Older people’s mobility within the community

*The impact of built environment and transportation on active ageing*

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KEYWORDS

Ageing, active ageing, Global Positioning Systems (GPS), mobility, older people, out-of-home activity, participation, transportation, travel behaviour
ABSTRACT

Population ageing is one of the major challenges of the 21st century and leads us to consider the ways in which societies can optimize opportunities for healthy and active ageing. Older people prefer to stay in their communities as they age, and mobility is essential to their continuing engagement and participation in these communities. While there is evidence that the community environment impacts on older people’s mobility, it is still not clear how transport options are linked with these environmental circumstances, and how they impact on participation within the community.

This research explores the influences of mobility and participation on older people within the community environment. To this end, it investigates two research questions, and presents the findings in four papers. The two research questions explore: 1) The impact of the built environment on the choice of transportation in older age; and 2) The impact of transportation choice on participation within the community.

The study uses an innovative, qualitative mixed methods approach, combining the recording of real-time travel behaviour and in-depth interviews. Travel behaviour was recorded using travel diaries (including questionnaires) in combination with person-based Global Positioning System (GPS) tracking. The in-depth interviews, which explored older people’s
perceptions of and experiences with mobility and participation in the community were informed and aided by Google earth maps. Conducted in low and high-density environments in Brisbane (Queensland, Australia), this research investigates travel behaviour and participation in out-of-home activities of people 55 years and older (n=23).

The car is found to be the most convenient transport option for older people living in suburban and urban environments. Private transportation is found to have specific benefits for older people, enabling them to stay engaged within their community, and providing benefits for their social network and the wider community. The environment was found to be car-dependent, which creates difficulties in accessing and using other forms of transportation, such as public and active transportation and has negative impacts on mobility and active ageing.

Given the world’s ageing populations, it is critical for policy makers and town and transportation planners to create environments that encourage the use of a range of different transport options so as to optimise older people’s opportunities to stay engaged and active within their community.
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STATEMENT OF ORIGINAL AUTHORSHIP

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: [Signature]

Date: 25.10.2013
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1 INTRODUCTION

1.1 Background

Population ageing is a worldwide phenomenon related to both an enhanced quality of life and an associated enhanced life expectancy, and to the fact that birth rates are decreasing worldwide (Kinsella & He 2009; Avramov & Maskova 2003; World Health Organization 2002). The phenomenon is creating countless challenges for societies around the world on social, economic and political levels (Kinsella & He 2009; United Nations 2009). Their central challenge is to determine how to best facilitate healthy and active ageing processes (World Health Organization 2002).

A powerful and known strategy to counter possible negative effects of population ageing is to enable older people to stay at home as they age. Not only is it the wish of the majority of older people to live independently within their community for as long as possible (Krout & Wethington 2003; Olsberg & Winters 2005), it is also believed that this has positive economic and social effects on their communities (Lui et al. 2009). This ability to age in place, however, can be compromised by a community environment which is inadequate in serving older people’s needs (Oswald et al. 2011); therefore, to be sustainable, cities must provide the structures and services to support their
residents’ wellbeing and productivity. Older people in particular require supportive
and enabling living environments to compensate for physical and social changes
associated with ageing (World Health Organization 2007b, p. 4).

Critical for older people’s ability to live independently is their ability to
maintain mobility within their community. Reduced mobility can cause
increased risk of social isolation and health problems (Ragland, Satariano &
MacLeod 2005; Marottoli et al. 2000), and place pressure on older people’s
social network and community to provide adequate transportation (Whelan
et al. 2006). Mobility is their link to the social and built environment, and
facilitates their participation in community activities (Mollenkopf et al. 1997).
This access to activities, in turn, has a positive impact on their quality of life
(Metz 2000; Musselwhite & Haddad 2010; Ziegler & Schwanen 2011).
Therefore, it is critical to enable older people to stay mobile within their
community for as long as possible.

1.2 Research Problem

Population ageing creates the urgent need to better understand how
communities can provide older people with the best opportunities for
staying involved and engaged as they age (Lui et al. 2009). As discussed
above, one critical element for participation and independent living within
the community is the ability to stay mobile. The balance between the social
and physical demands of the environment and individual capabilities influences the older person’s ability to function within the community (Lawton & Nahemow 1973; Wahl, Iwarsson & Oswald 2012). It is still, however, not well understood how environmental demands impact independent living within the community (Wahl & Weisman 2003; Wahl & Oswald 2010). While it is anticipated that the community environment has an impact on older people’s choice of transport options and, in turn, on their mobility within the community, this relationship is still not well understood (See Figure 1).
1.3 Significance

This research addresses the urgent matter of older people’s mobility behaviours and their impact on participation within the community. Little is known to date about what actually impacts older people’s uptake of transport options and how these, in turn, affect active ageing.

This research is based on the assumption that an older person’s behaviour must be investigated in the context in which it takes place (Lawton &
and that the uptake of a transport option is influenced by this context. It focuses on the investigation of environmental and activity-related influences on older people’s use of transport options. Given that it is still not well understood what influences older people’s choice of transportation, this focus is vital. The growing proportion of older people is believed to have an influence on existing transportation systems (Arentze et al. 2008; Scott et al. 2009); thus, investigating older people’s choice of transportation can provide essential knowledge for communities in planning to better accommodate their mobility needs. This research provides these valuable insights into how policy makers and transportation planners can provide environments that allow older people to remain active and engaged.

This research is located in Brisbane, Australia. Australia is no exception to the phenomenon of population ageing; it is estimated that, by 2051, approximately 28% of its population will be 65 years and older (Australian Bureau of Statistics 2006). Population ageing is believed to be a major cause of the fundamental changes that Australia’s major cities are facing (Commonwealth of Australia 2010). This research is of particular significance to the Australian context, as it addresses the specific issue of older people’s mobility within the Australian suburban and urban environment. It will assist Australian transportation planners and policy makers in their development of more sustainable and age-friendly transportation.
The research uses a mixed methods approach, employing person-based Global Positioning System (GPS) tracking to collect the real-time travel data of older people living in their community. While GPS tracking is believed to have great potential in investigating the spatial activity of older people (Shoval et al. 2010), its use is still in its infancy (Jones, Drury & McBeath 2011; Frignani et al. 2010). This research is also significant, as it adds to the small body of research using this method for the observation of travel behaviour.

The methodological approach of combining participants’ real-time travel behaviour data with their individual experiences and perceptions, contributes to a more in-depth understanding and analysis of the GPS data. This approach provides greater insight into how GPS data can be used for qualitative investigations into the living experiences of older people.

1.4 Questions and Objectives

Mobility in older age is the result of a complex relationship between environmental circumstances and an older person’s capabilities (Patla & Shumway-Cook 1999; Shumway-Cook et al. 2002). Communities, therefore, need to create environments that facilitate older people’s mobility, thus enabling them to stay involved and engaged as they age. Table 1 provides an overview of the research problem, the research questions, and the research objectives that have been established to address this pressing need.
### Table 1 Research problem, research questions, and research objectives

<table>
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<tr>
<th>Research problem</th>
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<td>In an ageing population, it is critical to enable and encourage older people to maintain their mobility so as to be able to participate within their community environment. Therefore, it is necessary to understand what influences the mobility and participation of older people within the community environment.</td>
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<th>Research questions</th>
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<td>What impact does the community environment have on the choice of transport options in older age?</td>
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<td>What impact do transport options have on participation within the community environment?</td>
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<th>Research objectives</th>
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<td>To explore how low density suburban environments impact the use of different transport options in older age, and the consequences of these options for active ageing</td>
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<tr>
<td>To explore how transportation choices and practices influence social participation and the daily lives of older suburban residents</td>
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<tr>
<td>To explore the effect of suburban and urban environments on the mobility and participation of the older age group within the urban Australian context</td>
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### 1.5 Scope of the research

This research focuses on the impact of the built environment on older people’s choice of transportation, and the impact of this transportation on their participation within the community. The research focuses on low and high-density environments (specifically, in Brisbane, Australia), and is not
concerned with semirural or rural environments. Furthermore, it addresses older people’s mobility and participation in the community, and is not concerned with their in-home activities. Nor does it investigate these issues as they relate to other age groups.

1.6 Thesis outline

The focus of this thesis (by publication) is the facilitation of community mobility and participation in older age. The thesis begins with Chapter 2, a literature review that introduces the framework for active ageing and mobility in older age. Research is presented on travel behaviour and choice of travel mode. The relationship between community engagement and mobility in older age is also established. Chapter 3 provides an overview of the research design, and details its methods and data preparation.

Four published papers are presented in Chapter 4, as part of the requirements for this research (see Table 2). The first paper (Title: Transportation- implications of accessibility for older people) provides the first insights into the study and the data collection processes, documenting the kilometres participants travelled by different transport options, and the motives for their transportation use. The second paper (Title: Mobility and active ageing in suburban environments: Findings from in-depth interviews and person-based GPS tracking) explores the impact of low density suburban
environments on the choice of transportation, and links the findings to consequences for active ageing. The third paper (Title: Mobility and out-of-home activities of older people living in suburban environments: Because I’m a driver, I don’t have a problem) explores how transportation choices and practices influence the participation of older people living in suburban environments. The fourth paper (Title: Travel behaviour and engagement in out-of-home activities of older people living in suburban and urban environments in Brisbane, Australia) then describes how different urban environments within one city impact the participation of older people.

Table 2 List of full papers published and submitted

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<td>Article 3</td>
<td>Zeitler, E. &amp; Buys, L., Mobility and out-of-home activities of older people living in suburban environments: Because I’m a driver, I don’t have a problem Revised and resubmitted August 2013 – Ageing &amp; Society</td>
</tr>
<tr>
<td>Article 4</td>
<td>Zeitler, E. &amp; Buys, L. Mobility in the City: Travel behaviour and engagement in out-of-home activities of older people living in suburban and urban environments in Brisbane, Australia Submitted August 2013 – Urban Studies</td>
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The final chapter synthesises the findings presented across all articles and outlines the theoretical contributions, as such: an enhanced understanding of the impact of the community environment on choice of transportation and the impact of this chosen transportation on community participation and the linkage of mobility and active ageing. It also outlines the practical contributions to policy and intervention development and the methodical contributions made by this research. The chapter concludes with recommendations for age friendly community environments which could facilitate older people’s mobility and, consequently, their active ageing.
This chapter provides an overview of the current literature on active ageing and mobility in older age. It is divided into five sections, each ending with a short summary.

The first section introduces the Active Ageing Policy Framework (World Health Organization 2002), including the concepts of life-space and the person-environment fit. The role of participation within the concept of active ageing is also discussed. This section also introduces the Age-friendly City Guide (World Health Organization 2007b). This guide is an amendment to the Active Ageing Policy Framework and is aimed at assisting policy makers in creating liveable cities for all ages.

The second section introduces different concepts of out-of-home mobility, each of which considers different angles from which to explore out-of-home mobility such as: quality of life, life-space, and the community environment as enabler and disabler. The third section of the literature review then gives an overview of studies of mobility, which focus on mobility and the older person in relation to the community environment and the social environment.

The fourth section presents what is known about older people’s travel behaviour and their choice of travel mode. The fifth section provides an
introduction to the relationship between engagement and mobility in older age.

The literature review concludes by outlining the directions for this research project: the identification of the impact of the environment on the choice of transportation, and the impact of transportation on participation within the community.

2.1 Active ageing

Active ageing (World Health Organization 2002) is a framework for policy development that promotes healthy and active ageing. Within this concept of active ageing, health is seen as the most important factor in ensuring quality of life during the ageing process (Kalache & Keller 1999). Quality of life in older age, which is itself a popular but broad concept (Bowling 2005), is seen within the active ageing framework as the product of a healthy ageing process.

2.1.1 Definition of active ageing

Active ageing is the most recent approach to policy development that is designed to enhance quality of life of older populations; it does this by fostering health, security and participation as people age (World Health Organization 2002; Kalache & Keller 1999). The emphasis of this active ageing framework lies in the word 'active', which refers to continuing
participation in social, economic, cultural, spiritual and civic affairs, not just the ability to be physically active or to participate in the labour force (World Health Organization 2002, p. 12). Active ageing is a concept which not only addresses the individual’s responsibility to look after him/herself throughout life, but which also demands governments and societies to be responsible for optimizing opportunities for people of all ages (Walker 2002; World Health Organization 2002). Consequently, active ageing is defined as the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age (World Health Organization 2002, p. 12). Therefore, ageing is conceptualized as a lifelong process which is influenced by historical, demographic and social changes (life-course perspective), and the social and physical environment (person-environment fit) (Hooyman & Kiyak 2008).

The life course perspective

The life course perspective emerged in the 1970s and was established as an essential concept for understanding human ageing (Dannefer 2010). It centres on the idea that individuals and their social networks cannot be viewed independently of cultural, historical and societal factors, as these influence decisions and opportunities as people age. The life course perspective framework attempts to bridge sociological and psychological constructs about processes at both the macro (population) and micro (individual) levels of analysis.
(Hooyman & Kiyak 2008, p. 319). It is a concept for examining changes and what causes them; however, there is still not a universal model for the life course concept, and it is still not clear why some factors influence some people and not others (Hendricks 2012).

Two perspectives can be identified within the concept of life course: the biographical and the sociological perspective. These perspectives are fundamentally different in their viewpoint on the life course concept. While the biographical perspective centres around individual experience, such as the trajectories and transitions within an individual life’s, the sociological perspective centres around social structure and culture as driving and defining individual life (Dannefer 2010).

Interestingly, the life course perspective is not defined within the active ageing discourse as either a biographical or sociological process. Rather, it emphasises the balance between the individual’s responsibility to look after themselves, and society’s responsibility to provide adequate opportunities to enhance health, security and participation as people age (Stein & Moritz 1999; World Health Organization 2002). The active ageing framework uses the concept of life course from both perspectives, and as a broad background concept. This broad stance sets the scene for the holistic consideration of the various areas included in the framework and, therefore, for a holistic approach to healthy ageing.
The person-environment fit

The *person-environment fit* was first conceptualised in the 1970s by Lawton and Nahemow (1973) as the ecology theory on ageing, and is still a widely used model. Central to the person-environment concept is the proposition that there is a link between the individual subject and its surroundings. This is conceptualised as ‘human ecology’, which holds that *one cannot understand one element in nature without considering its surroundings* (Lawton & Nahemow 1973, p. 619). Also fundamental to the concept is that the *unique combinations of personal competence and environmental characteristics determine an individual’s optimal level of functioning* (Wahl et al. 2012, p. 307). Finally, the notion of adaption is also a central aspect of the person-environment fit. ‘Adaption’ is defined as adjustments that can be made in two ways: firstly, the person can adjust needs and behaviours to the opportunities the environment provides; and, secondly, the person can make changes to the environment to fit their individual needs.

The person-environment fit model is used to understand the effect that social, technical and physical environments have on the ageing individual (Wahl et al. 2012). However, while the model shows promise for the study of the impact of the built environment on independent living within the community, there is still not enough research which uses this concept for this purpose (Wahl & Weisman 2003; Wahl & Oswald 2010).
Combination of the life course and the person-environment fit

Wahl et al. (2012) developed a framework which illustrates the interchange between people and their environments as they age. It builds on the concept of the ecology of ageing (person-environment fit) by Lawton and Nahemow (1973), and combines it with elements of the life course perspective (Hendricks 2012) to create a better understanding of ageing well (Rowe & Kahn 1997).

Wahl et al.’s (2012) framework also combines the person-environment fit model with the concepts of experience-driven belonging (the sense of positive connection to people and the environment) (Baumeister & Leary 1995) and behaviour-driven agency (intentional and proactive behaviour) (Bandura 2006). Wahl et al. (2012) conceptualize belonging and agency as related to the life course perspective with the process of belonging increasing in the importance as people enter old and particularly advanced old age, whereas the relevance of processes of agency decreases (Wahl et al. 2012, p. 309).

2.1.2 The role of participation within the concept of active ageing

Participation is a concept which can be seen as immanently bound up in different levels of power structures. The concept is always linked to structures of power distribution, decision making processes and profit
sharing – especially in political, economic, and social structures (Arnstein 1969; Singleton 2001).

**The meaning of participation within gerontology**

Within gerontology, participation is defined foremost as *sustained engagement* in a range of activities (Rowe & Kahn 1997): in paid or unpaid productive activities (Butler 2010); or in social activities. However, it lacks comprehensive definition (Levasseur et al. 2010). Participation in political decision making processes (Arnstein 1969), for example, while often referred to in social work literature, is hardly mentioned in the gerontology literature. Considering the changes in the composition of world populations due to population ageing, this is surprising. Within gerontology, participation is defined in accordance with the directions, the theories, and the frameworks focused on. This will be exemplarily shown in the frameworks for successful ageing and productive ageing.

‘Successful ageing’ can be defined as the *achievement of good physical and functional health, cognitive and emotional well-being in old age, often accompanied by strong social support and productive activity* (Hooyman & Kiyak 2008, p. 17). Successful ageing is founded on the idea of the continuity theory of normal ageing (Atchley 1989; Franklin & Tate 2009); it not only aims to add years to life, and to gain satisfaction from life (Havinghurst 1961), but acknowledges that this is dependent on a high level of social functioning, continuous
development, and adaption throughout the lifespan (Atchley 1989; Franklin & Tate 2009). Ageing is seen as a dynamic process of adapting strategies and a gradual evolution of the ageing self. This dynamic process allows the individual to continue with life practices, social contacts and inner concepts which have already been consistent over time. Successful ageing also links participation to psychological and physical health. ‘Participation’ can be defined within the concept of successful ageing, therefore, as sustained engagement in social and productive activities (Rowe & Kahn 1997, p. 439).

‘Productive ageing’, which highlights current and potential contributions of older adults through meaningful action (Hinterlong, Morrow-Howell & Sherraden 2001, p.4), discusses participation in terms of its monetary value and necessity within an ageing society. The concept emphasises older people’s often underestimated productivity and active contribution to the development of a society. It is a concept which focuses on the resources within the older population and the value of unpaid activities in older age to the gross domestic product (GDP) of a country (Butler 2010). ‘Participation’, therefore, is seen as a productive engagement within this theory.

Within gerontology, ‘participation’ is often referred to as ‘social participation’ or ‘engagement’. Levasseur et al. (2010) showed how broad the understanding of social participation is within the literature on ageing by preparing an inventory of the various definitions used; in papers published
between 1980 and 2009, they found 43 different definitions. The four databases searched included empirical studies, reviews, or conceptual papers which contained original definitions of the term. Interesting is the notion that involvement of the person in social activities and interactions can be seen on a continuum from relatively passive to very active (Levasseur et al. 2010, p. 2146). This statement shows another difficulty in defining participation: not only has it many different meanings, but it might also comprise notions of quality and time.

Older people as citizens

In 2002, the United Nations developed the Madrid International Plan of Action on Ageing (United Nations 2002). This is another framework which aims to guide practitioners and policy makers in implementing a new approach to ageing – an approach similar to the one taken in the active ageing framework. Most significant in the Madrid Plan is the need to acknowledge the importance of the participation of older persons as citizens with full rights, and to assure that persons everywhere are able to age with security and dignity (United Nations 2002, p. 10). In this guide, participation and empowerment – which is itself a social process – are simultaneously discussed. Empowerment is believed to improve the quality of life of groups and/or individuals in a community through their gaining a share of, and control over, resources (Perkins & Zimmerman 1995; Shearer et al. 2012). The
guide further emphasises that the older population should not be treated as a special group with special needs; rather, it should be mainstreamed into the overall policy, and not treated as an ‘add-on’.

**Participation as a pillar of active ageing**

Active ageing centres participation, alongside safety and health, as one of its determinants. It is further based on the human rights principles of *independence, participation, dignity, care and self-fulfilment* and is a “rights-based” approach that recognizes the rights of people to equality of opportunity and treatment in all aspects of life as they grow older (World Health Organization 2002, p. 13). However, participation within the active ageing framework is seen in terms of productive contribution towards the society. It is anticipated that participation throughout the life course is important in all areas of society, namely: labour markets, employment, education, health. It might, therefore, need special attention in the development of social policies and programs.

Within the active ageing framework, the WHO provides policy directions for participation. These are centred around three main themes: education throughout the life course; active participation in economic activities (formal and informal work and volunteering); and encouragement to stay engaged in family and community life (World Health Organization 2002). However, participation is scoped very broadly within the active ageing framework and
needs further definition (Boundiny 2013). The *active* in active ageing, for example, refers to one’s continuing participation while ageing. The terms ‘participation’ and ‘activity’ are not distinguished, but used interchangeably. ‘Participation’ can be generally defined as ‘taking part’; however, what this specifically means for policies depends on the focus taken (e.g. employment, physical activity, health, or other life domains) (Boundiny 2013).

### 2.1.3 Facilitating active ageing – The Age-friendly City

The policy framework of active ageing (World Health Organization 2002) was complemented by the Age-friendly City Guide (World Health Organization 2007b), to assist policy development for age-friendly environments. The Age-friendly City guide is one of many different approaches to age-friendly environments, such as liveable communities, lifetime neighbourhoods or elder-friendly communities (Lui et al. 2009). It embodies the idea that social and physical environments impact on older people’s ability to live independently and actively within their community as they age.

