehicles and parking demand reduction trajectories in Atlanta. *Land Use Policy.* **91**, p103963.

Appendix A – Interview structure, information sheet and consent form for transport professionals

Interview structure

1. Position and main activities within the organisation.
2. Benefits/ concerns about AVs

- What are your in view the main benefits of AVs?

- What are your main concerns about AVs?

3. AV-related projects and trials

- Are there projects or studies related to AVs in which the [organization/authority] is participating?

(Probe until topic well covered, scope, motivations, learning outcomes)

4. Accessibility of older people and other social groups

- How do you think AVs may affect accessibility inequalities among social groups and places?

(Probe about older people and other social groups and inequalities; disability, income)

If not discussed at part 2:

- How do you think AVs may impact on walking and cycling and the ability to access destinations by these modes?

- How do you think AVs may impact on public transport and the ability to access destinations by this mode?

- There is a hypothesis that people who will be able to do activities on board may choose to relocate further from the city centres. On the other hand, some argue that city centres may become more compact as parking spaces are freed-up. What do you think about the impact on built environment and land-uses?

5. Policies and regulations.

- Are there any policies or regulations that should be considered by national or local authorities in the short-term, while AVs are being developed?

- Are there any policies or regulations that should be considered by national or local authorities in the medium or longer-term, when AVs are ready to be deployed?

- Are there any policy decisions or guidance that you believe need to be developed from the central government to assist with AV planning locally?

(Probe until topic well covered)

Information sheet

I am pleased to invite you to take part in a study, part of the PhD research of Lamprini Papafoti at the Institute for Transport Studies, University of Leeds. The research is funded by the University of Leeds.

This study aims to understand if and how automated vehicles can be used for a transport equitable future. It explores transport policymaking in different case study areas in the UK, as it may evolve in the period up to 2050. It discusses the transport strategies that have been produced by the relevant authorities for that period and how their policies aim to address different equity issues and transport problems of mobility and/or socially disadvantaged groups. Moreover, it investigates the likely future equity impacts of automated vehicles and other relevant transport innovations, as perceived by various policymakers and stakeholders. Policies and planning decisions for automated vehicles are discussed to explore the potential impacts these may have on different groups of society, with a particular focus on older people. These outputs are explored in combination to a study involving older people to understand potential impacts for their mobility and accessibility.

Please be informed that whether or not you take part is your choice. If you do not want to take part, you do not have to give a reason. If you agree to participate, you will be asked to sign the Consent Form attached to this document. You will be given a copy of both the Information Sheet and the Consent Form to keep. Even if you decide to participate now, you can still withdraw from the study at any time until the 29^{h} of February 2020. Please take your time to fully assess all the relevant information. Ask me if there is anything that is not clear or if you would like more information. You can find my contact details below.

If you take part in this research, you will be requested to do a one-hour interview, covering topics related to the aforementioned, depending on the organization to which you belong (national department or regional/local authority) and the position you hold. The information that you will provide, will be published in the dissertation thesis of my PhD and possibly in specialised academic articles.

During the interview, you will be recorded, and notes will be kept in handwritten form, but this material will only be used for purposes of analysis and illustration in the research. No one outside the research project will be allowed access to the original recordings or notes. To protect your anonymity and the confidentiality of the information you provide, your name and other personal details will not be disclosed in any publication, unless you express the explicit will for your personal details to be disclosed, exactly specifying which ones. Your anonymity and confidentiality will be preserved by providing a pseudonym which will be further transformed in the research writing phase. In published material (reports, publications, presentations), your responses will be available either in aggregate form or in quotations. In quotations, your name will not appear, and you will be referred as ‘participant from the department/authority/organisation x’. However, despite these protocols followed to protect your anonymity, it might be possible that you are recognized by persons that are familiar with the organisation and its structure.

All non-electronic information produced in this study will be stored in secure locker inside my office in the University of Leeds. Electronic information will be stored in an encrypted folder when in a drive pen, then transferred through secure protocol in my personal encrypted folder at the University of Leeds servers.

Due to the nature of this research, your participation is not expected to find information that may put you at any risk.