The Age-friendly City Guide (World Health Organization 2007b) illustrates the role that the social, cultural and built environment play within the community for (active) ageing in place. The guide, which emphasises the importance of inclusive environments for all citizens, was developed from a study of 35 cities of different size around the world. The study investigated
the life experience of older people (60 years and older) with a special focus on age-friendly features, problems perceived, and perceptions of what would enhance their community environments (Plouffe & Kalache 2010). On the basis of this study, the following topic areas for age-friendly city development were developed: physical environment (outdoor spaces and buildings, transportation, and housing); social environment (social participation, respect and social inclusion, civic participation and employment); health and social service determinants (communication and information, community support and health services) (World Health Organization 2007b).

The Age-friendly City Guide (World Health Organization 2007b; World Health Organization 2007a) is in line with strategies and policies which emphasise the importance of enabling older people to stay in their communities as they age. Known as the concept of ‘ageing in place’, it is believed that this is the most effective strategy to address challenges created by population ageing (Lui et al. 2009). The strategy addresses the pre-requisite issues of safety, participation, and healthy in-home and out-of-home environments to enable people to age in their community (Pynoos, Caraviello & Cicero 2009; Oswald et al. 2011).
2.1.4 Summary

Active ageing is a concept which relates to preventive health, social participation, and quality of life as people age. Ageing is a journey over the life course and needs to be seen in the context of its social and physical environments. It is an essential feature of this concept that the individual and the society share the responsibility to optimize the circumstances which allow healthy and engaged ageing processes. Specifically, communities can optimize the social, built, and cultural environments to enable the participation, safety and health of people as they age.

It is critical for older people’s wellbeing that they are able to continue to participate within their community; however, defining ‘participation’ is not straightforward as the term is strongly linked to distributions of power. The active ageing framework does not specify what participation means in relation to active ageing; rather, it simply refers to it as continuing participation and activity in all areas within the community.

The Age-friendly City Guide is an amendment to the active ageing framework. It provides practical suggestions for areas which communities need to focus on if they want to be more accommodating of active living in older age. The guide covers all areas of community living within the physical and social environment, as well as the areas of health and services.
2.2 Frameworks for out-of-home mobility in older age

Out-of-home mobility in older age is a topic which has gained much attention in relation to an array of disciplines. The ageing population can, for example, change the demands on the current transportation systems and land use. Not only does older age have an effect on activity travel behaviour, it also has a significant effect on total travel demand and its temporal, spatial and modal distribution (Arentze et al. 2008; Scott et al. 2009). Older people might increasingly use the private car to stay mobile within the community, which leads to changing requirements for infrastructure and environmental development (Klein-Hitpaß & Lenz 2011). Furthermore, research raises concerns about the impact of mobility and mobility disadvantage on the ability of older people to participate in an array of out-of-home activities. This is a critical issue, as participation in out-of-home activities is perceived to impact upon quality of life in older age (Schwanen & Páez 2010).

‘Out-of-home mobility’ can be defined as the ability to undertake locomotion (Mollenkopf & Flaschenträger 2001) within the out-of-home environment, by active and other transportation means (Mollenkopf et al. 1997). Out-of-home mobility is not only important in overcoming distances within the outdoor environment; it is also the link between the individual and their outer social and built environment. It is necessary for the supply of essential commodities.
and consumer goods, but also for the participation in social relations and activities (Mollenkopf et al. 1997, p. 298).

Mobility in older age is a complex concept and cannot be viewed out of context; it depends on a range of variables: the physical, economic, social, and technical resources, and the structural conditions of the region (Mollenkopf et al. 2004). While research is still needed into contextual components that impact on older people’s out-of-home mobility, features of the built environment and transportation are already considered to determine older people’s mobility within the community (Schwanen & Páez 2010).

Frameworks of mobility in older age can be classified into three different categories of importance: quality of life (Metz 2000; Musselwhite & Haddad 2010); mobility within the life-space (Webber, Porter & Menec 2010); and the environment as enabler or disabler (Patla & Shumway-Cook 1999).

### 2.2.1 Mobility and quality of life

Mobility is believed to be a critical element of maintaining independence and an essential attribute of quality of life (Patla & Shumway-Cook 1999, p. 7). This section provides a brief introduction to mobility frameworks which aim to conceptualise this link between mobility and quality of life in older age.
Metz (2000) argues that the impact of mobility on quality of life is usually not measured and, therefore, does not inform travel and transport economics and modelling. Metz (2000) proposes a number of qualitative indicators which could be related to quality of life, namely: Travel to desired people and places; psychological benefits of movement – of ‘getting out and about’; exercise benefits; involvement in the local community; and potential travel (Metz 2000). Including these qualitative benefits of travel in the measurement of the impact of mobility on quality of life, could allow reduced quality of life and mobility-related disability per se to be distinguished.

Musselwhite and Haddad (2010) developed a similar approach on the basis of a qualitative study that identified the role of mobility and accessibility in older people’s quality of life. They developed a hierarchy of travel needs in older age which they conceptualised as utilitarian (primary), affective (secondary), and aesthetic (tertiary) travel needs. They also link these travel needs with the level of individual awareness of these needs. They found, for example, that people are most aware of their utilitarian travel needs, and least aware of their aesthetic travel needs. As Musselwhite and Haddad (2010) focus on issues that are created when older people need to give up driving, it is unclear how these travel needs relates to older people who have never driven.
On the basis of their qualitative study, Ziegler and Schwanen (2011) developed a model of conceptual relationships between mobility and wellbeing, which included individual factors of influence. They understand mobility as a multidimensional concept that links dimensions of mobility and dimensions of wellbeing, and believe that these dimensions influence each other. It is further conceptualised that mobility and well-being influence, and are being influenced by, individual factors. Dimensions of mobility are conceptualised as: practices, moving through space, disposition, attitudes towards mobility practices, and imaginary mobility. These mobility dimensions are related to dimensions of wellbeing, namely: physical health, autonomy and independence, mental health and emotional wellbeing, social relationships, continuity of the self, and identity. The researchers argue that an openness and willingness to connect to the world is a link between mobility and wellbeing. They also found that the loss of physical mobility does not necessarily impact on quality of life, as other dimensions of mobility can compensate for that loss. Independence and autonomy are essential to wellbeing and to the outcome of spatial mobility. These factors might also be related to balanced social relationships.

**Studies of mobility and quality of life**

Studies which are concerned with the impact of out-of-home mobility on quality of life focus mostly on the impact of reduced mobility, which is
caused by a lack of access to transport options or to health-related issues. The lack of access to transport options is found to create negative impacts on quality of life as it prevents older people’s participation in desired activities within the community.

Older people might also face mobility difficulties and negative impacts on quality of life, if they do not have a supporting social network. Mollenkopf et al. (1997) investigated the mobility needs of older people living in three different European countries. Participants in their study answered standardized questionnaires on living conditions and travel behaviour, and kept travel diaries for a 3-day period. They investigated factors that hindered mobility in older age, and found a clear connection between older people’s mobility patterns and their relationship with a social network. A network of family and friends was found to be as influential in determining an older person’s community mobility as was their age, health, and driving ability.

Health-related mobility disadvantages in older age reduce quality of life. Cvitkovich and Wister (2001), for example, undertook a study of the well-being of community-dwelling seniors (65 years and older) from Vancouver (Canada). In face to face interviews (n=174), the researchers investigated the seniors’ prioritised transportation needs, and their level of person-environment fit. It was found that transport dependency is created by an unsatisfactory person-environment fit, where health problems create barriers
to mobility and, in turn, unfulfilled transportation needs. This limits both interactions with family and friends, and accessibility to shopping facilities and other amenities.

Mobility itself creates benefits which influence the quality of life in older age. Spinney et al. (2009) present a study from Canada. In this study, the researchers used time budgets to assess older people’s activities in relation to benefits of transport mobility, such as the psychological, exercise and community benefits. The statistical analysis of time budget data from people aged 65 years and older (n=15 558) found age- and gender-related differences in their exposure to all transport mobility benefits. Older age and being female, for example, reduced the range of mobility benefits enjoyed, and disability was found to be connected to social isolation as it limits the possibilities for engagement in activities.

2.2.2 Mobility and life-space

Webber et al. (2010) base their mobility framework on the concept of life-space, and include a set of categories perceived to influence mobility in life-space levels. Life-space can be defined as the area through which the subject moved in each 24 hour period (May, Nayak & Isaacs 1985, p. 182). Life-space areas include indoor environments (room and house), community environments (neighbourhoods, the town), and environments that lay beyond (Peel et al. 2005). Mobility within these life-space areas is, in Webber
et al.’s (2010) framework, dependent on financial, psychosocial environmental, and on physical and cognitive resources and capabilities. Furthermore, it is emphasised that gender, culture and biography influence a person’s resources and capabilities and, therefore, their mobility. Webber et al. (2010), therefore, provide a framework which addresses the spatial aspect of mobility, and the various factors within the individual, the environment and the society that influence mobility.

Studies of life-space mobility in older age

This review is focused on studies of life-space mobility within the community, and excludes clinical trials and health assessments which are predominantly concerned with physical functioning in daily life.

Older people who have problems performing the activities of daily living (ADL) might not only be older and of poorer health, but also be moving within smaller life-spaces within the community. Murata et al. (2006) present a study which identifies factors that are influencing the life-space of older people (n=2409) within the community in a rural town in Japan. The survey investigated daily activity levels, which were used as a proxy for life-space accessed within the community. Physical and psychological health, difficulties performing ADL, social engagement at private (e.g. friendship) and community (e.g. club membership) levels were measured. A strong relationship between being female, older, or having ADL limitations and a
smaller life-space within the community was found. Further, ADL difficulties are also shown to be related to problems with accessing transportation and engaging in social activities. Finally, Murata et al. (2006) show that mental health issues can also lead to less participation and smaller life-space in older age.

King et al. (2011) present a study that investigates mobility-related personal perceptions, meanings, and emotions. Older people 57 years and older (n=30) from a North American city participated in focus groups. King et al. (2011) found that, for most participants, their life-space mobility was found to be related to the ability to drive. They also found that managing mobility loss is dependent on older people’s attitude; some might focus on things they can still do; others are more flexible and redefine their life-space by focusing on priorities and activities that they still can reach, with or without assistance. However, the fear of being dependent or a burden to others is present.

Having a valid driver’s license in older age reduces the risk of restrictions to life-space mobility. Shah et al. (2012) present a study of 571 community-dwelling older people in the USA. The study design comprised: a combination of uniform clinical evaluation at baseline and follow-up evaluations; the assessment of the extent of their movement within the environment (Life-Space Questionnaire); data on driving status; and socio-demographic data. The data was statistically analysed, and results show that
a valid driving license provides a lower risk of restrictions within the life-space, even for those with health issues. Furthermore, results indicate that a valid driving license in older age provides a high chance of life-space mobility being regained after being restricted for some reason.

2.2.3 Mobility and the community environment as enabler and disabler

The literature on the mobility of older people uses the concepts mobility disability to explain how the built environment and transportation create mobility difficulties within the community environment.

Patla and Shumway-Cook (1999) argue that mobility and mobility disability are inseparably linked. They define the level of mobility within the community as a complex relationship between the environment and the individual’s capabilities. The more the environmental context creates difficulties for the older person to manage tasks safely, the more mobility is disabled. Therefore, the authors define mobility disability as a product of the interaction between the individual and the environment (Patla & Shumway-Cook 1999, p. 8). They define mobility in space and time as dependent on eight dimensions, namely: minimum walking distance, time constraints, ambient conditions, terrain characteristics, external physical load and attention demands, postural transitions, and traffic level. They claim that the introduction of these dimensions allows for identification of the unique
pattern of performance of a person within these dimensions, and that it is possible to specify in which areas mobility disability might occur.

Rosso et al. (2011) provide a framework for the role of the built environment in the disablement process. Their framework is an adaptation of Verbrugge and Jette’s (1994) and Frank et al.’s (2003) earlier mobility frameworks. Verbrugge and Jette’s (1994) health-centred approach conceptualises the process of disability as a gap between personal capabilities and demands by the activity and the environment. Three levels of personal capability, which can lead to disability if the environment creates unachievable demands of the person, are introduced in their concept; namely: pathology, impairments, and functional limitations.

The Frank et al. (2003) model conceptualises the link between the physical environment, physical activity, and health. It highlights features of the built environment (land use, urban design characteristics, and transportation systems) as setting the scene for all activities within the community. Rosso et al.’s (2011) framework links personal capabilities (pathology, impairments, and functional limitations) with environmental features to visualise how individual and environment interact to create mobility disability within the community.
Studies of the role of the community environment as enabler and disabler

The environment creates demands that are difficult for older people with mobility disability to deal with. Shumway-Cook et al. (2002) investigated the impact of environmental features on the mobility of older people with and without mobility disabilities. The research involved 36 older people, of whom 19 were without physical disabilities and 17 with mobility disabilities. Participants’ health status and walking performance were measured. Their mobility within the community was also measured by using an activity/trip log and field observations. It was found that older people with disabilities have more problems with mobility in terms of temporal factors, physical load, terrain and postural transition; therefore, mobility disability was found to result from the interaction of individual and environmental factors (Shumway-Cook et al. 2003). In addition, older people with disabilities can adapt their mobility behaviour by using less challenging environments and, for that reason, encounter fewer challenges within the community than people who are not disabled.

The built environment plays a central role in the disablement process. Clarke et al. (2008) investigated the effect of the built environment on mobility disability by analysing data of adults aged 45 and older (n=1195) with different levels of lower extremity physical impairment. Environmental conditions, such as street and sidewalk quality around each participant’s
home location, were measured using systematic social observation. The researchers found that a higher level of physical impairment is related to mobility disability within street and walking environments that are in poor condition.

The likelihood of developing mobility disability increases with older age. A study using data from the American Changing Lives Survey followed people 45 years and older over a period of 15 years. Clarke, Ailshire & Lantz (2009) analysed the role of the built environment in relation to the development of mobility disability over time. They found that being female, or having lower education or a chronic health condition increases the likelihood of developing mobility disabilities over time. Furthermore, they found that being older and living in car-dependent environments also increases the risk of developing mobility disability.

2.2.4 Summary

In the light of population ageing, out-of-home mobility in older age is a topic which has gained much attention. A range of frameworks has been developed to understand the complex issue of older people’s mobility in relation to quality of life, life-space and the community as enabler and disabler.
Frameworks on mobility and quality of life, take very different approaches which indicates that there still is a need to better understand and link the concepts of mobility, wellbeing and their interrelationships (Siren & Hakamies-Blomqvist 2009). It might also be necessary to test the concepts. Furthermore, the reviewed literature shows that research on mobility and quality of life mostly focuses on the impact of reduced mobility on older people’s wellbeing. This narrows the focus and impedes a full understanding of the interrelationships of mobility and quality of life.

The concept of life-space provides the opportunity to consider the spatial aspects of mobility concepts. Webber et al.’s (2010) framework links individual capabilities with cultural and spatial demands and shows that, within different environments, different individual capabilities and resources are demanded. While this theoretical approach is most promising in aiding the understanding of the complexity of mobility within space, the model needs to be tested. A focus on health and the activities of daily living, or the availability of specific transport options, narrows the focus and does not take advantage of the holistic approach provided by the model.

Concepts which approach mobility as a result of individual capabilities and environmental demands are a most promising aid to understanding the complex interplay between demands and individual capabilities. Research however, mostly compares people with and without disabilities to develop
an understanding of the disablement process. While frameworks suggest that mobility and mobility disability are closely linked, there is, as yet, no research that has explored this link.

2.3 Influences on older people’s out-of-home mobility

While mobility in older age is influenced by personal circumstances and abilities, it is also influenced by the social and built environment (Mollenkopf et al. 2004). This section presents the findings from the research on mobility in older age which focuses on the older person, the social environment, and the community environment.

2.3.1 Mobility and the older person

Research shows that out-of-home mobility remains very important for older people as they age (Mollenkopf, Hieber & Wahl 2011). Socio-demographic factors such as age, sex, economic status, educational level, and marital status can create risks to an older person’s mobility (Hye, Fleury & Keller 2008). Danish studies investigated the impact of low financial status and low social participation and found that these factors increase the probability of lower mobility (Nilsson, Avlund & Lund 2010; Nilsson, Avlund & Lund 2011). Older people who have overall limited resources were also found to be more likely to experience mobility disadvantages (Siren & Hakamies-Blomqvist 2004).
Other research states that older women might be more dependent on others for transportation and, as a result, be less independent (Smith & Sylvestre 2001). In addition, being female can increase the likelihood of experiencing transportation disadvantages, as more older women than men have no driving licence or no access to a private vehicle (Siren & Hakamies-Blomqvist 2004; Siren & Hakamies-Blomqvist 2006; Rosenbloom 2006).

Mobility within the community is dependent on one’s actual physical ability to use transport options within the community environment. People over 75 years might experience mobility disadvantages because of accessibility issues within the community which are related to their health status; this is especially true in the case of the use of public or active transportation modes (Alsnih & Hensher 2003). Furthermore, physical inactivity, smoking, obesity, and physiological factors might create risks to mobility in older age (Hye et al. 2008). It was also found that fatigue in daily life activities increases the risk of mobility disability in older people (Avlund, Vass & Hendriksen 2003).

Older people might be able to drive a car for much longer than they can use public transport (Rosenbloom 2003). However, functional disabilities caused by the ageing process can restrict safe driving (Austroads 2000). Furthermore, when older people stop driving they may not be aware of their physical limitations and can have greater problems in adapting their lifestyle and mobility than older people who never drove (Alsnih & Hensher 2003).
Personal lifestyle was found to have an influence on older people’s mobility. Older people travel for recreational purposes earlier in the day than younger people (Okola 2003). Hildebrand (2003) describes the travel characteristics and behaviours of older people using a cluster system which was developed on the basis of their socio-demographic variables. It was found that there are diverse mobility and travel characteristics among groups. Not surprisingly, the clusters of workers, mobile widows and affluent males were found to be more mobile than the clusters of granny flats, mobility-impaired and disabled drivers.

Research also indicates that attitudes towards transportation options create distinct mobility patterns. Haustein (2012) presents a German study that uses a segmentation approach to identify subgroups of older people who display diverse lifestyles, attitudes, travel behaviour and needs. The research found four different types of older people: captive car users, affluent mobiles, self-determined mobiles and captive public transport users. These different segments not only show differences in their use of transportation, but also in their attitudes towards transportation options. The study indicates that car dependency is linked to a lower satisfaction with other mobility options.

Driving status and vehicle ownership in older age was found to impact on mobility. Mobility in older age is negatively impacted by the absence of a driving licence, especially in rural (Siren & Hakamies-Blomqvist 2004; Siren
Car ownership in older age has a positive relationship to higher trip frequency, even though the distance travelled was found to be dependent on the proximity of destinations to home (Páez et al. 2009).

### 2.3.2 Mobility and the social environment

The social network and environment of an older person can have an impact on mobility in older age. The social environment, for example, can provide the older person with resources that have a positive impact on out-of-home mobility (Mollenkopf et al. 2004). Strong social networks can positively influence mobility in older age; however, the relationship between poor social networks and increased immobility is not a simple one, as mobility limitations might also lead to fewer social contacts (Hye et al. 2008). Furthermore, care-giving environments that are overprotective of the older person increase the likelihood of mobility limitations (Hye et al. 2008). A combination of low financial assets and poor social relations also negatively affects mobility in older age, especially in older males (Nilsson et al. 2011).

Living in a deprived neighbourhood can result in a higher risk of developing mobility disability. In a longitudinal study, Lang et al. (2008) found that the likelihood of the development of mobility difficulties increases significantly for older people living in deprived neighbourhoods, compared to those living in less deprived neighbourhoods. They measured deprivation in seven
dimensions: income, employment, health, education (and skills and training), barriers to housing and services, deprivation of the environment, and crime. However, they indicated that the mechanisms underlying these findings are unclear.

2.3.4 Mobility and the community environment

There is mixed evidence of the impact of land use and density on mobility in older age. Within the literature, it is agreed that higher street connectivity (shorter pedestrian distances), street and traffic conditions (safety) and proximity (to retail facilities and parks) lead to better mobility outcomes in older age (Rosso et al. 2011). Therefore, people living in rural and urban areas have different mobility conditions (Mollenkopf et al. 2004; Hye et al. 2008). Living in rural areas is believed to be a predictor of mobility disadvantages in older age (Siren & Hakamies-Blomqvist 2004). Urban areas, such as those investigated by Fobker and Grotz (2006) in Germany, provide everyday mobility and an active lifestyle in all environments. A combination of accessibility and proximity of services and facilities, walkability and rail-bound transit were characteristic of these environments.

Suburban areas can create mobility disadvantages for older people as they create low density environments that make travelling longer distances necessary. This can create reduced mobility over time, as older people adapt their lifestyles in order to be able to stay within their community as they age.
In so doing, they can reduce the area they access within their community (Lord, Després & Ramadier 2011; Lord, Joerin & Thériault 2009; Lord & Luxembourg 2007).

Denser environments which provide reliable public transport (bus- and rail-based) enable a high level of mobility and can reduce the dependency on car-based transport (Metz 2011). Local accessibility can be increased by transit-friendly and mixed-use communities. However, the role of environmental density for older people’s mobility is not clear (Páez et al. 2009); it might only play a limited role in preventing mobility disadvantages in older age in relation to other factors (such as a preference for travel by car, for low density living, and for ageing in place) (Guliano, Hu & Lee 2003).

The design of the built environment was found to affect mobility in older age (Carp 1980). Street design, such as surfaces, impacts on walkability and on the use of public transportation (Lavery et al. 1996). The design of neighbourhoods in terms of local facilities, walkable environments, neighbourhood attractiveness, and adequate public transportation can influence mobility and activity in older age (Michael, Green & Farquhar 2006). Furthermore, the need to travel on higher-order streets, the inaccessibility of destinations, and an unsatisfying pedestrian infrastructure along roads and intersections can create barriers to mobility in older age (Dumbaugh 2008).
Access to public transportation within the community can also have an impact on older people’s mobility. Research shows that older people travel more often if they have good access to public or private transportation (Smith & Sylvestre 2001). Public transportation is an alternative to driving, which can become challenging in older age. Therefore, it is necessary to provide safe and practical transportation alternatives (Dickerson et al. 2007). However, many older people can experience difficulties in accessing public transportation in their environments. In the US, for example, it is predicted that by 2015, 15.5 million older people will have poor access to transportation, thus facing mobility issues if driving is not an option (DeGood 2011).

2.3.5 Summary

The reviewed literature shows that factors related to the older person can create barriers to mobility; being older, female, poor, of low educational level, or unmarried can result in transportation accessibility issues. Older women especially seem to be more likely not to drive themselves and, consequently, face reduced mobility. The relationship between lifestyle and mobility in older age is less clear. Personal lifestyle is facilitated by mobility options, and can have an impact on travel behaviour; however, lifestyle still does not indicate the level of mobility per se. Personal attitudes to the use of transportation options can also have an influence on mobility patterns.
However, health is critical to accessing transport options, especially in the case of active or public transportation.

The impact of the social environment on mobility is also little understood. While the social environment can provide the older person with mobility resources that enable them to stay mobile, it can also act restrictively. Furthermore, mobility difficulties can create difficulties in accessing social networks. It is still unclear how the social environment within the neighbourhood impacts on mobility in older age.

The built environment can impact on older people’s mobility, and the literature gives some indices for the development of more age-friendly design within the community. It shows that lower density environments, such as rural or suburban environments, cause car dependency and, therefore, mobility disadvantages for older people who do not drive. Higher density living, in combination with mixed land uses in terms of retail and residential can also be more prone to providing transportation alternatives. These environments provide better accessibility for older people and reduce mobility disadvantages for those who cannot, or do not want to, drive. Central to older people’s use of these environments is to design them in such a way as to facilitate their use by this cohort.
2.4 Older people’s travel behaviour and travel mode choice

Research studies of community mobility in older age often investigate travel behaviour and choice of transportation. This section presents the findings from this area of research.

2.4.1 Travel behaviour

Research indicates that older people’s travel behaviour is different from that of other groups within society. Reduced mobility in older age can create different travel patterns and characteristics, as travel purposes can change due to lifestyle changes and more available time (Su & Bell 2009). Older people can also have a different trip-chaining behaviour compared to younger cohorts (Hensher 2007).

Older people’s travel behaviour is not homogeneous. The probability of making trips is influenced by gender, employment status, and household arrangements (Mercado & Páez 2009). Other factors such as health, living arrangements, and income can also impact on the frequency of trips for specific services and activities (Smith & Sylvestre 2001). While the possibility of making a trip is believed to decrease with older age, the trip-making of older drivers for non-work trips was found to increase, relative to other cohorts (Páez et al. 2007).
The distance travelled was found to decrease more for drivers than for passengers or bus users (Mercado & Páez 2009); however, it was also found that the average distance travelled in older age does not decrease (van den Berg, Arentze & Timmermans 2011). Another consideration is that high commercial and residential areas can impact on the distance travelled by car (Mercado & Páez 2009).

### 2.4.2 Travel mode choice

Research on the general population indicates that the community environment has an impact on the choice of transportation. It was found that land use has a significant influence on the decision to drive alone, share a ride, or to give someone a ride; the influence of urban design, on the other hand, was found to be not as strong (Cervero 2002). The impact of the built environment on the use of active transportation is unclear (Cervero & Duncan 2003). Land-use policies that facilitate proximity and alternative transportation to the car can also encourage citizens to drive less and walk more (Cao, Mokhtarian & Handy 2007).

Living in urban areas encourages citizens to walk more compared to suburban or rural residents, even if a car is available (Scheiner 2010). However, while this can be interpreted as a strong impact of the built environment, there could also be another process in place – the self-selection of residence; people might choose to move into a certain environments on the
basis of their preferred transport option. Therefore, personal preference rather than the built environment is influencing travel behaviour (Chatman 2009).

A range of factors are suspected to impact on older people’s travel mode choice. Neighbourhood and trip characteristics, individual and household characteristics, (Kim & Ulfarsson 2004), and the cost of transportation can all play a role (Lucas, Archilla & Papacostas 2007). Access to transport options can also be a factor influencing the travel mode choice in older age. Variables that can impact the access to transportation are personal health, gender, racial and ethnic background, and income (Kim 2011). Distance to transit stops and destinations was also found to be critical in the decision to use public transportation (Hess 2009).

The numbers of older people holding a driving license and owning a car are increasing. While this might be an indicator of retaining a lifelong habit of driving (Hjorthol, Levin & Sirén 2010), it could also indicate that the community environment is not encouraging the use of other means of transportation. Some researchers state that public transport and walking become more important in older age as driving ability decreases (Su & Bell 2009). However, convenience, affordability, and mobility-related health factors can also influence transportation choice and lead to a predominance of driving (Buys et al. 2012).
The Car

Many studies focus on the use of the car as the primary transport option used in older age. The number of older licence holders is rising (Rosenbloom 1999a; Rosenbloom 2009); therefore, a focus on this transport option is not surprising. It is further believed that the number of older drivers will increase rapidly (Burkhardt & McGavock 1999). While this creates concerns about sustainability and environmental impacts, it is evident that older people are more dependent on the private car to meet their increasing travel needs (Rosenbloom 2001). Furthermore, it is believed that keeping older people driving for as long as possible might be the most realistic option to provide older people with the mobility they need to stay within their communities (Rosenbloom 2009). Consequently, safety of the driving environment needs to be a focus in transportation planning (Austroads 2000; Charlton, Fildes & Andrea 2002; Dickerson et al. 2007; Eby & Molnar 2009; Oxley et al. 2006; Oxley, Langford & Charlton 2010).

Older people use their car differently from younger drivers. It was found that older people adopt self-regulatory driving practices if they are not confident in specific driving situations (Charlton et al. 2006). Self-regulation in driving is a complex social and psychological process which includes attitudes and behaviours, and automobile attributes (Donorfio et al. 2009). Available social networks have a critical role in the process of self-adaption.
and, eventually, when driving is finally relinquished (Donorfio et al. 2009; Rosenbloom 2010; Johnson 2008).

Driving cessation is a major concern within research on mobility in older age. Older people tend not to plan for driving cessation (Liddle, McKenna & Broome 2004). However, medical conditions, fear of involvement in accidents, crime, or having no need to drive (Ragland, Satariano & MacLeod 2004) can be reasons for reduction or cessation of driving. Other factors are low income and low confidence (Sims et al. 2007), and licensing policies (Kulikov 2011).

Research indicates that driving cessation has impacts on older people’s quality of life as they can no longer reach their desired activity destinations (Banister & Bowling 2004; Marottoli et al. 2000; Liddle et al. 2004). Depressive symptoms (Marottoli et al. 1997; Ragland et al. 2005) and decreased out-of-home activities (Marottoli et al. 2000) are linked with driving cessation in older age. Another effect of driving cessation can be a reduced network of friends. While this affects social integration in older age, the support by others is not affected (Mezuk & Rebok 2008). Older people living in rural environments particularly face mobility difficulties if they have reduced or ceased driving. Often, transport alternatives other than provided by family and friends are not available to them (Hanson & Hildebrand 2011; Fogg 2000).
It is critical that older people can maintain their ability to drive for as long as possible – not only to enjoy freedom and activity within the community, but also to minimize the burden for themselves, their families, and their communities (Whelan et al. 2006). Older people’s road knowledge and practice can be enhanced by educational programs that combine classroom lessons and on-road training that target common errors in their driving practice (Marottoli et al. 2007). It is also important to provide safe driving environments; for example, by enhancing road design (Oxley et al. 2006; Oxley et al. 2010) and developing safer vehicles (Charlton et al. 2002). Combining appropriate licensing procedures and improving alternative transport options for older people could also improve older people ability to stay mobile (Whelan et al. 2006).

Public transportation

Research on future trends in older people’s use of public transportation has mixed messages and is not explicit (Currie & Delbosc 2010). It is recognized, however, that in relation to driving cessation, access to alternative transport options is increasingly important (Alsnih & Hensher 2003; Alsnih & Hensher 2005; Páez et al. 2007). Travel training programs for the use of public transport could be beneficial for drivers who plan to stop driving, and who want to become more familiar with public transportation (Babka, Cooper & Ragland 2009). However, the ability of public transportation to actually
provide older people with the mobility they need is questioned (Rosenbloom 2009). One reason for this inability could be the shortage of transport alternatives (to the car) caused by car-orientated transportation planning (Butler 2008; DeGood 2011).

Public transport is commonly believed to be a good alternative to transportation by car. However, research indicates that it does not provide seamless movement within the community; this makes trip-chaining by public transport impractical. This might be one reason for the higher dominance of transportation by car (Alsnih & Hensher 2005). Public transportation was found to be less used by, and less attractive to, older users (Burkhardt 2003; Gilhooly et al. 2002). This might mirror transport operators’ lack of consideration for older passengers (Gilhooly et al. 2002). To enhance the attractiveness of public transportation systems for older people, the services need to provide more travel mode choices that are affordable, of higher quality, and tailored to older people’s specific travel needs (Burkhardt 2003). Focusing on providing seamless movement within the community, for example, can make public transportation more convenient for older people to use (Alsnih & Hensher 2005).

The use of public transportation, in particular, can present difficulties for older people. Getting to transit stops, entering the vehicle, and understanding and navigating the transportation system is perceived as a
more difficult task than using the private car (Scharlach 2009). Self-reported walking distance to public transportation has an influence upon ridership (Hess 2009). Predictors for the future use of public transportation (such as buses) are: the older person’s driving status, their perception of the safety of public transportation, and the attitudes of others (Salazar 1999). However, older people might also need to learn how to use public transportation or its alternatives (e.g. calling a cab), especially if they were drivers and have never used these forms of transportation (Purdie & Boulton-Lewis 2003).

A mix of person-centred factors (e.g. health issues, bearing a heavy load, or needing assistive devices), the reason for travel (e.g. shopping, work, social activity), and the community environment can negatively influence the use of buses (Broome et al. 2009). It is critical to understand barriers to, and facilitators for, older people’s bus usage (Broome et al. 2010). Environmental designs, such as pedestrian infrastructure and bus stop locations, could increase accessibility. Carefully determined time tabling, scheduling, bus routes, and user-friendly vehicle entrances and exits can increase transport usability. The friendliness and helpfulness of the driver also increase older people’s willingness to use busses, while information and training can reduce other barriers (Broome et al. 2010).
Active transportation

Research on transport-related physical activity is often related to health outcomes. Not only is walking perceived to be a preferred physical activity in older age, it is also the main active transportation mode. Walking is the second most used transport option in Europe (25 – 30 %) and the US (8%) (Mitchell 2006). Physical activity not only positively influences physical health, it also positively influences mood, and reduces anxiety and depression (Patterson & Chang 1999). Berke et al. (2007a) show that there is a link between neighbourhood walkability and depressive symptoms in older men. It was also found that walkable green space near an urban senior citizen’s residence can increase longevity, as it encourages them to participate in physical activity (Takano, Nakamura & Watanabe 2002).

The association of environmental components and physical activity in adult age is strong. It was found, for example, that urban density, street connectivity, mixed land use (Badland & Schofield 2005), and urban design (Bentley, Jolley & Kavanagh 2010) have an impact on adult walking behaviour. Also important are accessibility, opportunities for activities and aesthetic attributes (Humpel, Owen & Leslie 2002). However, only a limited number of studies investigate the impact of the built environment on physical activity in older age (Cunningham & Michael 2004; Cunningham et al. 2005).
Berke et al. (2007b) found that neighbourhood walkability is positively related to higher walking activities in older age. However, older people might have specific needs with respect to the walkability of their community environment. Individual variables such as functional limitations, use of mobility devices, and a dependence on walking as a transport option can make older people more sensitive to physical barriers within their walking environment (Wennberg, Ståhl & Hydén 2009). However, other issues such as shared space, lightning, or cleanliness impact on all older pedestrians. In environments where snow and ice are apparent, it is critical that these are removed from walkways and pedestrian crossings (Wennberg et al. 2009). At the neighbourhood level, density, green and open space, and the number of intersections impact walking in older age (Li et al. 2005).

Even small details within the community environment can make a difference for older pedestrians. Perceptions of safety and the number of recreational facilities close to the residence are positively related to high levels of walking (Li et al. 2005). Ståhl et al. (2008) found that a separation of pedestrians and cyclist, maintenance of walkways, more considered planning of walkways in terms of width, curb levels, form and surface, and speed limits enhance walkability for older pedestrians.

The impact of the built environment might not be the most significant impact on walking or other active transport modes in older age. Health and safety,
for example, were found to be strong predictors of physical activity within the community, and have more influence than environmental features (Bird et al. 2009). Nagel et al. (2008) could not find any association between the built environment and the likelihood of walking. However, they did find that, for people who do walk, the degree of walking activity and the time spent walking are connected to some local neighbourhood attributes. Factors that could act as barriers to walking are anticipated to be: general car dependency, a lack of well integrated public transportation and transit systems, and poor pedestrian infrastructure (Vine, Buys & Aird 2012).

There is also some evidence that the social environment within their community can have an impact on older people’s walking activities. Research found, for example, that social support (Booth et al. 2000) and the socio-economic status (Grant et al. 2010) of a neighbourhood can impact on walking behaviour in older age. Neighbourhood social cohesion can also increase the level of physical activity within the neighbourhood (Fisher et al. 2004).

Research on older people’s use of active transportation often does not clearly differentiate between walking that is undertaken for the purpose of commuting, and walking that is undertaken for the purpose of recreation. This is problematic in terms of understanding walking behaviour in older age for transport purposes; as a result, studies that do not distinguish
between recreational physical activities and active transportation misrepresent the impact of the built environment on active transportation in older age.

2.4.3 Summary

Research on the travel behaviour of older people is related to concerns about the changing demands on the current transportation systems as an effect of population ageing. The literature shows that older people today are more mobile. This can be substantiated by the increased use of the car and the lifestyle choices these age groups make. However, more research is needed to understand older people’s travel behaviour and how this is related to mobility and mobility disadvantages.

The reviewed literature shows that there can be a range of factors that actually influence the choice of transportation. External factors such as the built environment, land use, and density can influence the choice of transport options. However, it is also anticipated that individual and household characteristics, as well as the cost of transportation, could influence transportation choice. Furthermore, access to transport can also be decided and influenced by socio-demographic factors.

Car usage is the focus of many studies; this is to be expected, given the ever-increasing number of drivers within the older age cohort. Driving in older
age is, however, discussed in very different ways. Some researchers argue that older people should be driving for as long as possible, as this might be their most realistic transport option. Others are more interested in the reasons for, and the effects of, self-regulation of driving practices and driving cessation. All reviewed research indicates that older people’s mobility declines when they have to change their driving habits or to stop driving altogether. Some research even indicates a relationship between driving cessation and depressive symptoms in older age. Therefore, it is critical to do more research on the effectiveness of the car as a transport option for older people, and to determine ways to prevent mobility decline for those who can no longer drive.

Research on the use of public transportation in older age is not straightforward. While it is believed that public transportation could be a feasible transport option for older people, it is also found that its use might be difficult for older people, and that it might not be able to satisfy older people’s mobility needs. Since the car is the transport option used by an increasing number of older people, these users might not be as familiar with the public transportation systems available. Public transportation is less attractive than the car as a transport option for a number of reasons. Most critically, transportation systems need to focus more on older people’s
usability and accessibility needs, to make them better mobility options for this community group.

Walking is the active transportation mode which research mostly refers to. The importance of walking lies, according to the research, in the perceived health benefits that can be achieved if activity is incorporated within daily life activities, such as commuting. Research also indicates that walking in older age is strongly connected to a supportive and safe environment, which can be enhanced by providing a barrier- and hazard-free built environment. General car dependency, the lack of integrated public transportation, and an unsatisfying walking environment can act as barriers to walking.

2.5 The relationship between participation and mobility in older age

Research shows that an individual mobility disadvantage fosters social exclusion (Stanley et al. 2011b; Stanley et al. 2011a). It is known that social participation is connected to better health, skills, and quality of life in older age (Dahan-Oliel, Gelines & Mazer 2008). It is even more critical for older non-driving seniors as they are at risk of being socially excluded if the public transport system cannot provide access all over the community (Engels & Liu 2011).
Older people now travel more than ever before (Hjorthol et al. 2010; Miranda-Moreno & Lee-Gosselin 2008); their travel behaviour is influenced by the activities they participate in, and reflects their lifestyle. It is not surprising that work-related trips decline when people retire, while shopping and leisure trips only start to decline in very old age (Hjorthol et al. 2010). Research from Canada also shows that older people spent more time in travelling, but decreasing time in shopping activities (Farber et al. 2011). Older people do not like to have too many stops when they are shopping (Su & Bell 2009); this can impact on their shopping activities and travel behaviour.

Social engagement in older age is important for wellbeing. However, the relationship between mobility and social engagement still seems unclear. Higher education and involvement in clubs can lead to more social trips (van den Berg et al. 2011), thus making access to a private car vital. Research indicates that giving up driving can not only lower life satisfaction, but can also negatively impact on participation in volunteering, on assisting family members, and on engagement in out-of-home social leisure time (Liddle et al. 2012).

Other research found that the use of transportation can have an impact on the kind of activities older people participate in. A European study found that engagement in out-of-home activities can be related to gender and the
use of transport options. It found that men with good physical functioning who drive a car participate more in sport activities and hobbies, while females who use public transport are involved in more social activity (Gagliardi et al. 2007).

Leisure activities are often affected by reduced mobility and reduced participation in out-of-home activities. Living in rural areas, living alone, being female, and being older were all found to be critical factors in accessing leisure facilities (Siren & Hakamies-Blomqvist 2004). Participation in a greater range of leisure activities in older age was found to be connected to higher education and income, and to living in an affluent neighbourhood (van der Meer 2008).

Driving cessation is also shown to have a direct impact on the activity level within a community and to reduce quality of life (Harrison & Ragland 2003; Marottoli et al. 2000). This is critical for older people living in car-dependent environments such as suburban or rural environments, which can suffer from a lack of transportation (Kim 2011). Older people living in these environments adapt their lifestyle and mobility pattern to be able to stay in their neighbourhoods for as long as possible; this, in the long term, leads to less participation within the community (Lord & Luxembourg 2007; Lord et al. 2009; Lord & Després 2011; Lord et al. 2011). Older people living in rural areas can be at greater risk of not reaching specific services and facilities –
such as specialists, hospitals, and cinemas – especially if they have no access to a private car (Shergold & Parkhurst 2012).

Being dependent on others or service providers for mobility within the community can lead to less participation within the community (Dahan-Oliel et al. 2010). Older people who do not have a private transport option can have more difficulty in reaching activities for pleasure, than in reaching daily life activities, such as health facilities and shopping. This is because they are more likely to ask for a ride to access daily life activities than to access recreational activities (Davey 2007). However, research from Singapore did not find any difference in the time spent out of home by older drivers, and by non-drivers who were able to use a variety of transport modes to reach their desired activities (Krishnasamy, Unsworth & Howie 2011). This might be related to the availability of public transportation and the overall higher density of Singapore’s built environment.

The reviewed literature indicates that participation within the community is dependent on the mobility of the older person. The literature also indicates that the deficit of private transport options can have a more significant effect on engagement in social activities, than on engagement in daily life activities. Most research that investigates the relationship between travel behaviour and community engagement is concerned by the loss of car-related mobility.
and its impact on out-of-home activity. Older people engage in activities in
different ways to other cohorts, and this can impact their travel behaviour.

It is a central aspect of the active ageing framework to enable older people’s
sustained participation in an array of activities within the community (World
Health Organization 2002). However, it is surprising that the concept of
mobility is to date not specifically linked to the active ageing; while it is
acknowledged that mobility is crucial to older peoples independence and
everyday participation (Mollenkopf et al. 2011).

2.6 Conclusion

Participation is a key factor for a healthy ageing processes; mobility is
believed to have a significant impact on quality of life as it fosters older
people’s ability to participate within the community. The community
environment can have an impact on the kind of transportation older people
use and on their access to destinations for activities. Environments which are
more car-dependent, such as suburban or rural environments, can create
transport deficits for older people who have no access to a car. However, it is
not clear how low density suburban environments impact on the choice of
transport options, and what effects this choice of transportation has on active
and healthy ageing.
Older people are more mobile today than previous cohorts; this mobility can be linked to access to a private car and to the range of activities they participate in. A range of factors is believed to influence older people’s choice of transportation and, in turn, the activities older people participate in. However, it is still unclear what role different transportation options play in engagement in social and daily life activities, especially for older people living in lower density environments.

Mobility in older age today leads to engagement in a range of activities within the whole community. However, built environment characteristics vary within the community, impacting citizens and the provision of transport options in different ways. Built environments also create different demands on older people’s abilities to be mobile within these environments. It is still not well understood what allows older people to be mobile within the whole community; thus, it is necessary to investigate the impacts that different environments, within the same community, have on older people’s travel behaviour.
3 Method

This study uses data collected within the ARC Linkage Project: The neglected dimension of community liveability: Impact on social connectedness and active ageing (LP0883447). I was part of this ARC Linkage project in my roles as research assistant and doctoral student. This chapter describes the methods used to collect and analyze this project data.