Finally, the information you can provide us will help understand policy processes and provide recommendations for authorities of different levels to develop more socially inclusive transport systems in the future that cater for the needs of different social groups.

This document is three pages long, including the Consent Form. Please make sure you have read and understood all the pages. If you have any question regarding your participation or the research project, you can contact the PhD researcher Lamprini Papafoti by email (tslp@leeds.ac.uk) or telephone (+447731949458), or the supervisors Karen Lucas by email (K.Lucas@leeds.ac.uk) or telephone (+44 (0)113 34 38086) and John Nellthorp by email (J.Nellthorp@its.leeds.ac.uk) or telephone (+44 (0)113 34 36613).

Thank you.

This study has received a University of Leeds ethical approval with reference LTTRAN-090, amendment July 2019 and date 15/07/2019.

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Project title	Document type	Version #	Date
Automated vehicles and future transport equity in the UK. Exploring the role of policy-making and the potential impacts for older people	Information sheet	2	15/07/2019

Consent to take part in the research project:

Automated vehicles and future transport equity in the UK. Exploring the role of policy-making and the potential impacts for older people

	Add your initials next to the statement if you agree
I confirm that I have read and understood the information sheet dated 15/07/2019 explaining the research project and I have had the opportunity to ask questions about the project.	
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. If I request withdrawal all the information will be properly deleted from all the devices which store them. Any paper note will be destroyed as well. I understand that I can request withdrawal at any point of the research before the 29th of February 2020 when analysis will have begun, by contacting the PhD researcher: Lamprini Papafoti tslp@leeds.ac.uk, +447731949458	
I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports and publication or publications that result from the research.	
I am aware that despite those protocols, I might be identifiable by others who are familiar with my organization/authority/department in the publications and conference papers that result from this research.	
I understand that relevant sections of the data collected during the study, may be looked at by individuals from the University of Leeds or from regulatory authorities where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
I agree to the use of my anonymised quotes in reports, papers and presentations that result from the research.	
I agree for the data collected from me to be stored and used in relevant future research in an anonymized form.	
I agree to take part in the above research project and will inform the lead researcher should my contact details change.	

Name of participant	
Participant's signature	
Name of person taking consent	
Signature	
Date	

Appendix B – Photos/images, interview structure, information sheet and consent form for members of the public

Photos/images

[This image has been removed by the author of this thesis for copyright reasons]

Image B.1: Image used during interviews with members of the public (woman reading book in a driverless vehicle)