Data on older people’s travel behaviour was collected using travel diaries (including a questionnaire) and global positioning system (GPS) tracking. The older people’s perceptions of, and experiences within, their community were then gathered through in-depth interviews which were aided by Google Earth maps (Google 2010a). My role was to develop the use of GPS tracking for this research project, to gather, map and analyse this data, and to then to develop the Google Earth maps which were to be used as probes for the interviews. A detailed description of the preparation of the GPS data can be found in the Appendix.

3.1 Study design

The study uses a qualitative design that incorporates the data collected via mixed methods. The qualitative study design is justified by the complexity of the research topic because it allows development of an understanding of a phenomenon by engaging individual experiences and perceptions.
(L iamputtong 2009). A qualitative research design which uses a mixed data collection approach serves to minimize flaws of the individual data collection methods when used in isolation, and benefits from their collective strength (Johnson & Onwuegbuzie 2004).

Mobility is a human experience that influences quality of life (Metz 2000; Musselwhite & Haddad 2010). Research into older people’s mobility and travel behaviour still mainly relies on travel diaries to record travel data; this has some disadvantages, such as the higher possibility of missing some data (Stopher & Greaves 2007), or of placing a greater burden on the participants (Draijer, Kalfs & Perdok 2000). Mobility within the community environment can now be measured by using GPS tracking to collect data on travel behaviour; however, GPS data also has its limitation: it simply records movement within a space and time, and does not provide information on why a particular route was chosen or why the travel was undertaken.

The complementary combination of both travel diaries and GPS tracking is very valuable, because it enables to collect richer data, allowing a deeper analysis of the data. Furthermore, the incorporation of this combined data with interview data concerning older people’s experiences and perceptions of transportation and their community environment facilitates an investigation of the individual motives and reasons for the observed behaviour. This integration of the observation of real time behaviour and in-
depth analysis of individual experiences and perceptions suitably enhances the understanding of mobility in older age.

The data was collected in two phases by using a range of data collection methods (Figure 2). Firstly, participants’ (n=23) out-of-home mobility and engagement in activities were recorded for a seven days period by using travel diaries, a small questionnaire, and lightweight GPS recorders. The data collected was then processed to individual Google Earth maps (Google 2010a). After a period of about two weeks, participants were interviewed, and these interactive maps were used as a point of reference in these interviews.

**Figure 2 Data collection and analysis**

Development of the methodology, the testing, and the organization of the equipment took place between September 2009 and February 2010 (Table 3).
The tracking of participants living in higher and lower density environments in Brisbane (Australia), and the development of the individual Google Earth maps took place between March and April 2010. The interviews were carried out in March, April, and May 2010.

Table 3 Project timeline for development of methodology and data collection

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<tr>
<th>Activity</th>
<th>2009</th>
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<td>Sep</td>
<td>Oct</td>
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<tr>
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<tr>
<td>Interviews complete</td>
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The data on older people’s travel behaviour (travel diaries and GPS data) was collected in the Australian autumn (March and April 2010). Queensland’s climate is subtropical to tropical and it can be very hot and humid, especially in summer. To avoid a possible bias in the travel data due to these hot and humid weather conditions, it was decided to collect the data in the more moderate autumn conditions.

3.1.1 Participants

This thesis uses a qualitative methodology, which does not identify trends or suggest generalization of the results across whole populations; but collects
data which illuminates the phenomena under study. In this way a deeper understanding is obtained from full and meaningful responses made. Therefore, a sample size of 23 participants is suitable for this study to develop pattern and themes which adequately represent the participants’ experience (Cresswell 1998). Qualitative research is a recognized and rigorous social research method that is used to gain in-depth knowledge and understanding of a particular phenomena, issue or question and, therefore, often used to explore a topic for the first time.

Participants were either participants in a previous study who agreed to be contacted for further research, or contacts made through ARC Linkage partners (Council on the Ageing (COTA), Queensland). They were contacted via a posted information letter and then by phone to reinforce the contact, and to address their questions about the procedure and time schedule.

The participants were sent: the GPS device and written information on the process of handling it; the recharger; the diary; and a return envelope. The researcher confirmed that participants had received their package, and that they understood the data collection process.

Participants were encouraged to contact the researcher if they had any questions or problems during the research period. After seven days of tracking, they were asked to put the devices, diaries and signed agreement
form in the return envelopes, which were then collected and delivered to QUT.

This study focuses on data collected from participants living in low (n=13) and higher (n=10) density environments within Brisbane (Australia) (see Table 4). The 12 men and 11 women participants were aged between 57 and 87 years; 13 of these were married and living with their spouse; and all but four (3 = male, 1 = female) were fully retired. Participants’ income ranged from AUD$20 000 (or less) to AUD$100 000 a year.

All but six participants were driving a car alone for most of their travel. Four of these six non-driving participants (P9, P10, P14 and P23) were travelling as passengers of other car drivers, two (P12 and P13) did not drive at all, one had no access to a car (P12), and the other was not driving due to health issues (P13). Participants’ identity and information was confidentially handled.
### Table 4 Participants’ demographic information

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### 3.1.2 Case study location

Brisbane, the case study location, is the subtropical capital city of Queensland, Australia, and is one of the fastest growing regions in the
country (Mees & Dodson 2011). European settlement dates from 1825 and, in 1859, Brisbane was named and declared the capital of Queensland (Cole 1984). The city holds 9.08% of the Australian population and, with 1 945 000 citizens, is Australia’s third largest city (Commonwealth of Australia 2010).

Brisbane is also the second least dense major city within Australia, with a population distribution of 918 persons per sq km (Commonwealth of Australia 2010). Recent developments in outer areas and urban renewal in inner city areas are highly attractive and account for the steady growth of the city. In recent years, the city acquired an average of 16 000 new residents per year. In 2026, the number of dwellings is expected to grow by an additional 145 000 (Brisbane City Council 2011).

3.2 Description of data collection instruments

3.2.1 Daily travel and activity diaries

The daily travel diary was a vital part of this study as it allowed the participants to record their own travel, including information on the transport options used and the purpose of their travel. It was also vital for the mapping and coding of the GPS data. The diary also provided information on: demographics; modes of, and reasons for, transport; activities participants were engaged in; and additional observations on daily
health conditions or environmental barriers to activities. Some participants also included suggestions on how their community could improve.

The first pages of the daily travel and activity diaries were devoted to a survey of participants’ lives and living circumstances, and their connections and engagement within the community. They were also asked to make a statement about their health status and travel habits, and about what they thought about the age and disability friendliness of their community.

The second part of the diary provided space for recording their basic travel information: the points of departure and arrival, and the respective times and modes of transport. There was a separate space for each day, and a separate page for participant comments about that day.

### 3.2.2 GPS tracking and data preparation for interviews

Within a timeframe of seven days, the participants were requested to take the GPS data logger with them every time they left their homes. They were instructed to switch on the device and place it in a handbag or pocket, or on the dashboard of the car when leaving their homes. They were free to decide whether to leave the device on all the time or to switch it on only when leaving the house, depending on what they thought would work best for them. They were also advised to recharge the device every night to avoid poor performance due to low battery levels. In this same seven day
timeframe, in the provided diaries, they were also asked to log their travel details: the day, time, place of departure and destination/s, choice of transport, purpose of their trip, and any comments they wished to make.

The recorded GPS data of each participant was used to prepare a Google Earth map (Google 2010a) which was used as a tool in the in-depth interviews. The maps were displayed on 22 inch computer screens that showed the individual’s movements per transport option, and the destinations reached during the time of GPS tracking.

Converting the GPS data into Google Earth maps that were used to assist the in-depth interviews took around 1.5 days per participant dataset. The data was converted to CSV files which where customised to daily records. By using the daily diary entries as reference, the GPS data was converted into Google Earth tracks for the whole week, every single day, transport option used and the places where activities occurred.

### 3.2.3 In-depth interviews

The participants were invited to attend semi-structured interviews with a researcher. These interviews generally took place at QUT where a room was set up for this purpose. Participants who could not come into the university

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due to mobility issues were visited at home, and the interviews were conducted using a laptop to show the Google Earth maps. The length of the interviews varied between 45 and 120 minutes.

The interviews were organized in two parts. The interviewers created structure by using a prop-sheet that was developed on the basis of the age-friendly city guide (World Health Organization 2007b), information collected via the travel diary, and topics emerging from the mapping process. In the second part of the interview the individual Google Earth map (Google 2010a) was used to explore individual travel and daily activities, and to discuss participants’ experiences with mobility within their community.

The first part of the interview was centred on three main questions relating to the topic of community liveability. The structure of the interviews was dependent on the participants’ answers to these questions. Prompts and leading questions were provided in paper form to assist the interviewer; if questions arose during the mapping process, they were individually added to this paper. The three main interview questions were:

Q.1 What is it like to live in your community?
   Possible prompts concerned issues of: safety, affordability, availability and accessibility.

Q.2 Are you an active member of your community?
   Possible prompts concerned issues of: inclusion, policy plans, working/volunteering, and intergenerational interactions.
Q.3 What kind of technologies do you use?

Possible prompts concerned the use of technology within the participant’s community or home, to stay in contact with others, and to gather information for personal use.

The interview then followed up on participant responses to the diary questionnaire. For this discussion, questions needed to be designed individually for each participant; for example:

Q3  (For a retired participant): Has the affordability of living in your community been affected by retirement?

Q8  (For a widowed participant): Has the fact that you are alone affected the way you integrate into the community?

Q13 (For a participant living in a flat): Do you interact with others in the complex?

Q15 (For a participant with stair access to their home): Are the stairs easy or difficult to manage?

Q22 (For a chronically ill participant): How long have you been ill? Has your illness affected the way you integrate into the community?

In the second part of the interview, the research assistant introduced the participant to the Google Earth maps, confirmed the accuracy of the GPS data displayed, and questioned them about their means of travel, the condition of the built environment, accessibility, and safety. The main intention here was to discuss the participant’s week and the activities in which they participated. It was also possible to discuss environmental
features that impacted upon transport and activities within the community environment.

This part of the interview was structured by follow up questions about information in the travel diary and the Google Earth maps. The latter were displayed on large 22 inch LCD computer screens. This ensured that the information could be viewed by any participants who might have eyesight problems.

### 3.2.3 Trial of instruments

The instruments for the data collection were trialled after they were approved by the QUT Human Ethics Committee. Two older people who were relatives of members of the research group – one male (75 years) and one female (82 years), living in Maroochydore (Queensland, Australia) – agreed to test the data collection instruments and information in terms of its usability and comprehension. This trial was important to the researchers as a means of identifying possible problems with the instruments, and subsequently improving their usability if the trial participants’ feedback considered this to be necessary.

The instruments (travel diary, including questionnaire; GPS device and recharger; and participant information and agreement forms) were sent to the trial participants. The quality of the travel diary data and the GPS data
was tested by mapping the data in Google Earth maps. This also helped in estimating how time-intensive the GPS data mapping process would be, and in developing the tree of layers that needed to be developed for the maps. The travel diaries and the information on how to use the GPS device were adjusted according to the recommendations provided by the trial participants.

Another test was undertaken with a male trial participant (64 years) from Brisbane (Queensland, Australia). This participant took part in the tracking process and a trial interview. The latter tested how well the interview prompts and the Google Earth maps worked together as interview tools. This trial interview procedure was discussed in the research group, and it was decided that the map should be shown in the second half of the interview. This enabled the interview to be conducted more flexibly, and to be guided by the interview prompts.

### 3.3 Data analysis

The GPS data and interview data were analyzed individually for each participant and then compared. The combination of the real time out-of-home travel data, and information about participants’ activities and experiences within their community, allowed for the capturing of the complexity of out-of-home engagement in older age.
3.3.1 GPS data analysis

GPS tracking was used to gather objective data on the participants’ travel and activity within the community environment. Mapping participants’ movements using Google Earth as a GIS tool enables the gathering of objective indicators about their urban environment. Depending on what additional data and visualization is used, environmental conditions – such as transportation, services, facilities, and their proximities and service patterns – as well as socioeconomic dimensions can be described.

The GPS data was first coded in terms of out-of-home travel per transport option. The distance travelled per transport option was determined using a formula (Pearson 2009) that allowed the calculation of distance from different waypoints measured by the GPS device.

The data was then coded in terms of the out-of-home activities the participants engaged in. A coding scheme was developed using the travel diaries, the individual maps, and information from the interviews to identify participants’ activities. This allowed analysis of the data in terms of time spent outside home in specific activities.

The coding scheme then enabled the analysis of the GPS data in terms of kilometres travelled for engagement in these out-of-home activities, and the time spent in this travel. The number of trips participants undertook and their number of activity destinations were also analysed.
Limitations of the GPS data

A trip by foot in a high-density environment cannot always be clearly identified as having a start, an endpoint and a clear direction. If the GPS has connection problems the data can be very messy and the distances to be calculated cannot be precisely determined. Walking is also sometimes related to activities such as shopping or social activities, as participants browse and then leave shops. In Brisbane especially, the city centre is very dense, with opportunities for many different activities; this makes it difficult to differentiate locations and activities. However, the total time spent within this environment can be estimated, and is a useful indicator. ‘Messy’ tracks within a high-density environment were able to be defined when a participant described their activities for this time period in their diary. Comments were made in the colour coded Excel files when this occurs.

A similar situation arises if a person is active indoors; for example, at a large shopping centre. While participants might walk quite a lot, the distance cannot be estimated, as the GPS cannot connect indoors. Shopping centres are also locations where multiple activities are possible, such as visits to: hairdressers, doctors, coffee shops and food outlets, and grocery or other stores. Social and engaging activities are also possible within these centres. Thus, if a participant spent time in this environment and multiple activities were noted in their diary, the situation was defined as an unspecified activity.
in a known (multi-option) environment. An explanatory comment was made in the nodes where these activities took place.

### 3.3.2 Interview analysis

The interviews were recorded, transcribed and uploaded into NVivo9 (QSR 2010), a program for managing qualitative data. As the interviews were semi-structured, there was no catalogue of questions and answers that could be used to structure the coding. Therefore, the data was carefully read and openly coded (Neuman 2011) to develop a deeper understanding of the interview data and emerging themes. The main themes that were developed during this coding process were themes around the use of transportation, mobility and community engagement. As a result, the interviews not only provided new insights into older people’s perceptions, but also complemented the GPS data and embellished it with deeper meaning.

### 3.4 Data collection via GPS

Data collection via GPS provides real time information about position, speed and time. It is a satellite-based navigation system that was developed in the early 70s by the U.S. Department of Defence for military purposes. GPS devices record their position in longitude and latitude by triangulation of their position with 3 or more satellites. The device memory contains accurate information about the satellites’ positions and their time is synchronized.
using the Coordinated Universal Time (UTC), which is based on the International Atomic Time (TAI). GPS devices need to see the sky to get in contact with the satellites; thus, they do not work indoors and have problems in environments with many high-rise buildings (Hinch 2007; El-Rabbany 2002).

GPS tracking is increasingly used in transportation research. Early research investigating the use of GPS tracking for transportation research found it to be a promising technique for the collection of trip-chaining patterns (Yalamanchili et al. 1999) and for tracking the use of different transport options (Draijer et al. 2000). Nevertheless, problems were found in missing data (Yalamanchili et al. 1999) and in the inconvenience of using the devices; the latter created barriers to data collection, especially with respect to active transportation modes (Draijer et al. 2000). Researchers also investigated whether GPS tracking could be used to eliminate the need for travel diaries, the traditional method of trip data collection. It was found that GPS, in combination with GIS, could be a successful application (Wolf 2000; Wolf, Guensler & Bachman 2001). The development of newer GPS technologies might make this proposition even more realistic (Stopher, FitzGerald & Zhang 2008).

GPS tracking was also used to estimate whether the shortest commuting routes, which are estimated by GIS methods, are appropriate representations
of actual commuting routes (Badland et al. 2010). Participants (n = 37) were tracked for 7 days. They wore a person-based GPS unit during waking hours, and also completed a travel log. The data was mapped to represent the real trips made, and a GIS application was used to model the shortest trip. It was found that the comparability of the data was dependent on the variables used in the GIS applications. Therefore, the use of GPS real time measurements is a valuable way to develop more effective approaches to commuter modelling. However, it was also found that issues with the GPS tracking, such as reception problems due to high buildings and trees, need to be investigated in future research.

Only a small number of studies investigate older people’s travel behaviour using GPS tracking devices and GIS. The use of portable GPS devices is in its infancy (Jones et al. 2011; Frignani et al. 2010). Advanced tracking technology was used in a collaborative project undertaken by researchers from Germany and Israel (Senior Tracking – ‘SenTra’) (Shoval et al. 2008; Shoval et al. 2010; Shoval et al. 2011; Oswald et al. 2010). This research used person-based GPS to investigate differences in the distances travelled for out-of-home activity by older people with and without cognitive impairment. The GPS tracking was done in 3 waves within one year using a tracking kit that incorporated a Personal Watcher, a STaR Monitoring Unit, and a Home monitoring Unit (Shoval et al. 2008). The tracking methods were found to allow for the
assessment of out-of-home mobility dimensions and the gathering of quality data.

Frignani et al. (2010) also investigated urban travel routes and activity choices using a combination of portable GPS devices and a web-based activity travel survey as data collection methods. Half of the sample participants were aged 65 and older, and the other half were aged between 18 and 64 years. While the method was found to provide valuable data, it was considered that the commitment required of the participants was high as it was very time intensive. For that reason, it was recommended that the data collection period should not last longer than 2 weeks.

GPS units built into vehicles were used in combination with recall interviews to investigate older people’s vehicle use, and their ability to adapt to age-related changes in mobility (Hanson & Hildebrand 2011). The researchers found that the use of GPS data not only provided valuable insights into the community mobility of older people living in rural environments, but also provided valuable information about the speed, distances, and time of day of their travel. It was found to be further beneficial in minimizing the possibility of under-reporting trips, which is usually the case with travel diary surveys.

A recently published study investigated the use of GPS technology to define ‘neighbourhood’ by considering the walking behaviour of older people (n=41) living in retirement homes (Boruff, Nathan & Nijënstein 2012). Buffer
sizes, developed on the basis of GPS data, were found to represent an accurate representation of the older person’s engagement within the neighbourhood. It was found that the use of GPS devices was the strength of the study because it enabled the observation of travel data, without participants having to recall travel activities. It was also found that, while the GPS tracking could be corrupted by environmental features such as trees or tall buildings, this drawback might be overcome by the use of other technologies such as mobile phones. The researchers found that the fact that errors occurred when start and end points were automatically identified was a critical issue.

The reviewed literature shows that GPS tracking can be a beneficial method to gather real time data on older people’s travel behaviour within the community. It can prevent errors which can occur when traditional travel diaries are used. On the other hand, data collection by GPS can be corrupted by technical problems such as high-rise housing environments. Therefore, it is believed that a combination of GPS tracking and other data collection methods, such as the daily travel diary and individual interviews to discuss experiences and perceptions, is beneficial.

This research was concerned with older people’s use of transport options within the community. It was important to choose an approach to data collection that allowed participants to record private, public, and active
transport options. Thus, GPS devices inbuilt into a vehicle, as used in the study by Hanson and Hildebrand (2011), were dismissed as a suitable option for tracking in this study; rather, it was decided that autonomous (non-differential) GPS devices were considered a better choice. These devices not only allow the collection of data on all kinds of movement and transportation within the community, but are also cost-effective, do not need external power, and are lightweight and easy to use.

For this research, it was also decided to use GPS data logger which stores the recorded data on the device, rather than using the option of analogue recording and storing of the data on the internet. It was found that using devices which utilize analogue transition of data, such as live GPS tracking devices or mobile phones, can be more costly. The devices themselves, and the fees charged by mobile companies for their operation, can also be costly (Wiehe et al. 2008). Dealings with mobile companies or other service providers can also be complicated in terms of rights, ethics, and data ownership.

The use of GPS data loggers, however, also has its limitations; for example, no data can be collected in indoor environments, and participants do not have the direct benefit of using the device for messaging or telephoning, as they would if mobile phones were used for the tracking (See information on the use of the GPS device in Appendix).
3.5 Summary

This chapter discussed the methods used to collect and analyse the data used in this research. It explained how older people’s movement within the community was tracked by GPS devices and their self-documented daily travel diaries. The use of GPS tracking in other studies was also discussed, as were the reasons for its beneficial use in a qualitative mixed methods approach for this research. The specific use of person-based GPS devices was also justified.
This thesis by publication includes four articles which address the research questions and objectives established in its introduction. The articles are based on the frameworks of active ageing and mobility in older age, as explored in the literature review. All articles share the basic theme of the interrelationship of the community environment, the choice of transport option, travel behaviour, and community participation (see Figure 3).

The articles thematically and progressively develop towards answering the research questions: What impact does the community environment have on the choice of transport options in older age? And What impact do transport options have on participation within the community environment?
Each article focuses on different research objectives:

- Articles 1 and 2 explore the impact of low density suburban environments on the use of different transport options.
- Article 3 explores how transportation choices and practices influence social participation and the daily lives of older suburban residents.
- Article 4 explores the effect of suburban and urban environments on the mobility and participation of the older age group within the urban Australian context.

Each article introduces the specific research topic it investigates, introduces the data collection methods and the different measures used, and presents the study’s results. These results are then discussed in relation to the literature.
4.1 Transportation – Implications of its accessibility for older people (Article 1)

Article 1 is an initial description of the research project undertaken. It presents the first insights into the use of GPS tracking in combination with qualitative data collection, and displays the real time travel data of 13 older people living in suburban environments. The article also provides the first insights into older people’s reasons for their use and non-use of different transport options (see Figure 4). The link between transportation and active ageing is identified as a critical topic for transport policy and practice. It is also stresses that further research in this area is needed.
Statement of joint authorship and authors contributions

Article published in the conference proceedings of the Conference ERA 2012 (Making an Impact – 11th national conference of emerging researchers in ageing).