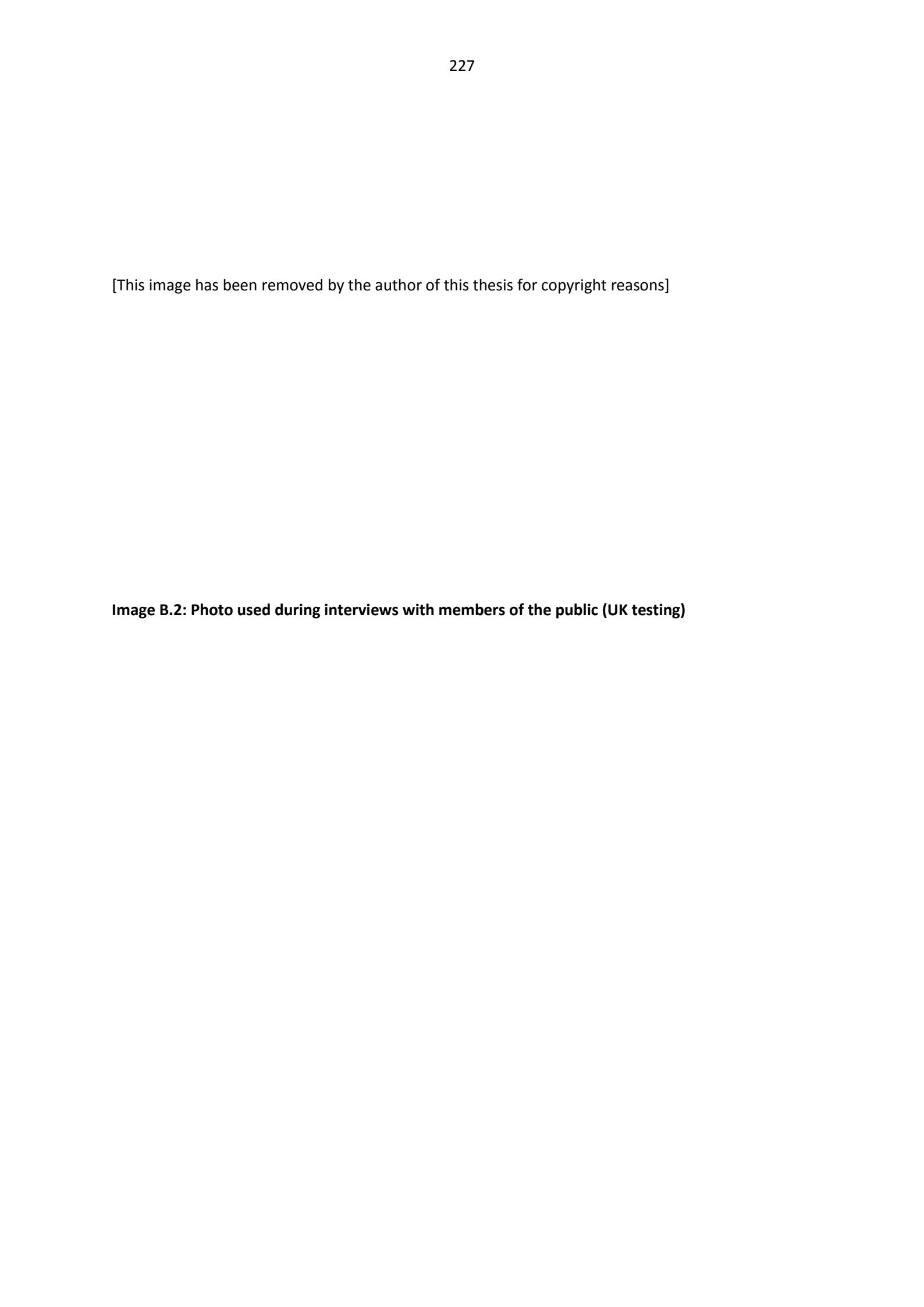

Image B.2: Photo used during interviews with members of the public (UK testing)

[This image has been removed by the author of this thesis for copyright reasons]

Image B.3: Photo used during interviews with members of the public (driverless mini-bus)

Interview structure

1. **Driving**

Do you have a driving license?
If yes,

Are there any cars in your household?

Do you drive? How often?

Do you enjoy driving? What do you enjoy about it?
Do you know if your car has any automated features?
Ask for which ones, if they are useful for driving.

If not,

Did you ever use to drive?
Did you stop because of poor health or any mobility difficulty?

2. CARD 1, CARD 2

3. Views on driverless vehicles

Have you heard about these driverless vehicles?

***If yes, ask if the person can say a bit more (where they heard about it, what).

Think about a future that we are able to buy and use driverless cars, taxis and buses.

How does this seem to you?

Can you imagine any benefits from these driverless vehicles for society? If yes, which are these?

Can you imagine any benefits for yourself? If yes, which are these?

Do you have any concerns about these driverless vehicles? If yes, which are these?

(Probe until well covered)

4. CARD 3 * Ask drivers only

5. CARD 4 – 7 Ask everyone

I will ask you to think about different types of driverless vehicles and transport services and tell me if you would be interested in using them.

I would ask you to think that these are safe to use in these scenarios both for the persons inside the vehicles as well as for the pedestrians, cyclists and users of other vehicles. The price of the service would be similar to what you pay today for these options – if not I will suggest a different cost.

CARD 4 BUSES

Prompt specifically for issues of safety without a driver and customer assistance.

CARD 5 TAXIS

CARD 6 DRIVERLESS NEIGHBORHOOD COMMUNITY CAR CLUBS

CARD 7 PRIVATE CARS

If the person says something about cost – ask if the cost is lower, would their opinion change?

CARD 8 ALTERNATIVE TRANSPORT FUTURE SCENARIOS

CARD 9 Socio-economic details

CARDS

CARD 1

Can you tell me how often you use these transportation modes?

	Everyday	Few times per week	Few times per month	Once a month or less	Never
Car (driver)	☐	☐	☐	☐	☐
Car (passenger)	☐	☐	☐	☐	☐
Bus	☐	☐	☐	☐	☐
Taxi	☐	☐	☐	☐	☐
Walking	☐	☐	☐	☐	☐
Cycling	☐	☐	☐	☐	☐
Community transport	☐	☐	☐	☐	☐
Train	☐	☐	☐	☐	☐

CARD 2

In this card I will show you a series of out-of-home activities. I would like you to think where you usually need to go to do these activities and how you travel there.

How easy is it usually for you to do these by your main mode of transport?

- Go for grocery and other shopping
- Meet my friends and family
- Visit my GP or go to other medical appointments
- Do my hobbies or any leisure activity
- Do any business or work activities

Would you like to do any of these more often but find it difficult to get there?

CARD 3 (Drivers only)

If you had the option to choose between these two what would you prefer?

1. Driverless cars. You wouldn't need to manually drive – a wheel and driving system wouldn't exist, you would just need to step in and choose your destination. While you were in the vehicle you could do other activities.

2. Driverless cars that allow you to manually drive. The vehicle would mostly be able to drive on its own. While doing so, you could do other activities inside the vehicle. However, the car would have a steering wheel and you could choose to drive it.

CARD 4

Scenario A: Imagine that there were *driverless buses* operating in your area. These would be buses that you could get on and off just as you do today from a bus stop but they would not be driven by a driver.

Would you be interested in using a driverless bus?

Why/why not?

Would something change in the way you moved around if there were driverless buses?

CARD 5

Scenario B: Imagine that there were *driverless taxi services* that you could book through an application in a smartphone. They would be operated by a taxi company that would set up the rides. It would come and pick you up and it would leave you wherever you wanted it to.

Would you be interested in using a driverless taxi?

Why/Why not?

Would something change in the way you moved around if there were driverless taxis?

There would also be the option to share the ride with someone else that has booked a journey from and to nearby places. If you shared the ride, it would be quite cheaper.

Would you be interested in sharing a driverless taxi?

CARD 6

Scenario C: Imagine that there were *driverless neighbourhood car clubs.* These would be driverless cars that you could rent out for a short period, for instance some hours when you needed to go do a specific activity. You would not have to buy them and own them, you would just be able to use them once in a while. There would be a parking spot in your neighbourhood with these driverless cars where you could access them and then you would command them to take you to your destination.

Would you be interested in using a "neighbourhood community car"?

Why/Why not?

Would something change in the way you normally move around if there were driverless neighbourhood car clubs?

CARD 7

Scenario D: Imagine that there were *driverless cars* available in the market to buy and cars driving themselves on the roads. You could access them, command them to take you where you need and then allow them to be parked or command them to return to a parking spot close to your house. Think that the price was similar to that of a good brand-new car.

Would you be interested in buying such a driverless car?

Why/Why not?

Would something change in the way you moved around if there were driverless cars?

CARD 8

In this last task I will give you two options for your transport experience sometime in the future and you can tell me which one you prefer and why. Please think what option would suit more your needs in your later life, which can be similar or quite different from your current needs.

Which of the two would you be happier if they were a reality? And why is that?

Option A

In this transport future cars are much fewer; everything is designed to make walking, cycling and using the buses and trains easier for us. The buses and trains are more frequent and usually have lines that take you where you need and stops nearby your house. Walking is more enjoyable because the

sidewalks are in a good condition, there is not much traffic around and the crossing time in the traffic light gives priority to the pedestrians. If you have difficulties to move around there are options to call some taxi or minibus services and pick you up to take you where you need.

Option B

In this transport future the situation for walking, cycling and public transport is not much different to what you experience now around you. However, driverless vehicles are available and on the roads. You can either hire or buy one to move around at a cost similar to what someone pays today for these options. They have been designed to be suitable for people that may have various issues with their health and they are quite easy to use. There are driverless car lanes – just as the bus lanes today - and therefore people that use them do not get stuck in the traffic.