Title of the article:

Transportation – implications of accessibility for older people

The authors listed below have certified* that:

1. they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
2. they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. there are no other authors of the publication according to these criteria;
4. potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit, and
5. they agree to the use of the publication in the student’s thesis and its publication on the QUT ePrints database consistent with any limitations set by publisher requirements.

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<td>Professor Laurie Buys</td>
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<tr>
<td>Dr Rosemary Aird</td>
<td>Aided data analysis and assisted with the preparation and evaluation of the manuscript</td>
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Principal Supervisor Confirmation

I have sighted email or other correspondence from all Co-authors confirming their certifying authorship.

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Name Signature Date
4.1.1 Abstract

Objective: This research investigates older people’s use of transportation to develop strategies for age-friendly transportation within the community.

Methods: Data for this study was derived from Global Positioning System (GPS) tracking of thirteen people aged 55 years and older, together with self-report information recorded in travel diaries about daily activities undertaken outside the home over a period of seven days. Semi-structured interviews were aided by individual maps to investigate engagement in out-of-home activities and verify the recorded GPS data.

Results: Overall, participants were highly reliant on the car for daily commuting. Walking, biking and public transport options were unattractive due to environmental conditions, accessibility and usability.

Conclusion: Participation within the community and access to services is facilitated by private and public transportation. It is therefore critical to address accessibility and usability issues faced by older people to enable them to maintain their mobility, and ensure access to services, especially when driving ceases.

Keywords: older people, transportation, accessibility, age-friendly, active ageing
4.1.2 Background

In recognition of an ageing population the policy framework *Active Ageing* (World Health Organization 2002) was established to support healthy ageing. This framework promotes participation as one of three main determinants of active ageing along with health and security, and encompasses both social (recreation, socialisation, cultural, educational and spiritual activities) and civic (paid and unpaid work) involvement (World Health Organization 2007b). Research shows a high degree of variability in older people participation levels because of factors such as the range of activities in which they engage, as well as the time they spend alone and in the company of others. A report (Australian Bureau of Statistics 1999) on time-use by older people (aged 65 years and over) shows that on average, the majority of older adult time was spent on recreation/leisure, unpaid work, personal care, social participation and paid work. Although the majority of older people’s time was found to be spent with others, those living alone spent far more of their waking time alone.

Access to affordable transportation is a key to enable participation within the community (World Health Organization 2002). Findings from a number of studies that have examined driving cessation and its link to activity in later life provide some insight into the extent transportation acts as a determinant of the activity pattern of older people. Marottoli et al. (2000) for example
found a strong relationship between driving cessation and a decrease in out-of-home activities (Marottoli et al. 2000). Kim and Richardson (2006) found that older people who give up driving need alternative transport options to facilitate greater levels of out-of-home activity, especially for higher order activities (Kim & Richardson 2006). The shift from being a driver to a non-driver forces older people to rely on public or alternative forms of transport (such as taxis, family and friends) for travelling beyond walking distance. While public transport potentially allows older people the opportunity to avoid unwanted dependence on family and friends by providing an option which preserves their capacity to travel independently, research suggests that it is also fraught with problems for older age groups. Broome et al. (2009) concluded that the use of buses is an issue for a large proportion of older people, due to poor usability of and accessibility to busses. These findings are consistent with the results of an Australian study that focused on older people living in inner Sydney (Dent et al. 1999) where one third of the sample had difficulties using public transport, 29% had difficulties with both public and private transport, and 15% were deprived of any transportation.

There is currently little insight into the extent different modes of transport are related to both kilometres travelled and engagement in out-of-home activities of older people. This study uses real time travel data of older
people in combination with qualitative interviews to develop an understanding of older people’s use of transportation and therefore is able to inform strategies for age-friendly communities.

### 4.1.3 Method

The sample used for this study (n=13) was drawn from a larger sample of 49 men and women recruited to participate in an Australian Research Council Linkage project *The neglected dimension of community liveability: impact on social connectedness and active ageing*. The participants lived in low density suburbs in Brisbane (Australia). The sample comprises eight men and five women, aged between 57 and 87 years.

The data for this study was collected using lightweight GPS devices, worn by participants every time they left home, for seven consecutive days. Participants wrote travel diaries for the same timeframe, including a brief questionnaire. Semi-structured interviews were aided by individual maps (Google Earth) showing the individual movements and activities of the participant.

The GPS data and travel diaries were used to classify mode of transport. The interview data was coded and analysed in terms of participant perceptions of the transportation system. Categories were devised for each of the different modes of transport and recreational activities.
4.1.4 Results

Table 5 summarizes the daily average kilometres travelled by transport option. Commuting by car was the main transport option used during the tracking period. Nine participants (P1-P9) travelled more than 90% of the kilometre commuted by car; four of these participants (P6-P9) also walked for travel (1-6% of kilometre travelled) and two of these participants (P7, P9) used also the bus (6-7% of kilometre travelled). Two participants (P3, P4) within this group participated in recreational walking or biking, but did not travel walking or biking. Two participants did not drive themselves (P9, P10) and another two did not use a car at all (P12, P13), from which one (P13) walked everywhere. Public transport was used by five participants (P7, P9, P10, P11, and P12). While four of these five participants used public transport for 5-7% of the kilometres travelled, one participant travelled by train for 59% of kilometres travelled (P12).
Table 5 Daily average kilometres travelled by transport option and participant (low-density)

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</tr>
<tr>
<td>Car</td>
<td>Driven myself</td>
<td>35.4</td>
<td>33.7</td>
<td>66.8</td>
<td>29.4</td>
<td>16.1</td>
<td>24.1</td>
<td>18.2</td>
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<td>Someone else drove</td>
<td>1.9</td>
<td>5.2</td>
<td>1.0</td>
<td>1.0</td>
<td>13.6</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
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<td>3.3</td>
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<td>Bus</td>
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<td>0.8</td>
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<td></td>
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<td></td>
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<td></td>
<td>Ferry</td>
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<tr>
<td></td>
<td>Taxi</td>
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<td>Recreational</td>
<td>Walk</td>
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<td>0.1</td>
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<td></td>
<td></td>
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<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Bike</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Participants P9, P10, P12 and P13 had different reasons for not driving during the data collection period. P10 and P12 could not afford to have a car; P13 was temporarily not driving due to health conditions, while P9 has never had a driving license. While giving up the car appeared to have positive benefits for P10 (I love not having the responsibility), P12 and P13 experienced not driving as an unsatisfactory situation. For one of them it meant to be restricted (Well I used to drive... but now I’m grounded - P13), while the other highlighted that access to a car would give the means to again use this as the preferred mode of transport (I’ll just go in the car - P12). The non-driving participants were found to travel a far smaller distance per day than drivers
with the exception of P12, who travelled for work. Therefore, non-drivers were found to use a smaller area of their respective communities compared to participants who drove.

The participants were unlikely to use transport alternatives to the car. Environmental conditions within the study area (As long as you don’t mind walking up the hill - P7) and safety issues (I don’t really feel safe riding on the roads - P10), made the use of alternative transport options unattractive. Shared space between walkers and bikers were found to create safety issues and anger (It’s shared with pushbikes, shared with joggers; very rude people - P8). Active commuting was found exhausting and therefore impeding other activities (I object to having to sleep all the time - P1). The use of public transport, especially buses, was disliked by most participants for reasons such as longer travel time (I start walking into the city and quite often I beat the bus into the city - P13), usability (The buses aren’t made to drop down so that you could wheel the walkers up - P4), and accessibility (There is no access to buses here - P5).

4.1.5 Implications for policy and practice

Mobility of an ageing population is an urgent topic for policy development and practice. It is critical to identify the extent transportation hinders or promotes active ageing and the different modes of transport that are accessible to and used by older people. It is their connection to differences in
levels of out-of-home activity that is also vital. The negative impact of driving cessation on participation in out-of-home activities (Marottoli et al. 2000) and the difficulties of older people using public transportation (Dent et al. 1999; Broome et al. 2009) illustrate the importance of developing an inclusive, age-friendly transportation system. In order to develop effective practice outcomes, practitioners should consider the extent transportation hinders or promotes engagement in services for older people.

While mobility studies using GPS tracking exist, the real time measurement of older people commuting using GPS is still limited in gerontology. The mixed methods approach of GPS tracking, travel diaries and interviews provides therefore, an effective approach to develop a comprehensive understanding of older people’s travel behaviour. This means that service providers and policy makers can be informed by detailed and complex data of real-time transportation use and out-of-home activities of the older people. This enables barriers and facilitators of mobility in older age to be identified so as to initiate and create age-friendly communities. Retrofitting the community to be safe for walking and biking is one such example. Though this study included a small sample size and exaggerated activity levels may have been recorded, these results do provide comprehensive data and promotes the need for future research which focuses on the impact of transportation on participation in out-of-home activities.
4.1.6 Summary

Transportation is the key to facilitating opportunities for older people and to maximize their participation in out-of-home activities as a means to meet active ageing objectives. Future research is needed to explore how transportation can facilitate older people’s participation within the community.
4.2 Mobility and active ageing in suburban environments: Findings from in-depth interviews and person-based GPS tracking (Article 2)

Article 2 explores the impact of the community environment on older people’s choice of transportation (see Figure 5). It focuses on data related to 13 older people living in suburban environments. It includes data on residential character and location, the availability and use of different transport options, and the perceived positive and negative attributes of the community environment.
Statement of joint authorship and authors contributions

Article published in Current Gerontology and Geriatrics Research

Title of the article: Mobility and active ageing in suburban environments: Findings from in-depth interviews and person-based GPS tracking

The authors listed below have certified* that:

1. they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
2. they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. there are no other authors of the publication according to these criteria;
4. potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit, and
5. they agree to the use of the publication in the student’s thesis and its publication on the QUT ePrints database consistent with any limitations set by publisher requirements.

In the case of this chapter:

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<th>Statement of contribution*</th>
</tr>
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<tr>
<td>Elisabeth Zeitler</td>
<td>Chief investigator, significant contribution to the planning of the study, data collection and analysis, literature review and writing of manuscript</td>
</tr>
<tr>
<td>Signature</td>
<td>Date 25.10.2013</td>
</tr>
<tr>
<td>Professor Laurie Buys</td>
<td>Significant contribution to the planning of the study (as principal supervisor) data analysis and assisted with the preparation and evaluation of the manuscript</td>
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<tr>
<td>Dr Rosemary Aird</td>
<td>Aided data analysis and assisted with the preparation and evaluation of the manuscript</td>
</tr>
<tr>
<td>Dr. Evonne Miller</td>
<td>Aided data analysis and assisted with the preparation and evaluation of the manuscript</td>
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</table>

Principal Supervisor Confirmation

I have sighted email or other correspondence from all Co-authors confirming their certifying authorship.

__________________________  ____________________________  ______________________
Name                       Signature                       Date
4.2.1 Abstract

*Background:* Governments face a significant challenge to ensure that community environments meet the mobility needs of an ageing population. Therefore, it is critical to investigate the effect of suburban environments on the choice of transportation, and its relation to participation and active ageing. *Objective:* This research explores if and how suburban environments impact older people’s mobility and their use of different modes of transport. *Methods:* Data derived from GPS tracking, travel diaries, brief questionnaires and semi-structured interviews were gathered from thirteen people aged 56 to 87 years, living in low density suburban environments in Brisbane, Australia. *Results:* The suburban environment influenced the choice of transportation and out-of-home mobility. Both walkability and public transportation (access and usability) impact on older people’s transportation choices. Impracticality of active and public transportation within suburban environments creates car dependency in older age. *Conclusion:* Suburban environments often create barriers to mobility, which impedes older people’s engagement within their wider community and ability to actively age in place. Further research is needed to develop approaches towards age-friendly suburban environments which will encourage older people to remain active and engaged in older age.
4.2.2 Introduction

Population ageing is a global phenomenon. By 2051, it is estimated that 28% of the Australian population will be aged 65 years and older, representing a doubling of this older cohort from 2004 (Australian Bureau of Statistics 2006). Most of Australia’s ageing population (64%) reside in urban areas (Australian Bureau of Statistics 1999), characterised by a predominance of low density suburban environments (Randolph 2006). As most older Australians intend to age in place and remain living in their community as they get older (Olsberg & Winters 2005), urban planners and policymakers are focused on ensuring that the design of the urban environment meets their changing needs. Issues of health, housing, income and mobility typically dominate policy discussions, with increasing acknowledgment that the quality of life for older people depends on them being able to maintain their participation within the community in preferred out-of-home activities (Bartley & O’Neill 2010). Thus, this paper specifically investigates if and how characteristics of suburban environments might impact on older people’s mobility, transport-mode choices and participation in community activities.

Mobility, succinctly defined as ‘the fundamental physical capacity to move’ (Mollenkopf et al. 2011, p. 782), is important for active ageing. The World Health Organization’s (2002) definition of active ageing identifies participation (alongside health and security) as one of three key contributors
to quality of life in older age. Healthy and active living in older age is conceptualised as an outcome of an ageing process that allows equal opportunities and treatment for people at all stages of their life, regardless of their personal characteristics (World Health Organization 2002; Walker 2002). The community environment should enable everyone to stay active and engaged, regardless of varying needs and capacities. The built environment, which describes all aspects of the environment created and built by humans, has a central role in facilitating older people’s opportunities for health, participation and security (World Health Organization 2007b). Critically mobility is often central to enabling older people’s participation – particularly when they reside in suburban communities where the characteristics of the built environment and transport infrastructure may either enable or impede their participation in out-of-home activities.

Research has demonstrated that the built environment has an influence on quality of life and mobility, as it facilitates safe, accessible and affordable services in reasonable travel time (Alley et al. 2007). Neighbourhood characteristics such as affluence, better amenities and facilities also promotes higher levels of social activity, although social contact is unrelated (Bowling & Stafford 2007). The walkability of neighbourhoods is critical to active ageing, as it inhibits or allows the integration of physical activity into daily routines, and fosters interaction with others (Michael et al. 2006). Specific
neighbourhood characteristics (such as density, greater number of safe street intersections, and green and open spaces) have been found to positively influence walking activity in older age (Li et al. 2005). The use of public transport options is generally found to be difficult in older age because of service design and provision, vehicle accessibility, provision of information, other people, and personal mobility (Broome et al. 2010). Older drivers also change the use of their car, due to factors such as retirement, age and health as well as difficult traffic situations (Raitanen et al. 2003), and might therefore also face reduced mobility. However, while there is evidence that the environment sets the context for out-of-home mobility, it remains unclear to what extent the built environment impacts the use of different transport options in older age (Rosso et al. 2011) and thus its effects on older people’s capacity for active ageing.

The idea, that community environment affects out-of-home mobility in older age, is based on the assumption that the interplay between the individual’s competences and environmental characteristics determines the optimal function for the individual (Wahl et al. 2012; Lawton & Nahemow 1973). Webber et al.’s (2010) holistic concept demonstrates the complex relationship of individual determinants (such as cognitive, physical, psychosocial and financial), cultural determinants (gender, culture and biographical influences) and environmental determinants of mobility. This mobility model
illustrates that diverse life-space environments (such as home, outdoors, neighbourhood etc.) require the interaction of mobility determinants at different levels. A number of cross-national European studies have investigated the complex mobility issues of older people in relation to either their urban or rural environment (Mollenkopf et al. 2004; SIZE Consortium 2006). One study focussed on older people’s day to day mobility and the complex interplay of personal resources and the physical and social environment (Mollenkopf et al. 2004). It was found that health, housing, the environment and social network resources impact on older people’s out-of-home mobility (Mollenkopf et al. 2004). Further, the use of transport options differs between rural and urban environments and between nations. While walking is used most, especially in combination with services, public transportation is used little in rural settings and more in urban settings. Familiarity with an area positively influences out-of-home mobility (Mollenkopf et al. 2004). Another study focussed on the perspective of older people and experts on the current mobility situation in older age (SIZE Consortium 2006). Mobility was found to be critical to fundamental needs of daily life, walking and leisure activities. Mobility is also important to maintain a positive self-perception, especially when it allows participation in caring activities (childcare, care for other people), with being mobile also adding to quality of life itself (SIZE Consortium 2006).
In America, over half of older people live in highly car dependent suburban environments (Rosenbloom 2003), which is mainly related to the non-availability of alternative transport options and impractical walking conditions (Rosenbloom 1999a). Suburban environments create mobility constraints and difficulties in older age and adaption processes of mobility practices were found to be important to avoid having to move somewhere else (Lord & Luxembourg 2007). Driving is essential within suburban environments for active daily life and allowing independent and autonomous living (Lord et al. 2011). In order to stay in their suburban environment, older people change their daily routines (unconsciously) and with this their travel behaviour on an ongoing basis (Lord et al. 2009). This is critical as these adaption strategies often result in the reduction or fragmentation of space used within the community, which might lead to a significant loss of autonomy (Lord et al. 2011).

As the majority of older Australians live in suburban environments, it is critical for policy makers and urban planners to identify strategies to enhance out-of-home mobility in those environments. While the literature identifies the built environment as an influence on travel behaviour, the direct effect of suburban environments on older people’s travel behaviour, and consequently their mobility remains rather unclear. Thus, this current study explores how low density suburban environments impact the use of different
transport options in older age and discusses its consequences for active ageing.

4.2.3 Method

This research uses a qualitative research design. Investigating the link between active ageing, mobility, transport options and the built environment is a complex undertaking. Therefore, a range of instruments was used to collect data for an in-depth analysis exploring the effect of the community environment on older people’s travel behaviour. This paper focuses specifically on mobility aspects, with the data for the cases (n=13) including socio-demographic characteristics, residential location and character, available travel options, preferred or non-preferred built environment and real time measurement of travel behaviour. Ethical approval for this research was given by the Queensland University of Technology (QUT) Human Research Ethics Committee.

Sample

This study focuses on the experiences and travel behaviour of older Australians residing in 11 different low density suburbs across Brisbane (the state capital of Queensland), with a range of 5.05 to 27.74 people per hectare (The population experts 2012). These suburbs are typified as residential areas with lone standing family homes with yards, and pockets of business areas with shopping centres or strips with shops and facilities. The data used for
this study were collected as part of a larger project exploring active ageing and liveability in rural, regional, suburban and urban locations. This research focuses on data concerning older people residing in low density suburban environments. Industry partners cooperated by recruiting participants aged 55 years and older. As one purpose of the study was to investigate the differing perceptions and experiences of older people of various ages, the age of the sample (n=13) for this study ranges from 57 to 87 years. Table 6 illustrates participants socio-demographic characteristics, with the majority retired (only one was still working part time) and females on average were 7.75 years younger than males.

Data collection

Participants’ data were gathered in 2010 in two phases (see Figure 6), as part of a larger project with a focus on ageing and liveability in rural, regional and urban locations.
Firstly, a travel diary (including a brief questionnaire) was handed out in combination with a GPS tracking device (TransSystem Inc. 2010), to collect data on travel behaviour and out-of-home activities, over seven consecutive days. Secondly, semi-structured interviews were conducted. Those were aided by individual Google Earth maps (Google 2010a), showing activities and transport options used during the week of tracking (see Figure 7). The maps were created prior to the interviews by using the travel-diaries and the GPS data. The use of transport options was coded in different colours. The main focus of the interviews was to explore how participants conceptualised the liveability of their respective communities. All interviews were audio-recorded. A brief questionnaire in the travel diary assessed key socio-
demographic characteristics (see Table 1) and participants’ reflections about their activities. External sources were used to identify residential characteristics, such as distance to CBD (Real Estate Institute Queensland 2012), population density (The population experts 2012) and available transport within five to seven min walk (TransLink Transit Authority 2012).

Figure 7 Maps showing use of transportation by one participant

**Measures: Residential location and character, available travel options**

Distance to CBD and public transport was represented in kilometres and population density as people per hectare. Participants were asked during their respective interviews what they would do if they could not drive anymore or if they could not maintain the way they currently move around when travelling outside of home. Five categories were developed from participants’ responses to this question, namely: *Would need to re-locate elsewhere*; *Could stay with help from family*; *Could stay by changing current transport mode*; *Could stay by using local services* and *Not thought about*. 
Measures: Preferred or non-preferred aspects of the built environment

In the questionnaire, participants were asked questions about their local community: why they live here, whether they liked it and how long they thought they could live there. A thematic analysis of the interview transcripts explored in depth participants preferred and non-preferred aspects of their community, focusing on built environment characteristics, transport options, land use, and design (see Table 2).

Measures: Travel behaviour

Data on participants’ travel behaviour was collected using GPS tracking and a questionnaire (see Table 3) with participants asked *how do you get around?* (Options: I walk; I use a bicycle; I drive myself with a car, motorcycle, motored wheelchair, mobility scooter; Someone else drives me: my partner, my children/grandchildren, community members, social or senior services; I use public transport: bus, train, taxi, ferry; I would like to use public transport but: It is not available in our community, It doesn’t go where I need it to go, It is too far away from my home, It is too expensive, I do not feel safe, It is too hard to use). The maps, the travel diary and interview responses were also used to code the GPS data. Two main categories emerged: travel by transportation (by car as driver, by car as passenger, bus, train, walking, cycling, and ferry); and out-of-home activities, which were classified as daily life activities (e.g.,
shopping, health) and social activities (e.g., meeting friends, volunteering). This article focuses on the data about travel by transportation.

Data analysis

Researchers assigned each participant a unique code number. Each individual’s GPS data were analysed to determine the distance travelled per mode of transport used (in kilometres), and the destinations reached (representing activities). All interview audio-tapes were transcribed verbatim. The text of the transcripts was manually coded for relevance to preferred and non-preferred aspects of the built environment and its components (transport options land use, and design). All measures were grouped by participant and the amount of car use for transportation (100% car, 90-99% car, 75-77% car and 0% car). These groups were compared to each other in order to assess whether demographic characteristics, residential location and character, as well as preferred and non-preferred features of the built environment influence travel behaviour.

4.2.4 Results

Demographic characteristics, residential location and character, and travel options

Multiple factors, such as socio-demographic characteristics, residential location and character and available travel options, might influence mobility (see Table 6). In this research, the car was the predominant transport choice;
five older people drove by car for all trips made during the monitored week and four used the car for between 90-99% of their transportation. People within these two groups were, on average, older than people who drove 75-77% of the distance, or not at all. Of the thirteen participants, seven were married and one widowed, all eight travelled 90-99% and 100% by car.

Table 6 Demographic characteristics, residential character and location

<table>
<thead>
<tr>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
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<td>P2</td>
<td>P3</td>
<td>P4</td>
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<td>80</td>
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<td>x</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
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<td>x</td>
<td>x</td>
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<tr>
<td></td>
<td>Widowed</td>
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<td></td>
<td>Not married</td>
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<td>x</td>
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<td></td>
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<td>x</td>
<td>x</td>
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<td></td>
<td>$20k-$40k</td>
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<td>x</td>
<td></td>
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<td></td>
<td>$40k-$50k</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ $70k-$100k</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Residential character and location</td>
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</tr>
<tr>
<td>Approx distance to CBD (in kilometres)</td>
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<td>19.0</td>
<td>8.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Density (People per hectare)</td>
<td>13.7</td>
<td>5.1</td>
<td>21.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Available transport</td>
<td>Car</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Service frequency</td>
<td>Quarter-hourly</td>
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<td>x</td>
<td>x</td>
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<td></td>
<td>Half-hourly</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Hourly</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Peak time more frequent</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Suitability of location for ageing in place</td>
<td>Would need to re-locate</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Could stay with help from family</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td></td>
<td>Could stay by changing current transport mode</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Could stay by using local services</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Not thought about</td>
<td></td>
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</table>
The character and location of participants’ residential areas varied considerably (see Table 6). Seven participants lived less than ten kilometres and six lived ten to twenty kilometres from the CBD. Most people had access to a car and public transport within a five to seven minute walk. However, the frequency of available transportation options varied widely. People living closer to the CBD tended to have a more frequent bus service than those living further away. While only four participants had access to quarter-hourly services (three of these lived within six kilometres of the CBD), nine participants had access to only half-hourly or less frequent bus services. Services were more frequent during peak hours for three participants in this group. The frequency of services was generally lower for people that drove 100% of kilometres by car.

Participants’ perceptions of the suitability of their environment to allow them to age in their present location also varied across the sample. Out of the nine participants who drove 90-99% or 100% by car, five stated that they would have to re-locate if their physical mobility declined. In the whole sample of thirteen participants four said that they would need to change their current transportation mode, while two said they could remain in their current location with the help of family and friends.
Preferred and non-preferred features of the built environment

Features of the built environment, preferred and non-preferred, also have an impact on liveability and travel behaviour (see Table 7). Participants described proximity to family and friends being significant to where they lived: ‘But that is an important part of where we live, is having reasonable access to your kids.’ (P12). Proximity to shops and services was also most commonly cited reasons for living within the current environment: ‘We always said as we got older we would be going back to the city, where you have got the services.’ (P6).

Most participants said they would like to live in their community as long as they were able to live independently. All those participants who stated in the interview that they would have to move away from their current neighbourhood when their physical mobility declined used the car for 90-99% or 100% of their travel. One participant highlighted at interview: ‘When our mobility slows down to a point where perhaps we can’t drive, that might be just about the time [to move].’ (P2)
Most people either loved their community or found it ok to live there, although one participant stated he hated where he lived (see Table 7).

Participants who drove everywhere by car were more likely to state that where they live is ok while most participants who used the car for 90-99% of all distance travelled stated that they loved where they lived. The main

### Table 7 Preferred and non preferred features of built environment

<table>
<thead>
<tr>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant</td>
<td>P1</td>
<td>P2</td>
<td>P3</td>
<td>P4</td>
</tr>
<tr>
<td>Reasons for living in the community</td>
<td>P5</td>
<td>P6</td>
<td>P7</td>
<td>P8</td>
</tr>
<tr>
<td>Affordability</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Proximity</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>Preferred features of built environment</td>
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<td>Wide streets</td>
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<td>Design public transport</td>
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</table>

Most people either loved their community or found it ok to live there, although one participant stated he hated where he lived (see Table 7). Participants who drove everywhere by car were more likely to state that where they live is ok while most participants who used the car for 90-99% of all distance travelled stated that they loved where they lived. The main
preferred aspects of the built environment by the participants included proximity, ambience, and access to public transport. Statements at interview related to these factors include: ‘So it’s all sort of within reach and it’s nice.’ (P10) and ‘You can get a bus anywhere over there.’ (P9)

However, most of the non-preferred features within their current environments were related to transportation (access to public transport, bikeability and walkability). Safety was a main issue that deterred participants from using active transportation, with participants describing how limited sidewalks and the speed of pedestrian lights limited their mobility: ‘People can’t actually step off the road with safe access - On both sides of the road in some sections.’ (P7) and ‘There are lights on the corner with a pedestrian crossing, I tried to get across as fast as I can and I can’t get across in one change of the lights.’ (P8). Brisbane’s hilly environment and the lack of well-maintained footpaths or bikeways were also perceived as key barriers to active commuting within the community. Participants explained how ‘I would do a lot more walking if I could walk uphill and downhill.’ (P6), ‘To get on the bikeways, you’ve still got to ride on roads.’ (P3) and ‘You might see some scrapings along on the footpath - and people could trip up.’ (P13)

Access to public transport was a topic raised mainly by people who drove the majority (90-100%) of their total travel distance. Some of these participants reported having good public transport services within their
environment, describing how ‘We are quite fortunate in that the bus goes past us either way, almost on a half-hourly basis.’ (P2) Within the same group, however, there were also participants who stated that public transport was not accessible where they lived: ‘You can see why I push for a bus three/four times a week. There will come a time where I cannot drive anymore. How do I get to the shopping centre?’ (P5)

While affordability was one reason participants gave for living in their current environment, across all groups, proximity (to services, the city, friends and family) was the main reason given by older residents who drove for the majority (more than 90%) of the distance that they travelled during the monitored week.

**Modes of transport used and distance travelled for out-of-home activities**

The transportation system and built environmental features also had an impact on travel behaviour (see Table 8). Most participants stated that they would use the car, walk and take the bus. Only a small number within the sample ever used a bicycle, train or ferry. However, about half of participants reported that they would like to take public transport but that it was either too far from home or would not take them where they wished to go (or both in the case of one participant, see Table 8). One person identified busses as being overcrowded and services being too infrequent.
While the questionnaire data suggested that people use different forms of transport, the GPS tracking over the monitored week shows that the car was used for the majority of distance travelled by all but two participants. These two people did not drive at all, while the other participants travelled by car for between 75% and 100% of all distance between home and their various destinations. Participants, for whom the car accounted for 100% of the distance travelled over seven days, had travelled on average 27.3 kilometres further than the rest of the retired participants.

Engagement in active transportation modes such as walking and biking varied widely within the sample. Eight people engaged in active transportation. Five of them walked 1-4% of their total distances, one walked 5% and biked 8% of the total distance tracked, one walked everywhere and another one was working part-time and combined train (60% of kilometres travelled) and bike (40% of kilometres travelled), mostly for work related travel. This particular participant travelled by bike as many kilometres as other participants did by car and overall, travelled the second greatest distance of the entire sample. The participant who walked 100% stated that he would usually drive a car himself but could not drive temporarily due to health issues.
Table 8 Travel behaviour and daily average distance travelled by mode of transport

<table>
<thead>
<tr>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
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<td>P1</td>
<td>P2</td>
<td>P3</td>
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<td>Walk</td>
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<td>Car</td>
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<td>Drive myself</td>
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<td>Reasons not to use public transport</td>
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<td>Unavailability of routes to preferred destinations</td>
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<td>Transit depot too far from home</td>
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<td>Overcrowded and infrequent</td>
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<td>Daily average distance travelled per mode of transport (kilometres)</td>
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<tr>
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<tr>
<td>Drive myself</td>
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<td>33.7</td>
<td>66.8</td>
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<td>Bike</td>
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The GPS data showed that only five of the thirteen participants used public transport and that the extent of usage varied. Distance to CBD and frequency of services seem to influence its usage. Public transport was used by three participants, living 9 to 10 kilometres away from CBD, for 5% to 6% of the distance travelled. Only one of them had a quarter-hourly bus service available. Another participant, with a quarter-hourly bus service available, lived closer to the CBD and was using public transport for up to 18% of her travel.
Trips were generally made between 7 am and 9 pm. Only four people engaged in recreational walking or cycling activities during the tracked week.

### 4.2.5 Discussion

This research provides some significant insights into the impact of the suburban environment on the use of different transport options in older age. The qualitative study has provided a snapshot of travel behaviour of thirteen older people, gained by a combination of qualitative interviews, travel diaries and unique person based GPS observation of a week’s travel. Combined, the findings highlight how suburban environments in Brisbane influence older people’s travel behaviour.

Three key findings warrant specific attention. Firstly, low density suburban environments are impractical for walking or biking for older people. Factors such as lack of footpaths or bikeways and the hilly environment create difficulties for older people wanting to use these forms of transportation. Consistent with previous research (e.g. Michael et al. 2006) our findings also suggest that suburban designs discourage older people from incorporating physical activity into their daily lives. This raises two critical aspects in relation to active ageing: the importance for physical activity in older age for health and the engagement in social encounters within the community (Michael et al. 2006). People that walk or bike might be more engaged in their
community, because the act of walking within the local community helps to foster an appreciation of it (Michael et al. 2006; Alley et al. 2007). This finding lends support for Alley et al.’s (2007) proposition that the creation of safe walking and biking environments has the capacity to enhance quality of life in older age not only by encouraging physical activity but by also facilitating engagement with and appreciation of one’s local community.

Secondly, low density suburban environments often tend to make the use of public transportation impractical. Our findings show that most participants (across eleven suburbs) had access to public transport within a walking time of 5 to 7 minutes, but only a small number used public transport. Even though the distance between home and bus stops might be walkable, the quality of the pedestrian infrastructure might be discouraging older people from using public transport (Broome et al. 2010). If the street environment does not support walking to and from public transport, it is likely to impede its use by older people. Infrequent or low frequency scheduling might also be an impact factor on the non use by older people (Broome et al. 2010). Our findings suggest that policy makers and transportation planners promoting active ageing might want to increase the use of public transportation by older people. This is critical as public transportation allows car-independent transportation within the wider community. Strategies need to be developed to encourage the use of public transportation by provision of a reasonable
frequency of transportation throughout the day and a pedestrian friendly infrastructure at all stages of the journey between home, transit nodes and destinations as well.

Thirdly, this research highlights that low density environments are likely to create car dependency in older age. This is not a problem as long as the older people can drive. But, the car is not a sustainable transport option (Rosenbloom 2001) – as our older participants themselves acknowledged. However, it is unlikely that older people begin to use public transport when they retire, especially if they never used public transport before (Rosenbloom 2009). The results of this study show that suburban environments put ageing in place at risk if driving is not longer an option. Interestingly, Lord (Lord et al. 2009) found that older people change their lifestyle in order to remain in their communities as they age. Consequently, this adaption process also results in a change of travel behaviour and the reduction and fragmentation of the action space within the community (Lord & Després 2011). This has implications for active ageing, as the reduced mobility could lead to reduced participation within the community. Retrofitting neighbourhoods is, in combination with a range of policy and program development, a possible way to reduce mobility lost for older people that are ageing in place (Rosenbloom 2009). While on one hand the aim should be to make suburban
environments less car dependent, it also would mean keeping older people driving safely as long as possible.

Finally, this is a qualitative study with a small sample size conducted in Brisbane in Australia, which necessarily precludes its findings being generalised to older people living in other suburban contexts. It needs also to be acknowledged that the combination of Brisbane’s subtropical climate and its hilly topography might make the use of active and public transportation more difficult in certain locations and at certain times of the year (e.g. the humidity and storms at heat of summer). The way GPS data was prepared and analysed in this research is likely to be infeasible for use among large samples. Still, the collection from different data sources allowed the researchers to capture the effect suburban environments can have on the use of transport options in older age. Given the nature of the findings, they are also likely to be relevant to suburban environments elsewhere. Of course, much more research (with larger, more diverse samples in different contexts) is needed to better understand the design characteristics of age-friendly environments, and the relationship between mobility and activity within the suburban environment.
4.2.6 Conclusion

Active ageing is a concept that encompasses preventive health, social participation and overall wellbeing during the ageing process. Our findings suggest that environments that support active transportation modes not only allow older people opportunities for maximising their physical activity but also their use of public transportation and, in turn, their engagement within the wider community. Governments need to prioritise forms of urban development that create the conditions whereby older people are able to walk and bike safely and gain easy access to public transport. However, as older people might potentially be physically able to drive a car longer than they are able to use active and public transportation, the environment also needs to facilitate safe transportation by car in older age. Given that Australia’s population is ageing, and that out-of-home mobility is critical to active ageing within the community, there is an urgent need for further attention to be paid to the impact of built environment characteristics and available transport options to encourage older people’s mobility. This is critical for policymakers and planners to be better informed about the development of tailored strategies that will help ensure that people can remain active and engaged within the community as they age.
4.3 Mobility and out-of-home activities of older people living in suburban environments: Because I’m a driver, I don’t have a problem (Article 3)

Article 3 explores the impact of the use of transport options on older people’s (n=13) out-of-home activities within the suburban environment (See Figure 8). It analyses the GPS data to investigate kilometres travelled for different categories of out-of-home activities. It then links this analysis with findings from the interviews which indicate the reasons why participants travelled more kilometres for social or daily life activities. It also investigates the GPS data to identify the amount of time spent in activities in different categories, and uses the interviews to investigate the role of transportation in facilitating those activities.
Statement of joint authorship and authors contributions

Revised and resubmitted to Ageing & Society in August 2013

Title of the article:

Mobility and out-of-home activities of older people living in suburban environments: Because I’m a driver, I don’t have a problem

The authors listed below have certified* that:

1. they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
2. they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. there are no other authors of the publication according to these criteria;
4. potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit, and
5. they agree to the use of the publication in the student’s thesis and its publication on the QUT ePrints database consistent with any limitations set by publisher requirements.

In the case of this chapter:

Zeitler, E. & Buys, L., Mobility and out-of-home activities of older people living in suburban environments: Because I’m a driver, I don’t have a problem
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<td>Elisabeth Zeitler</td>
<td>Chief investigator, significant contribution to the planning of the study, data collection and analysis, literature review and writing of manuscript</td>
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<td>Date 25.10.2013</td>
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<tr>
<td>Professor Laurie Buys</td>
<td>Significant contribution to the planning of the study (as principal supervisor) data analysis and assisted with the preparation and evaluation of the manuscript</td>
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Principal Supervisor Confirmation

I have sighted email or other correspondence from all Co-authors confirming their certifying authorship.

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Name                   Signature            Date
4.3.1 Abstract

Background: Governments are challenged by the need to ensure that ageing populations stay active and engaged as they age. Therefore, it is critical to investigate the role of mobility in older people’s engagement in out-of-home activities, and to identify the experiences they have within their communities. Objective: This research investigates the use of transportation by older people and its implications for their out-of-home activities within suburban environments. Methods: The qualitative, mixed method approach employs data collection methods which include a daily travel diary (including a questionnaire), GPS tracking and semi-structured interviews with older people living in suburban environments in Brisbane, Australia. Results: Results show that older people are mobile throughout the city, and their car provides them with that opportunity to access desired destinations. This ability to drive allows older people to live independently and to assist others who do not drive, particularly where transport alternatives are not as accessible. The ability to transport goods and other people is a significant advantage of the private car over other transport options. Conclusion: People with no access to private transportation who live in low density environments are disadvantaged when it comes to participation within the community. Further research is needed to better understand the relationship between transportation and participation within the community.
environment, to assist policy makers and city and transportation planners to develop strategies for age-friendly environments within the community.

*KEYWORDS:* mobility, older people, out-of-home activity, participation, Global Positioning System (GPS)
4.3.2 Introduction

One of the key issues of the 21st century is how best to manage the challenges and opportunities associated with rapidly ageing populations. In Australia, for example, the proportion of people aged 65 years and older will more than double from 2004 (13%) to 2051 (26-28%) (Australian Bureau of Statistics 2006).

The majority of Australia’s older population live in urban settings (Commonwealth of Australia 2010), characterised by a predominance of suburban areas (Randolph 2006); these low density environments can create mobility issues in older age, and can lead to a decline in participation in out-of-home activities (Lord et al. 2011; Lord et al. 2009). This engagement in out-of-home activities is critical for active ageing; indeed, the World Health Organization (2002) includes participation (along with health and security) as one of three key contributors to good quality of life in older age.

Since older Australians want to be able to ‘age in place’ (Olsberg & Winters 2005), it is significant that policy makers and transportation planners make informed decisions about more age-friendly environments to enable older people to stay engaged and active in their communities (World Health Organization 2007b). Consequently, this paper specifically investigates the travel behaviour and out-of-home participation of older people, and their experiences within their suburban environments.
Mobility, defined as *the ability to move* (Mollenkopf et al. 2011, p. 782) is crucial to enabling older people’s independence and everyday participation in the community, and remains crucial throughout their later life (Mollenkopf et al. 2011).

As mobility is a multifaceted concept, Webber, Porter and Menec (2010) propose a framework that visualises determinants for mobility in older age within different life-spaces relevant to older people. Mobility within those life-spaces depends on a complex relationship of individual determinants (cognitive, physical, psychosocial and financial), cultural determinants (gender, culture and biographical influences) and environmental determinants. Together, these determinants create increasing requirements for independent mobility, the further a person moves from home.

Mobility is a common human experience that impacts on quality of life (Metz 2000; Musselwhite & Haddad 2010). Metz (Metz 2000) argues that the benefits of mobility in older age are not taken into account in transportation research, and that there is still a need to further establish this relationship between mobility and quality of life. Therefore, five key elements are proposed to articulate the quality of mobility as a human experience: travel to achieve access to desired people and places, psychological benefits of movement, exercise benefits, involvement in local community, and potential travel (Metz 2000).
Musselwhite and Haddad (2010) similarly developed a hierarchy of mobility needs based on a qualitative study of travel needs and quality of life of older people and their association with giving up driving. They found that mobility is essential to access shops and services, and that mobility needs can be categorized as utilitarian needs (primary needs derived from demand and accessibility); affective needs (secondary needs related to control and independence); and aesthetic needs (tertiary needs such as the need to enjoy the journey).

Low mobility might be an undesired effect of ageing, which reduces participation in out-of-home activities which, in turn, might also decrease quality of life. Banister and Bowling (2004) describe a British survey which focused on three aspects of the travel patterns of older people in relation to quality of life: mobility pattern (ability to get out and about), locality of participation (accessibility and proximity), and social networks (relatives and friends, and neighbourhood networks). While the engagement in out-of-home activities and the availability of a car varied widely, the authors established the clear links between the quality of the local area and quality of life in older age. These links are: availability, safety, trust, engagement and vulnerability, and isolation.

Transportation, which is increasingly provided by the private car, is an important factor in mobility as it provides access to local services, facilities
and social engagement. Older people have generally a positive view of their locality. Walkability of a local area was found to be essential to access destinations of activity and public transportation. Perceptions of safety and risk at night time can lead to less activity and a higher risk of loneliness and isolation after dark.

Activity and travel patterns of different groups of older people living in Scandinavia were investigated with a focus on the development of travel and activity patterns during a lifetime (Hjorthol et al. 2010). This investigation found that the number of driver’s licence-holders and car availability increased (especially for women), and that these factors affected the choice of travel mode and distance travelled.

Older people today travel greater distances compared to older people 25 years ago; this results in a higher possibility of engaging in activities outside the home and maintaining shopping and leisure trips until an older age (Hjorthol et al. 2010); however, to date, research on car use in older age is primarily focussed on driving experience (Peel, Westmoreland & Steinberg 2002); license guidelines (Langford et al. 2004); and the predictors, process and impact of driving cessation (Adler & Rottunda 2006; McCray & Brais 2007).

While the vast majority of older adults rely predominantly on their own private vehicles for transportation (Rosenbloom 2001), it was found that
older age and female is related to the higher possibility of being a non-driver (Ross et al. 2009). Driving becomes more physically and mentally challenging as people age; this may explain why many older drivers choose to stop or restrict their driving (by driving only in the daytime, and avoiding busy traffic or rain) (Charlton et al. 2006). Thus, changes to mobility behaviours might be a process of selection, optimisation, and compensation adaption, which results in withdrawal of activities and mobility habits such as driving (Rush, Watts & Stanbury 2011). However, these adaption processes in mobility behaviours can have a negative impact on the quality of life of older people.