CARD 9

Age:……

Gender: …….

Home location/area……..

Employment status: Full-time Employed ☐ Part-time Employed ☐ Unemployed ☐ Retired ☐ Other ☐ ……..

Do you have any ongoing health issues that make walking/cycling or getting to a bus stop difficult for you?

Do you live alone or in a household with others? Alone ☐ With others ☐

- Do you live with any other family members or a partner?

Could you tell me at which level is your a) personal income, b) household income?

Up to £12,999	☐	☐
£13,000 to £24,999	☐	☐
£25,000 to £44,999	☐	☐
£45,000 to £49,000	☐	☐
£50,000 and over	☐	☐

Information for the study 'Driverless cars, taxis and buses for older adults' mobility'

I would like to invite you to take part in a study, part of the PhD research of Lamprini Papafoti at the Institute for Transport Studies, University of Leeds. Before you decide it is important for you to understand why the research is being done and what it will involve, so please take time to read the following information carefully in order to decide whether or not you wish to take part. Do feel free to ask me if there is anything that is not clear or if you would like more information. You can find my contact details below.

If you take part in this research, you will be invited to a one to one conversation interview in which you will be asked questions about your everyday activities and the way you travel to them. You will also be asked about your views concerning a future technology commonly referred to as 'driverless vehicles'. Driverless vehicles are also sometimes called as 'autonomous', 'automated' and 'self-driving'. These are vehicles, cars, buses and taxis that will not need a driver at all. This means that when and if they are developed, it will be possible to be used by people who do not have a driving license and people who cannot drive for any reason, either because of ill-health or any sort of physical and cognitive disabilities.

Your interview and the information you provide us will help researchers and policy officials from transport authorities understand if and how these driverless vehicles will affect the way older adults in the UK move around to get to their everyday activities and the extent to which they are included or excluded in society in the future.

In the interview, the researcher will present to you some photos, images and other text material about driverless vehicles for you to look at and read together. This is to help the discussion and allow you to think about this future technology, if you would be interested in using it and whether it would be a good or bad change for you. You will not need any technical or specific knowledge about the driverless cars in order to participate.

The only requirement for participating in the interview is that you belong to either of these age groups: 55 - 65, 65 - 75 or 75 and over. Whether you are a car driver or not does not matter.

The interview will last about one hour and it can be arranged at a time and place that is convenient to you. Please be informed that it is up to you to decide to take part.

If you do not want to take part, you do not have to give a reason. If you agree to participate, you will be asked to sign the Consent Form attached to this document. You will be given a copy of both the Information Sheet and the Consent Form to keep.

Due to the nature of this research, your participation is not expected to find information that may put you at any risk.

The interview will be audio recorded and notes will be kept in handwritten form, but this material will only be used for analysis and illustration for this research. ***No one beyond the PhD student and the***

supervisors will be allowed access to the original recordings or notes. All the contact information that we collect from you will be kept strictly confidential and it will be stored separately from the other research data you provide us. ***We will anonymise the research data so that you will not be identified in any reports, presentations or publications.*** The only exception is that if you were recommended by another participant or have recommended another participant in this study, you could be identified by them in any published material.

All non-electronic information produced in this study will be stored in secure locker inside my office in the University of Leeds. Electronic information will be stored in an encrypted folder when in a drive pen, then transferred through secure protocol in my personal encrypted folder at the University of Leeds servers.

This document is three pages long, including the Consent Form. Please make sure you have read and understood all the pages. If you have any question regarding your participation or the research project, you can contact the PhD researcher **Lamprini Papafoti by email (tslp@leeds.ac.uk) or telephone (07874 360091)** or the supervisors Karen Lucas by email (K.Lucas@leeds.ac.uk) or telephone (+44 (0)113 34 38086) and John Nellthorp by email (J.Nellthorp@its.leeds.ac.uk) or telephone (+44 (0)113 34 36613).

Thank you.

This study has received a University of Leeds ethical approval with reference LTTRAN-090, amendment July 2019 and date 15/07/2019.

Lamprini Papafoti
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Project title	Document type	Version #	Date
Automated vehicles and future transport equity in the UK. Exploring the role of policy-making and the potential impacts for older people	Information sheet	1	11/07/2019

Consent to take part in the research project:

'Driverless cars, taxis and buses for older adults' mobility'

	Add your initials next to the statement if you agree
I confirm that I have read and understood the information sheet dated 11/07/2019 explaining the research project, I have discussed it with the researcher and I have had the opportunity to ask questions about the project.	
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.	
I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports and publication or publications that result from the research.	
Despite this, I am aware that if I was recommended to participate by another participant or if I have recommended to someone to participate, I might be identifiable by these individuals	
I understand that relevant sections of the data collected during the study, may be looked at by individuals from the University of Leeds or from regulatory authorities where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
I agree to the use of my anonymised quotes in reports, papers and presentations that result from the research.	
I agree for the data collected from me to be stored and used in relevant future research in an anonymized form.	
I agree to take part in the above research project and will inform the lead researcher should my contact details change.	

Name of participant	
Participant's signature	
Name of person taking consent	
Signature	
Date	

Appendix C – Sample characteristics – members of the public

Person	Accessibility level	Age	Driver	Driving difficulties	Living with others	Mobility issues	Personal income level	Use of car	Use of other modes beyond car
Alex	Good	61	No	N/A	No	No	up to 12,999	Few times per week (passenger)	Walking, bus - every day, taxi - few times per week
Alice	Good	68	Yes	No/ Did not mention	No	No	13,000 to 24,999	Few times per week (driver), once a month or less (passenger)	Walking - few times per week, bus - few times per month, train - once a month or less
Anna	Not satisfying	58	No	N/A	Yes	No	13,000 to 24,999	every day (passenger)	Bus - every day, walking - few times per week, train, taxi - once a month or less
Ben	Good	58	Yes	No/ Did not mention	Yes	No	50,000 and over	Few times per week (driver), Once per month or less	Train - Few times per week, bus/tram few times per month, walking every day
Brian	Good	84	No	No/ Did not mention	No	No	up to 12,999	Few times per month (passenger)	Bus, walking - every day, tram - few times per week, taxi - few times per month, train - once a month or less
David	Good	86	Yes	No/ Did not mention	No	Yes/ Uses Motability car and mobility scooter	13,000 to 24,999	every day (driver), Never (passenger)	Mobility scooter - every day
Elena	Good	70	Yes	Yes	No	Yes	up to 12,999	Few times per week (driver), once a month or less (passenger)	Walking - few times per week, Bus, tram - few times per month, taxi, train - once a month or less
Emily	Not satisfying	73	No	N/A	Yes	No	up to 12,999	Few times per week (passenger)	Tram, walking - few times per week, bus - few times per month, taxi - once a month or less
George	Good	55	Yes	N/A	Yes	No	-	every day (driver), Once a month or less (passenger)	Walking - few times per week, train, tram - few times per month, taxi, bus - once a month or less

Person	Accessibility level	Age	Driver	Driving difficulties	Living with others	Mobility issues	Personal income level	Use of car	Use of other modes beyond car
Helen	Good	84	Yes	No/ Did not mention	No	Yes/ Uses Motability car	-	Few times per week (driver), few times per month (passenger)	-
James	Good	76	Yes	No/ Did not mention	No	Yes	13,000 to 24,999	every day (driver), Never (passenger)	Bus, train, tram - once a month or less
Grace	Good (self-reported), not	73	No	N/A	No	No	13,000 to 24,999	Few times per week (passenger)	Walking - every day, bus - few times per week, taxi - few times per month
John	Good	72	Yes	No/ Did not mention	No	No	up to 12,999	every day (driver), Never (passenger)	Walking - every day
Kate	Not satisfying	66	Yes	No/ Did not mention	Yes	No	up to 12,999	Few times per week (driver), once a month or less (passenger)	Walking - every day, bus, train - few times per week
Linda	Good	63	No	N/A	Yes	Yes/ Uses mobility scooter and stick	up to 12,999	Few times per week (passenger)	Mobility scooter - every day, train, tram - once a month or less
Lucy	Good	67	Yes	Yes	No	No	up to 12,999	every day (driver), Few times per month (passenger)	Walking - few times per week, taxi, tram - few times per month
Natalie	Good	69	No	N/A	No	No (only difficulty to walk long distances)	13,000 to 24,999	Few times per week (passenger)	Bus, walking - every day, tram, taxi few times per week
Nick	Good	77	Yes	No/ Did not mention	Yes	No	25,000 to 44,999	every day (driver), Once a month or less (passenger)	Taxi - once a month or less
Olivia	Not satisfying	85	Yes	Yes	Yes	Yes (occasionally because of arthritis)	up to 12,999 or 13,000 to 24,999	every day (driver), Few times per week (passenger)	Bus, walking - few times per week, taxi - once a month or less
Robin	Good	72	Yes	Yes	No	No	up to 12,999	every day (driver), Never (passenger)	Walking - every day, bus, tram - few times per week, train - few times per month, taxi - once a month or less
Sally	Not satisfying	75	Yes	Yes	Yes	No	-	Few times per week (driver), few times per week (passenger)	Walking - every day, bus, tram - few times per week