The meaning and implications of reduced mobility because of driving cessation in terms of out-of-home activities has been the subject of some studies; for example, in the USA, driving cessation not only had a negative impact on engagement in out-of-home mobility (Marottoli et al. 2000), but was also linked to an increased risk of depressive symptoms (Marottoli et al. 1997; Ragland et al. 2005).

The transition to life as a non-driver can be particularly difficult for older adults residing in car-dependent rural and low-density suburban areas, where alternative transportation options (such as public transport services) are less available or inaccessible. Research also shows that only a few older
people actually prepare for a stage in their life when they can no longer drive (Charlton et al. 2006).

A Canadian study in suburban environments found that the desire to ‘age in place’ leads to coping strategies which include a decrease in mobility and participation in out-of-home activities (Lord et al. 2009). Immobility was also found to be inevitable for older people living in suburban environments, and can lead to dependency on others in order to stay active within their community (Lord et al. 2011).

Several key individual and structural factors which impede community participation and the use of alternative transport options for non-drivers are identified. Individual barriers include limited income (McCray & Brais 2007), declining health (Broome et al. 2009), and the psychological difficulty associated with changing lifelong travel habits (Rosenbloom 2009). Structural barriers, on the other hand, include neighbourhood characteristics that constrain active transport (such as walking), as well as inadequacies of the public transportation system itself. The latter is frequently criticised for not being affordable, flexible, convenient or accessible for users of all ages, but especially for older people (Broome et al. 2009).

A growing number of studies have explored the extent to which mobility facilitates social participation and active ageing; however, few have used global positioning system (GPS) and Geographic Information System (GIS)
technologies to track and map older adult travel patterns and social activities. GIS has been used to model neighbourhood characteristics (Li et al. 2005) and travel demand (Maoh et al. 2009), while data yielded from portable GPS devices worn by older people is in its infancy (Jones et al. 2011; Frignani et al. 2010).

A collaborative project ‘Senior Tracking’ (SenTra) involving researchers from Germany and Israel (Shoval et al. 2008; Shoval et al. 2010; Oswald et al. 2010) used person-based GPS to investigate differences in distances of home to outdoor activities between older people with and without cognitive impairment. A sample of 41 people, 64 years and older, was used for this purpose; the sample comprised individuals with mild cognitive impairment (n=21), mild dementia (n=7), and those with no cognitive impairment (n=13). Participants were tracked day and night over 28 days. The results show that those with mild dementia and those with mild cognitive impairment spent less time in out-of-home activities and more time close to their residences than the healthy control group (Shoval et al. 2011).

Person-based GPS provides a new frontier for researching older people’s spatial activity, destinations, and travel patterns. It is for this reason that the study presented in this paper used daily travel diaries (and a questionnaire), person-based GPS units and in-depth interviews to explore the mobility and engagement of older people living in suburban environments within
Brisbane, Australian. The key aim of the study is to identify how transportation choices and practices influence social participation and the daily lives of older suburban residents.

4.3.3 Method

Investigating the travel behaviour of older people and its relationship to community participation, experiences and activities is a complex undertaking. This research, therefore, uses qualitative design methods that incorporate a range of data collection methods – such as travel diaries (with a questionnaire), GPS tracking, and in-depth interviews – to explore travel behaviour and perceptions of community liveability and active ageing. Ethical approval for this research was provided by the Queensland University of Technology (QUT) Human Research Ethics Committee.

Location

Brisbane and South East Queensland are the fastest growing regions in Australia. In 2011 the local government area (LGA) of Brisbane was home to 1,089,743 residents living on 1,326 square kilometres, with a population density of 6.76 people per hectare (The population experts 2012). About 21.7% of Brisbane’s population is older than 55 years (Australian Bureau of Statistics 2010). Brisbane can be described as a dispersed city, where suburbs are typified by low density single-standing family homes with yards. Typically also, the suburbs contain pockets of business areas, shopping
centres, or street strips with shops and facilities. The central business district (CBD) and its surrounding suburbs are of higher density.

**Participants**

Participants (55 years and older) were either participants from a previous study who had agreed to be contacted for further research, or were provided by senior organisations which were industry partners in this research. This research focuses on a sample (n=13) of five women and eight men (see Table 9 for demographic characteristics), living in 11 different low-density suburbs within Brisbane (Capital city of Queensland, Australia), with a range of 5.05 to 27.74 people per hectare (The population experts 2012). This study used convenience sampling and therefore is not representative of older people living in suburban environments in Brisbane.

Participants ranged in age between 57 years (P10) and 87 years (P9) (see Table 9). The annual income of participants varied considerably: n= 4, under $20 000; n = 4, $20-40 000; n = 2, $40-50 000; and n =3, $70-100 000. Participants lived either with their partner, family members, other people, or alone: n = 7, married or living with a partner; n = 2, living with family members or other people; and n = 4, living alone. All participants but one (P12) were retired.
Table 9: Demographic characteristics of suburban participants

<table>
<thead>
<tr>
<th>Participants per car use (percentage of distance travelled)</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Demographics**

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
<th>P9</th>
<th>P10</th>
<th>P11</th>
<th>P12</th>
<th>P13</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td>65</td>
<td>71</td>
<td>75</td>
<td>80</td>
<td>84</td>
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<td>63</td>
<td>80</td>
<td>87</td>
<td>57</td>
<td>72</td>
<td>67</td>
<td>69</td>
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<tr>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
</tr>
<tr>
<td></td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
</tr>
<tr>
<td></td>
<td>Not married</td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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</tr>
<tr>
<td><strong>Living arrangements</strong></td>
<td>Living with spouse</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Living alone</td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Living with family</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>Living with friends/other people</td>
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<tr>
<td><strong>Paid work</strong></td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Part-time</td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td><strong>Annual income</strong></td>
<td>Under $20k</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>$20k-$40k</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
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</tr>
<tr>
<td></td>
<td>≥ $70k-$100k</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

**Data collection**

Data collection took place from March to April 2010 and was organised in two phases. Firstly, participant out-of-home movement was tracked using GPS in combination with daily travel diaries. Participants received a package with an information sheet and consent form, travel diary (including a brief questionnaire), a lightweight portable GPS device (Blue747A+ and recharger), and a manual explaining how to use the device.

Participants were asked to complete a questionnaire on demographic characteristics, housing, transportation use and community living. They were
also asked to complete the travel diary at a time of their convenience, describing details of their travel: the location, time of departure and arrival, transport option used, and activity undertaken. They were asked to carry the GPS device for seven consecutive days whenever they left the home.

Interrviews were conducted in the second phase, about 14 days after the tracking period. Prior to the interviews, GPS data was converted into Google Earth (Google 2010a) maps and an interview guide was developed for each participant. The travel diaries identified the transport options used, and the out-of-home activities undertaken by the participants. These were then mapped to produce individual participant maps (see Figure 9). The individual Google earth maps displayed the transport methods used in different colours, and the destinations were represented by place marks. The individual Google earth maps were used in discussions with participants about their own travel behaviour and their perceptions of mobility within the community. They were also used to verify the data.

Figure 9 Maps of a participant’s transportation usage
The Age Friendly City Guide (World Health Organization 2007b) provided the basis for the research interviews. Its main themes are: safety, affordability, availability, accessibility and walkability. Three community domains were addressed including: people, facilities/activities, and the built environment.

**Data analysis**

Participant GPS data was coded individually and referenced to the travel diaries and interview responses. Data from the travel diaries was used to develop categories for mode of transportation and activity type. Participant GPS data was coded individually, with time spent outside home categorised according to activity type. Subcategories were also developed. These included: average daily kilometres travelled by *car* (total average kilometres, percentage as driver, percentage as passenger, percentage unspecified); *public transport* (bus, ferry, taxi, train); and *active transport* (walking and cycling, but excluding kilometres travelled for recreational walking and cycling). The GPS data was also analysed for average daily kilometres travelled for various activities, including: *social* (socialising, assisting, volunteering, worship, education, and leisure); *daily life* (shopping, services, and health); *recreational* (commuting to recreational activities, and kilometres spent in walking/cycling); *work*; and *unspecified* activities.
Analysis of time spent for activities, included the categories of: social (socialising, assisting, volunteering, worship, education, and leisure); daily life (shopping, services, and health); recreational (commuting to recreational activities, and walking/cycling); work; unspecified activities; and commuting. Time spent commuting (by driving a car or being a passenger in a car; travelling by bus, ferry, taxi, train; and waiting for public transport) included all time spent commuting by all transport options, for all activities.

The number of trips made and destinations reached were determined. Trips were defined as any travelling with leaving home as the starting point and getting home as the end point of the trip. When participants accessed more than one destination, this was defined as a ‘trip-chain’. Trip-chains commonly involved multiple destinations of different activity categories (for example, social and daily life) and sometimes also the use of different transport modes (for example, walking to bus stop; taking bus to city; passenger with a neighbour to return home). Kilometres and minutes travelled to each destination within the trip-chain were assigned to the activity category in which the participant engaged. Data was sorted into four groups for comparison to represent the percentage travelled by car: 100%, 90-99%, 70-75% and 0%. All interview audiotapes were transcribed verbatim, with the text imported into NVivo 9 (QSR 2010), and thematically analysed for relevance to out-of-home activities and transportation.
4.3.4 Results

Driving status and use of transportation

The data shows that participants were very dependent on the car as their main transport option (Table 10). All but two participants (P12 and P13) travelled most of their kilometres by car, either as a driver or passenger (Table 10). Three participants (P9, P10, and P12) did not own a car; two for financial reasons (P10, P12), and one had never driven (P9). One participant had a licence and owned a car, but was restricted from driving due to health conditions (P13).

The average kilometres travelled per day varied widely; however, participants who used their car for 100% of the kilometres travelled were more likely to travel more kilometres than the other participants. Public transportation was the second most used transport option for four participants (P7, P9, P11, P12), and was only used by these to travel into the inner city. Only two of these participants used public transportation for a larger portion of their kilometres travelled (P11 – 24%, P12 – 59%). Active transportation was used mostly for small distances only; however, P10, P12 and P13 were exceptions to this general trend: P10 walked for 15% of their kilometres travelled; P13 walked for 100% of their kilometres travelled; and P12 combined cycling and public transportation for 41% of kilometres travelled.
### Table 10 Driving status, use of transportation, and numbers of trips and destinations

<table>
<thead>
<tr>
<th>% of kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>P1</td>
<td>P2</td>
<td>P3</td>
<td>P4</td>
</tr>
<tr>
<td>Driving licence and car ownership</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving licence holder</td>
<td>yes</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Owns private car</td>
<td>yes</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average daily kilometres travelled by transport option</th>
<th>37.3</th>
<th>41.1</th>
<th>66.8</th>
<th>33.7</th>
<th>16.1</th>
<th>24.1</th>
<th>18.4</th>
<th>7.8</th>
<th>13.6</th>
<th>8.7</th>
<th>9.5</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>Percentage as driver</td>
<td>99%</td>
<td>82%</td>
<td>100%</td>
<td>87%</td>
<td>100%</td>
<td>87%</td>
<td>87%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Percentage as passenger</td>
<td>6%</td>
<td>13%</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td></td>
<td>Percentage unspecified</td>
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<td>5%</td>
<td>0%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>Public Transport</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.2</td>
<td>0</td>
<td>0.8</td>
<td>0.8</td>
<td>3</td>
<td>36.4</td>
<td>0</td>
</tr>
<tr>
<td>Active</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
<td>1.6</td>
<td>0.2</td>
<td>24.8</td>
<td>6.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLM daily average kilometres travelled by transport option</td>
<td>37.3</td>
<td>41.1</td>
<td>66.8</td>
<td>33.7</td>
<td>16.1</td>
<td>24.2</td>
<td>19.8</td>
<td>8.1</td>
<td>14.6</td>
<td>11.1</td>
<td>12.7</td>
<td>61.2</td>
<td>6.3</td>
</tr>
</tbody>
</table>

| Daily average number of trips | Non recreational trips | 1.4 | 1.6 | 1.1 | 0.7 | 1.5 | 2 | 1.6 | 1.5 | 1.2 | 1.4 | 0.8 | 1 | 1.7 |
|                              | Recreational trips (e.g. walking dog) | 0.1 | 0.9 |     |     |     |   |     |     |     |     | 1.7 | 1.1 |

| Daily average number of destinations reached | Social activities | 0.6 | 1 | 1.3 | 1.1 | 0.5 | 2 | 1.6 | 0.7 | 0.8 | 0.7 | 0.1 | 0.3 | 0.4 |
|                                             | Daily life activities | 1.4 | 1.3 | 0.6 | 1.9 | 0.9 | 1.7 | 2.3 | 1.7 | 0.5 | 1 | 1.1 | 0.2 | 1.6 |
|                                             | Work |     |     |     |     |     |     |     |     |     |     |     |     | 0.8 |
|                                             | Unspecified activities | 0.4 | 0.3 | 0.3 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 |     |     |     |     | 0.1 |
| SLM daily average number of destinations reached | 2 | 2.7 | 1.9 | 3.3 | 1.7 | 4.2 | 3.9 | 2.4 | 1.5 | 1.8 | 1.3 | 1.3 | 2.1 |

All participants engaged in trip-chaining, which explains the higher number of non-recreational trips made, compared to the number of destinations reached (Table 10). All but two participants (P4 and P11) made at least one non-recreational trip per day. All but four participants (P3, P6, P9 and P12) visited more destinations for daily life activities than for social activities. Eight participants (P2, P4, P5, P6, P9, P10, P11 and P12) reached destinations in the unspecified categories (such as a shopping mall); however, the reason
for this destination was not specified in the diary. Four participants engaged in recreational activities such as walking (P2), cycling (P3), walking the dog (P10), and playing golf (P11).

**Distance travelled for activities**

The distances participants travelled to reach out-of-home activities varied widely (Table 11). While five participants travelled most of their kilometres to reach social activities (P2 – 44%, P5 – 58%, P10 – 59%, P9 – 93%, P3 – 94%), five other participants travelled most of their kilometres for daily life activities (P4 – 51%, P7 – 54%, P8 – 75%, P13 – 57%, P1 – 79%). One participant travelled most kilometres to engage in recreational activities (P11 – 39%), while two others travelled mostly for unspecified activities (P6 – 51%) or work (P12 – 89%).

The reasons participants spent more kilometres to reach social or daily life activities varied. Those who drove more kilometres for social activities reported travelling to see family and friends who lived long distances away (P2, P3); to engage in family functions or other social events (P9 and P10); or to visit and help friends or family who were ill (P5). Participants who travelled longer distances for daily life activities did so as a personal preference. Participants stated that they shopped at particular locations because they preferred their selection of goods (P4, P8), and because they
could shop and combine other activities there, such as going to the library (P7) or visiting speciality stores (P1).

<table>
<thead>
<tr>
<th>Participant</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
<th>P9</th>
<th>P10</th>
<th>P11</th>
<th>P12</th>
<th>P13</th>
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</thead>
<tbody>
<tr>
<td>% kilometres travelled by car</td>
<td>100%</td>
<td>90-99%</td>
<td>75-77%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Social</td>
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<td>18.1</td>
<td>65.8</td>
<td>16.6</td>
<td>9.3</td>
<td>5.1</td>
<td>9.2</td>
<td>2</td>
<td>13.6</td>
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<td>1</td>
<td>4.7</td>
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<td>17</td>
<td>5.7</td>
<td>6.7</td>
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<td>Walking/Cycling</td>
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<td>2.9</td>
<td>1.8</td>
<td>3.7</td>
<td>54.7</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Work</td>
<td>7.8</td>
<td>0.1</td>
<td>1.1</td>
<td>12.4</td>
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* Amount of time spent: P2 recreational activities 0.035 hours, P3 unspecified activities 0.015 hours, P11 unspecified activities 0.012 hours

**Table 11 Kilometres travelled and time spent in activities**

**Time spent in out-of-home activities: The role of transportation**

Participants spent between 2.2 (P8) and 5.9 (P3) hours per day in activities outside of their homes (Table 11), with the group median being 3.6 hours. All participants spent time in social (10%-73%) and daily life activities (2%-27%), and in commuting (9%-52%). Two participants spent a larger percentage of
time on recreational activities (P10 – 24%, P11 – 36%), while one participant (P12) spent most of his time working (60%). Another participant (P6) spent 37% of their time outside of their home in unspecified activities.

Time spent for social out-of-home activities

The two social activities most participants spent time in were socialising with family members and friends, and leisure (Figure 10). Nine participants spent most of their out-of-home time on social activities (P4 – 33%, P10 – 33%, P11 – 41%, P5 – 43%, P1 – 43%, P2 – 47%, P8 – 62%, P9 – 66%, P3 – 73%); all but one of these (P1) spent most time socialising. Seven participants (P1, P3, P4, P5, P6, P7, and P10) spent time in leisure activities; for one of these participants (P1) leisure activities accounted for 81% of the social time spent outside home. Four participants (P3, P4, P6, and P7) spent time assisting family members or friends. One of these participants (P6) spent 80% of her social activity time in this way. One participant (P2) spent about 32% of the time spent outside home on volunteering activities.
Socialising with family and friends was an important activity for most participants, and being mobile was important in accessing these social contacts. Most participants had family and friends in locations across the city, making the private car the preferable transport option, as public transportation was perceived as inconvenient: [If I could not drive] I wouldn’t be able to go to my friends’ places so easily or my sister’s place or things like that (P1). An inability to drive made participants dependent on visits from family and friends and on receiving rides from family and friends. For some, disturbances in social networks (such as conflicts between their children) created difficulties in socialising with family; this, in turn, created the need
for independent transport: Well, it’s like a gate goes up. They don’t visit. Therefore, it becomes more isolating (P4).

Engagement in leisure activities added to quality of life in older age, and transportation was critical to this engagement. All participants reached leisure activities by car and found it to be the transport option that provided flexibility and freedom to engage in these activities: [The car] gives us the opportunity that, from time to time, we might go down to Colleges Crossing just down here, the Brisbane River. Take a book. Go and have a sandwich at the little cafe that’s there, watch the kids play, and come home (P4). The private car also creates the opportunity to reach leisure destinations further away which are difficult to reach by public transport. Car ownership, therefore, provided participants with the option to travel for leisure: Whether it goes to Coolum or the beaches up there or anything like that, if you want to go to those places. You do still need a vehicle (P6).

The car was found to be essential for participants who assisted family and friends, or who engaged in volunteering activities. Most assisting activities involved either transportation of goods or people by car. Participants assisted family members and friends by organising shopping, transportation, or health appointments. Assisting is a reciprocal activity that acts like money in the bank and ensures help for the assistant when he or she may need it: We all try to be very supportive of each other (P7). Participants volunteered in roles
that were dependent on car ownership. The volunteering activities involved transporting other people in the volunteer’s own car: *I use my own car, or I’d use [my wife’s] car, actually, to go and pick them up and take them to their appointments, and wait for them, and then take them back home* (P2). Therefore, the cessation of driving or car ownership can end a volunteering activity; for example, one participant (P10) had to stop her volunteer work for the *Meals on Wheels* program, when she could no longer afford her own car.

*Time spent for daily life activities*

Only one participant spent most time outside the home for daily life activities (P7 – 36%). All participants went shopping during the week (Figure 11). Four spent all of their time within the daily life categories on shopping (P6, P7, P10 and P12). Eight participants (P1, P2, P4 P5, P8, P9, P11 and P13) also visited destinations for health, and six participants (P2, P3, P4, P7, P8 and P13) visited destinations for services. Four participants (P4, P5, P8 and P11) spent most of their time within the daily life categories in health-related activities.
The role of transportation in facilitating daily life activities

Using the car for shopping was necessary for most participants, so that they could transport purchased goods. Participants stated that they liked to visit shopping facilities that provided a range of shopping and leisure opportunities. Shopping malls were, therefore, frequent destinations; however, these were perceived to be only accessible by car, thus creating accessibility issues. While some participants were aware they could use online shopping options, they still preferred to shop themselves. Therefore, retaining the ability to drive becomes a focus: *Each day we get in the car and drive to the shop* (P2).
Most participants travelled by car to health facilities. For some, most of their daily life travelling was for health-related reasons; due to poor public transport accessibility, they needed a car for this purposes: As my wife needs a walker, if the bus can’t drop you out close to where you want to go, it’s still not practical (P4). Participants stayed with their family doctor even if they or the doctor had moved to another suburb. Losing the ability to drive impacted their ability to reach the required health service and constrained their access to health treatment: Well, I used to drive there [to see my doctor] but now I’m grounded (P13).

Anxiety or difficulty in giving up driving

Participants who drove had not seriously considered their strategies for when they could no longer drive. Moving into another area was an option for some: If we can’t drive anymore I think we’d be at the stage of thinking about moving. It’s a very car dependent area (P7). Participants who drove were, overall, happy with the level of mobility they enjoyed; however, during the interview, most driving participants expressed concerns about their limited transport options if they could not drive. The ability to live independently and to perform daily life activities (such as shopping) were perceived as being closely connected to the ability to drive. Participants expressed concerns about accessibility of the shopping areas because of a lack of
available public transportation: *There will come a time where I can’t drive any more. How do I get to the shopping centre?* (P5).

Some participants said they would use public transportation if they could not drive. The generally low use of the public transportation system was described by participants as the result of a general lack of available and reachable public transportation options. However, it also appeared that participants who drive might not be aware of the range of public transportation opportunities, as their car was always the main transport option: *I’ve never taken any notice...I haven’t needed to* (P7).

Walkability, vehicle accessibility, and the ability to understand the transportation system can be more problematic than using the private car (Scharlach 2009). Participants appeared to be unwilling to consider public transport as an option and driving participants were concerned they might not be able to reach desired destinations by other transport means; rather, they believed that they would continue using a car to reach their destinations as a passenger of friends or children: *I wouldn’t go out there by public transport, see if the kids are around [to drive me]* (P6).