Person	Accessibility level	Age	Driver	Driving difficulties	Living with others	Mobility issues	Personal income level	Use of car	Use of other modes beyond car
Tony	Good	55	Yes	No/ Did not mention	Yes	No	45,000 to 49,999	Few times per week (driver), few times per week (passenger)	Walking - few times per week, train, tram - few times per month, taxi - once a month or less
Victoria	Good	69	Yes	No/ Did not mention	No	Yes - temporary	up to 12,999	every day (driver), Never (passenger)	Walking - few times per week, bus, taxi - once a month or less
Zoe	Good	71	Yes	No/ Did not mention	No	Yes/ Uses wheelchair and Motability car	-	every day (driver), Never (passenger)	Taxi, bus, train, community transport - once per month or less

Appendix D – Categorisation of participants' responses about their willingness to use different automated transport vehicles and services

Category	Criteria	Example	Responses	
			Drivers	Non-drivers
		Automated buses		
Might use an automated bus	Interviewee gives a neutral or positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	"We already have driverless trains, so it is basically the same thing. I would not be interested in using but I would use. It wouldn't stop me from using my own car." (James, 76, driver)	11 (Alice, Ben, Elena, James, John, Kate, Lucy, Olivia, Sally, Tony, Victoria)	4 (Anna, Emily, Grace, Natalie)
Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	"That is why and why not I would use it. I would use it if it is safe, if there is someone in the bus, who can control the passengers and take charge when something goes wrong to the passengers." (Alex, 61, non-driver)	1 (Robin)	1 (Alex)
Would not probably use an automated bus	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	"No, I would still carry on coming into town, by train, tram whatever. Because I want to get out, I want to get some exercise. With the driverless buses..I am a little bit..I can't imagine it all all. Maybe one day it will come. If they are like a tram and they are on a line. I can't seem to get round it at all." (Brian, 84, non-driver)	4 (George, Helen, Nick, Zoe)	2 (Brian, Linda)
		Automated taxis		
Might use an automated taxi	Interviewee gives a positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	"Possibly I would be interested to use one. As I said I am not using very often, it might be once per year and that's it." (Alice, 68, driver)	9 (Alice, Ben, Helen, John, Kate, Nick, Sally, Tony, Victoria)	3 (Alex, Anna, Natalie)

Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	"That would be strange, wouldn't it? [laughs]. Oh dear, I am not sure about that. At the moment it would seem strange. I suppose if it became the normal thing I would. Once things started, I think I would, it would be fine." (Lucy, 67, driver)	2 (Lucy, Zoe)	1 (Emily)
Would not probably use an automated taxi	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	"I would not like to go in a driverless taxi. You don't know where it will take you. There is no one to talk to, you are on your own. Another way to stop the act of conversation, you know?" (Robin, 72, driver)	4 (Elena, George, James, Robin)	3 (Brian, Grace, Linda)
Automated shared taxis				
Might use an automated shared taxi	Interviewee gives a positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	"I would be happy with that. That might be different for a woman. A woman who had booked a taxi and wasn't sure who she would share the taxi with. In my case that would be fine." (Ben, 58, driver)	4 (Ben, John, Lucy, Sally)	1 (Natalie)
Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	"I suppose it would be something I would have to think about. If it was during the day or maybe sharing with a female, maybe, but if it was an evening and you were going out or coming home late at night, you don't know who, maybe not. There are different ways of thinking about this, I think." (Anna, 58, non-driver)	1 (Victoria)	1 (Anna)
Would not probably use an automated shared taxi	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	"If it is driverless, it depends, I would be interested if there is someone I know, but I would not be interested if there is someone I don't know. There is a danger here again, you could be ill or a danger that I could be attacked." (Alex, 61, non-driver)	10 (Alice, Helen, Elena, George, James, Kate, Nick, Robin, Tony, Zoe)	5 (Alex, Brian, Emily, Grace, Linda)
Automated neighbourhood car club				
Might use an automated shared car	Interviewee gives a positive response to questions "would you be interested in using it?", "would something change in the way you move around?"	"Yes, I might change the way I move around. But, I'd like to think that they trained you to use it if you are not a driver. I wouldn't use it if I wasn't sure that I'm a safe person to be in it. I am not sure. As it is today, I wouldn't use them. I think it is a good idea. It's like with hiring a bike, you need to know how to ride one." (Emily, 73, non-driver)	9 (Ben, Elena, George, John, Kate, Lucy, Sally, Tony, Zoe)	4 (Anna, Emily, Grace, Natalie)

Unsure	Interviewee states that she/he is unsure about future adoption or does not provide a clear response.	"Well, that could cause a lot of problems I would have thought. It sounds very good idea, but I would have thought that someone should have set up a system by where the people have the car at specific time. In the face of it, it sounds quite good, but then everybody would be clashing, wouldn't they? Depends on how big the neighbourhood is, how many people are involved in it. It doesn't sound like a bad idea, but I get back to my point who pays for it? It says you can rent it out. But then would you need insurance, would you want the club paying for the insurance for all the named drivers that are using it and then the tax would have to be sorted out. Would there be so many car club members in there, but then I could see that everybody will want to use it at the same time. Would it be for people that are not working anymore or for people with disabilities or for everybody?" (Alice, 68, driver)	4 (Alice, Helen, Nick, Victoria)	0
Would not probably use an automated shared car	Interviewee gives a negative response to questions about "would you be interested in using it?", "would something change in the way you move around?"	"It would be ok for the airport to have those. I think I'd ride them first. Like with the buses, taking passengers from the terminal to the aircraft, use them that way. The only thing there is the Aircraft. You could try them in large companies, where cars are going around the factory? It does not really sound appealing to me, no." (Robin, 72, driver)	2 (James, Robin)	2 (Brian, Linda)
		Automated private cars		
Might be interested in buying an automated car	Interviewee gives a positive response to questions "would you be interested in buying a driverless car?", "would something change in the way you move around?", even when she/he mentions cost or wish to override	"If I was on my own or my husband was not driving, then yes, it would give me more freedom to..Because if I hadn't had my husband's support, that would have an effect on being able to get out and about and continue my life. So yes, I would. I would still have my independence." (Grace, 73, non-driver)	5 (Helen, James, Lucy, Tony, Zoe)	2 (Anna, Grace)
Unsure	Interviewee states that she/he is unsure about buying a driverless car or does not provide a clear response.	"At the present moment, I wouldn't be interested in buying a driverless car. Maybe if I couldn't drive. At the moment I am quite happy driving." (Kate, 66, driver)	6 (Alice, Ben, George, Kate, Nick, Sally)	1 (Natalie)

Would not probably be interested in buying an automated car	Interviewee gives a negative response to questions about "would you be interested in buying?", "would something change in the way you move around?"	"For me no. My husband probably would, if they were cheap enough. He is used to his independence. It doesn't worry me that somebody else is driving. For his independence, yes, he would probably like this driverless. I am giving you his views as well as mine." (Emily, 73, non-driver)	4 (Elena, John, Robin, Victoria)	3 (Brian, Emily, Linda)