**Being part of a social network**

Being part of a social network influenced older people’s travel behaviour. Participants (P3, P4, P6 and P7) contributed to the mobility and organisation of daily and social activities for others within their social networks,
providing transportation for grandchildren to or from school (P6), and driving their spouse (P3, P4) or friends in need (P7) to health appointments. The driving ability of these older people is, therefore, critical for daily life and social activities of friends and family members: [I’m going quite around] to support friends who need me (P7). Participants who did not drive themselves but had a strong social network relied on family and friends to travel to most destinations (P9 and P10). This activity created a sense of being cared for (P9), but also the need to be grateful for the mobility and contact that was provided: They are terribly good to me. Very, very good to me... (P9). Participants who did not drive (P12 and P13) and lacked a social network which provided access to a car did not travel by car at all.

4.3.5 Discussion

This qualitative study provides insights into older people’s travel behaviour, their participation in out-of-home activities, and the role of transportation in facilitating this participation. A set of data collection methods – including travel diaries (and a questionnaire), GPS tracking, and an in-depth interview – provides a snapshot of older people’s engagement within the community. The findings have implications for the planning of age-friendly environments and transportation which enable older people to stay active and engaged within their communities.
Participants within this study live in suburban environments which are likely to create car dependency (Zeitler et al. 2012). Three key findings warrant specific attention: firstly, older people need to reach a variety of locations across the city to engage in their daily activities, and prefer flexible transportation options; secondly, access to a car might not only benefit the driver, but also other people within a social network; and, thirdly, the ability to transport goods and other people is an advantage of car transportation, enabling independent living within suburban environments. These three findings are discussed in detail below.

The first finding – that older people need to reach a variety of locations across the city to engage in their daily activities, and prefer flexible transportation options – has implications for community and transportation planning, especially for a sprawling city such as Brisbane. This is particularly pertinent in light of the fact that older people living in suburban environments are likely to adjust their lifestyle to stay within their environment (Lord et al. 2009). Cities with a predominance of suburban environments need to develop strategies that promote car-independent transportation to and from all areas of the city, and to provide access to services and facilities that are accessible for non-drivers. The withdrawal of older people from community activities could be caused by inadequate transportation systems or the lack of proximity of local amenities.
As public transportation is planned to accommodate work-related trips, it might not meet older people’s travel needs which are more related to social and daily life activities (Burkhardt 2003). Other issues that might prohibit older people’s use of public transportation include affordability, flexibility, convenience and accessibility (Broome et al. 2009). Rosenbloom (2009) also argues there is little evidence to support the assertion that public transport will meet older adult mobility needs in lieu of their cars; this means that the policy direction of transportation planning might have to change to accommodate older people’s travel requirements, not only by accommodating diverse travel needs in older age, but also by considering and incorporating suitable transport design and pricing.

Banister and Bowling (2004) found that access to a car can improve perceptions of quality of life in older age. Town and transportation planners need to learn from the mobility perspectives a car provides and integrate these into new approaches to public transportation and the distribution of services and facilities; for example, suburban areas could be retrofitted to provide: closer services and shopping areas; a higher frequency public transportation service during the day; and para-transit services which are available within and outside of normal service hours, and which are also accessible to a wide range of older people.
The second finding – that access to a car might not only benefit the driver, but also other people within a social network – also has significant implications. Musselwhite and Haddad (2010) describe utilitarian needs as the travel needs related to basic needs of social and daily life. In relation to these needs, this research found that older people who are mobile might serve not only their own needs, but also the needs of dependent others who cannot drive. Drivers also help others who are less mobile by assisting, volunteering, and providing social contact by visiting. Older people who drive can, therefore, play an important role in other people’s independent living and quality of life, especially when living in suburban environments.

The possibility of becoming a non-driver rises with older age (Ross et al. 2009), making it vital to understand how this affects mobility of the ageing baby-boomer generation. Assisting and volunteering to help others is only money in the bank if it is a reciprocal arrangement, and might also depend on relationships within different age groups. Overall, while car driving can have positive benefits for drivers and those whom they help, car dependency is a negative circumstance for those who have no access to this form of transport (Páez et al. 2009).

The third finding is the fact that the ability to transport goods and other people is an advantage of car transportation, enabling independent living within suburban environments. As living in low density environments
creates the need to travel further distances to reach desired destinations, older people might tend to trip-chain, and to organise their activities so that they reduce the number of trips they have to make during the week. This is only possible in a timely and practical manner when a car is used as the main transport option. Its space and transport capacity might, therefore, be an advantage which is not yet fully included in perceptions of older people’s travel needs.

Metz (2000) and Mussewhite and Haddad (2010) describe qualities of mobility and its possible impact on quality of life; however, their findings also highlight that an understanding of mobility includes the functions transportation provides for older people, beyond simply providing individual transportation from point A to B. The ability to transport goods and people, for example, can influence social participation within the community environment, and is an aspect of older people’s mobility that still needs to be examined in relation to their independent and engaged living.

Finally, this study is significant in providing Australia-specific information in this increasingly important field of providing for ageing populations. While Australian cities have similar growth patterns to those of Northern American cities where most of the research in the field has been conducted to date, the latter have been characterised by an increase in urban sprawl and inner-city decay; this is in stark contrast to the revitalisation and
gentrification of Australia’s inner city environments (Randolph 2004). Australian cities face significant changes as a result of resultant densification (Randolph 2006). However, they are also growing outwards and its citizens are dependent on the car as the main transport option (Dodson & Sipe 2007). This growth pattern leaves the ageing middleclass suburbs at risk of becoming locations of disadvantage, while new suburbs are developed for high-end customers on the outer fringes (Randolph 2004). It is clear, therefore, that this context-specific research makes a necessary and significant contribution to our local understanding of this important issue.

The mixed methods approach adopted for the study allowed for real-time-measurement of time and distance travelled, as well as for time spent on various activities within the community environment. It combined this data with accounts of the participants’ experiences with mobility and activity engagement within their community environment, to create a detailed picture of older people’s use of transport in relation to out-of-home activities, and of the quality of transportation they require.

Conventional household travel surveys might not be suitable for capturing the specifics of older people’s activity-related travel behaviour and its relation to accessibility (Alsnih & Hensher 2003). GPS tracking, however, provides more accurate and more objective records of older people’s travel behaviour over a longer period of time (Shoval et al. 2010). While it does not
seem feasible to use GPS measures for national travel surveys at this point of time, this could change with the development of automated analytical approaches, and the incorporation of mobility telecommunication devices (such as mobile and smart phones) for data collection. The use of this tracking methodology could help to develop an understanding of out-of-home activity and health behaviour in older age. Individual GPS-generated maps can be used to discuss the participation and activity of individuals within their communities. Data gathered could then be used for health planning and/or health education purposes.

Finally, this qualitative study is limited by its small number of participants and the specific geographical characteristics of its context – the subtropical city of Brisbane, Australia. While this small sample size and specific site location preclude the findings from being generalised for older people living in other environments, the study does, nevertheless, provide a detailed picture of the travel behaviour and community engagement of older people living in low density suburban environments, and contributes to a growing body of literature in this specific area.

### 4.3.6 Conclusion

Population ageing creates the need for societies around the world to develop strategies which allow older people to stay engaged and participating within their communities as they age (World Health Organization 2002). Given that
ageing in place is what most older people wish for their future (Olsberg & Winters 2005), it is essential to understand the specific, contextual factors which contribute to age-friendly communities (Plouffe & Kalache 2010). Low density environments, the predominant urban form in Australia, discourage participation in the community, especially for older people who do not have the mobility that a car provides (Lord et al. 2011; Lord et al. 2009). The findings from this study suggest that it is critical to establish age-friendly means of transportation to enhance older people’s engagement in all types of activities within their community. The findings also suggest the need for further research into this relationship between transportation and participation within the community environment. This further research, in turn, will enable policy makers, and city and transportation planners to employ informed strategies to encourage and facilitate active ageing for all citizens.
4.4 Mobility in the City: Travel behaviour and engagement in out-of-home activities of older people living in suburban and urban environments in Brisbane, Australia (Article 4)

Article 4 explores the link between the travel behaviour and engagement in out-of-home activities of older people (n=23) living in low and high-density environments in Brisbane, Australia (see Figure 12). It analyses the GPS data to investigate: the number of kilometres travelled by different transport options for different activities; the number of trips made; the destinations reached; and the time spent in out-of-home activities. It also analyses the perceptions and experiences of participants from both low and high-density environments with regard to their participation in out-of-home activities, and the accessibility of the community environment.

Figure 12 Transportation and activities in high and low-density environments: Central topic in Article 4
Statement of joint authorship and authors contributions

Submitted to Urban Studies in August 2013

Title of the article:

Mobility in the City: Travel behaviour and engagement in out-of-home activities of older people living in suburban and urban environments in Brisbane, Australia

The authors listed below have certified* that:

1. they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
2. they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. there are no other authors of the publication according to these criteria;
4. potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit, and
5. they agree to the use of the publication in the student’s thesis and its publication on the QUT ePrints database consistent with any limitations set by publisher requirements.

In the case of this chapter:

Zeitler, E. & L. Buys, Mobility in the City: Travel behaviour and engagement in out-of-home activities of older people living in suburban and urban environments in Brisbane, Australia
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<td>Elisabeth Zeitler</td>
<td>Chief investigator, significant contribution to the planning of the study, data collection and analysis, literature review and writing of manuscript</td>
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<td>Date 25.10.2013</td>
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<tr>
<td>Professor Laurie Buys</td>
<td>Significant contribution to the planning of the study (as principal supervisor) data analysis and assisted with the preparation and evaluation of the manuscript</td>
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Principal Supervisor Confirmation

I have sighted email or other correspondence from all Co-authors confirming their certifying authorship.

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Name Signature Date
4.4.1 Abstract

Background: As the population ages, the mobility of older people is of major concern in urban and transportation planning. Objective: This research addresses this concern by investigating the travel behaviour, engagement in out-of-home activities, and the facilitation of mobility within suburban and urban environments within Brisbane, Australia. Methods: The qualitative study uses a range of data collection methods, such as travel diaries (including a questionnaire), GPS tracking and in-depth interviews to collect data from twenty-three participants within low density (n=13) and high-density (n=10) environments. Results: The community environment affects older people’s mobility and their participation in social and daily life activities. Older people within both environments were dependent on the car as their main transport option. Conclusion: Densification of neighborhoods does not necessarily reduce car use. Planning for an ageing population focuses on providing low and high-density environments with services, shops and venues and spaces for social interaction as well as accessible public transportation.
4.4.2 Introduction

Population ageing is a worldwide phenomenon (United Nations 2009) which challenges town and transportation planners to meet the mobility needs of ageing populations (Arentze et al. 2008; Pisarski 2003).

Research that focuses on the mobility of the overall population shows that the density, diversity and design of the urban environment impact on the choice of transportation (Cervero 2002); for example, there is evidence that the community environment impacts travel behaviour (Handy, Cao & Mokhtarian 2005; Næss 2005). It was also found that access to transportation influences participation within the community (Kenyon, Lyons & Rafferty 2002; Cass, Shove & Urry 2005). It is further known that the degree of urbanization influences engagement in active transport modes, such as walking or cycling (Badland, Duncan & Mummery 2008). Finally, it has been found that the concentration of facilities leads to longer distances travelled by suburban dwellers than by inner city residents (Næss 2006).

Research that focuses on older people’s mobility, however, has mostly been conducted within a European and North-American context and is influenced by specific geographical, cultural and economic factors (Rosenbloom 1999b). The purpose of this paper is to analyse the effect of suburban and urban environments on the mobility and participation of the older age group within the urban Australian context. More specifically, this research analyses
the travel behaviour, the community participation, and the perceptions of community accessibility of older people living in low and higher density urban environments within Brisbane, Australia. A qualitative mixed methods approach is used; this combines data from community level research with data from individual travel diaries, questionnaires, GPS tracking, and qualitative interviews.

4.4.3 Background

Australia is no exception to the trend of population ageing, with an estimated 28% of its population being 65 years and older by 2051 (Australian Bureau of Statistics 2006). This makes population ageing one of the major causes of the fundamental changes that are expected for rapidly growing Australian cities (Commonwealth of Australia 2010). Australia is also one of the most urbanized countries in the world, with about 75% of all Australians living in the major cities (Commonwealth of Australia 2010). Therefore, it is critical for urban and transportation planners to understand, and to subsequently develop, appropriate strategies for the mobility and participation of the older age group within the urban environment.

The urban structure and nature of Australian cities is different to the urban sprawl and inner-city decay seen in the USA, and to the high-density environments of European or South East Asian cities (Randolph 2004). Unlike these cities, Australian cities grow outwards, creating a
predominance of low density suburban environments and higher density city centres (Randolph 2006). Furthermore, this growth pattern of Australian cities creates a high dependency on the car as the main transport option (Dodson & Sipe 2007).

The face of Australian cities changes rapidly, and inner-city areas prosper as a result of revitalisation and gentrification. However, while the middle class suburbs are ageing and at risk of becoming locations of disadvantage, new developments on the city fringes are attracting middle to higher income earners (Randolph 2004). To date, there is only limited understanding of how these developments affect the mobility and participation options of older Australians within their community.

Mobility, which is a precondition for participation within the community (Mollenkopf et al. 1997), can be described as a product of the interaction between the older person and the environment. The theoretical concept is the person-environment fit, which describes the dynamic of the interplay of individual abilities and environmental conditions. This concept facilitates an understanding of older people’s ability to successfully interact with their environment (Lawton & Nahemow 1973).

Webber et al.’s (2010) framework for mobility is based on this person-environment fit and includes the perspective of life-spaces. According to Webber et al. (2010), the further away from home an older person wants to
travel, the more resources are required. Webber et al. (2010) organise these resources into five categories: financial, psychosocial, environmental, physical, and cognitive. Furthermore, they believe that the performance of the older person is also affected by gender, cultural, and biographical influences. Mobility is also claimed to impact the quality of life (Banister & Bowling 2004; Metz 2000), and to serve a hierarchy of needs (Musselwhite & Haddad 2010). It is critical that we understand the complexity of this topic so as to undertake age-friendly urban and transportation planning.

Several research projects have compared mobility in older age in different countries. European cities are typically well endowed with services and public transportation (Næss 2006), and these urban features have been found to foster older people’s mobility and participation. It has also been found that health and supporting networks enhance mobility and participation in older age (Mollenkopf et al. 1997). Environmental factors such as broad, comfortable sidewalks, little traffic or traffic-free zones, and proximity to the destination were found to be important for engagement in active transportation modes.

Access to structural resources are another precondition for mobility within the community in older age (Mollenkopf et al. 2004). About 15% of the participants in Mollenkopf et al.’s (2004) study context had problems in reaching basic facilities within urban areas. These problems were mostly
caused by individual physical mobility issues or the lack of access to a private car. A German study, on the other hand, found that active lifestyles for the older age group were possible in all study contexts (Fobker & Grotz 2006), as the environments studied provided not only rail bound transportation (such as trams), but also, proximity to services and facilities. These factors allowed older people to participate within their neighbourhoods as active transportation modes and public transportation could be used, and provided good alternatives to driving (Fobker & Grotz 2006). However, the findings of these European research projects reflect the design, transportation and density of European urban environments and cannot be applied to low-density, car-dependent urban environments (Rosenbloom 1999b).

North American cities are highly suburbanized and exhibit both a very different urban pattern to European cities, and a different transport situation. This highly suburbanized environment was found to critically affect engagement in social and leisure activities in older age (Carp 1980). Older people in the US, for example, are generally very dependent on the car as their main transport option, and the use of alternative transport has declined (Rosenbloom 2003). The rising number of trips and kilometres travelled by car can be seen as a measure of low access to services and facilities; however,
it also shows higher mobility and the freedom to choose services, even if they are far away.

Research from Canada shows that older people living in suburban environments subconsciously and continuously adapt their lifestyle in order to be able to stay within their community as they age (Lord et al. 2009; Lord & Luxembourg 2007). Eventually and inevitably, however, this adaptation process will resonate in reduced mobility and reduced autonomy (Lord & Després 2011). The observed dependency of low density inhabitants on the car as their main transport option is of major concern. While the car provides older people with the opportunity to reach destinations further away, it also creates mobility disability when driving is no longer an option (Rosenbloom 1999a).

While there are some pockets or areas of more affluent, higher density development, Australian cities are generally dispersed and show a predominance of low density environments and high car dependency. This makes them different from other urban developments in other countries. Therefore, it is critical to specifically investigate the mobility and participation of older people in different Australian urban environments to inform the development of approaches to creating such environments that are age-friendly.
4.4.4 Method

Investigating the effect that different environments have on mobility and participation in older age is a very complex undertaking. Consequently, this research uses a range of instruments to collect data for an in-depth analysis. To compare the mobility and participation of older people living in lower (n=13) and higher (n=10) density environments, it considers residential location and character, individual travel behaviour and participation, and personal perception of accessibility to the community environment. (This research was ethically approved by the Queensland University of Technology [QUT] Human Research Ethics Committee.)

Research location

With a population of approximately 1,945,000, Brisbane is the third largest city in Australia, and holds 9.08% of its population (Commonwealth of Australia 2010). Brisbane is also the second most dispersed major city within Australia, with a population distribution of 918 persons per sq km (Commonwealth of Australia 2010). It is one of the fastest growing metropolitan areas in the country (Mees & Dodson 2011), and is predicted to grow by 114% to approximately 4.0 million people by 2056 (Commonwealth of Australia 2010).

Brisbane is a dispersed city and has a predominance of low density suburban environments; this creates a high dependency on the car for daily travel.
Shops and facilities are organised on street strips or shopping centres, as well as in pockets within business areas. Higher density developments are located within, and in closer proximity to, the Central Business District (CBD).

**Participants**

This study is interested in the mobility and participation of older people living in different urban environments, and their perceptions of the accessibility and age friendliness of their community environment; therefore, people aged 55 and over, living in different urban environments, were recruited. Participants (see Table 12) were recruited in two different ways: 1) the higher density participants \( n=10 \), most of whom had lived for around 5 years within relatively new residential buildings, were part of a previous study and had agreed to be contacted for further research projects; and 2) participants living in lower density environments \( n=13 \), most of whom live in traditional stand-alone houses, were drawn from industry partners. The income for almost all participants (three of the high-density environment participants did not reveal their income) varied from less than $20k to $70-100k per annum.
Table 12 Participants’ demographic information

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<tr>
<td>Living with family</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Living with friends/other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Paid work</strong></td>
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<td></td>
</tr>
<tr>
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<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Part-time</td>
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<tr>
<td><strong>Annual income</strong></td>
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</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>$20k-$40k</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>$40k-$50k</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>$50k-$70k</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>≥ $70k-$100k</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Participants from low density environments were aged between 57 and 87 years, with a median age of 71 years. The density of their environments varied from 5.9 to 27.9 people per hectare, with a median density of 19.3 people per hectare. Participants from high-density environments were aged between 55 and 78 years, with a median age of 69.5 years. The density of their environments varied between 35.3 and 53.8 people per hectare, with a median of 45.7 people per hectare.

**Data collection**

Individual data on travel behaviour and engagement within the community was collected from March to April 2010 in two phases.

Firstly, data was collected by recording out-of-home mobility and participation through travel diaries and GPS tracking. The participants received a package that contained the information sheet and consent form, and travel diary (including a brief questionnaire), a lightweight portable GPS device (Blue747A+ and recharger), and instructions for the GPS device. The questionnaire sought information on the participants’ demographic characteristics, housing, transportation use, and community living, while their travel diaries described their modes of transport, times of departure and arrival, and types of activity. The participants were asked to carry the GPS devices whenever they left the house, and to recharge these overnight.
Secondly, about two weeks after the first phase of data collection, participants were interviewed about their perceptions of the community. During this timeframe, the tools used for the interviews were developed: Individual Google Earth maps (Google 2010a) were created from GPS data; and travel diaries and an interview guide were developed based on the age-friendly city guide (World Health Organization 2007b), and the mapping and responses from the travel diary.

Secondary data on residential location and character was collected from external sources. Residential location and character are described by density, as people per hectare (The population experts 2012), and the distance to the CBD is given in kilometres (Real Estate Institute Queensland 2012; Google 2010b). The type of housing the participants lived in was established through the questionnaire, with participants being asked whether they lived in a flat/unit, a townhouse, a duplex, or a house.

**Measures**

The GPS data was coded individually and referenced to the travel diaries and interview responses. Categories of activity and modes of transportation were developed using the travel diaries. Several categories with subcategories were developed: *social activities* (socialising, assisting, volunteering, worshiping, education, and leisure); *daily life activities* (shopping, accessing general services and health services); *commuting*
activities (travelling by car; waiting for public transport; being a passenger on bus, ferry, taxi, or train); and work and unspecified activities. The time participants spent on activities, the kilometres travelled for these activities, and their transport choices were derived from the individual GPS data.

**Data analysis**

Each participant was assigned a unique code number. Analysing the GPS data allowed determination of the distance travelled per mode of transport used (in kilometres), and the time participants spent in activities and travelling. The GPS data was organized according to the percentage of kilometres that lower and higher density participants used their cars (Table 2). The results are as follows: 100% usage (n=8, five lower and three higher density participants); 90-99% usage (n=7, four lower and three higher density participants); 72-83% usage (n=4, two lower and two higher density participants); 39-41% usage (n=2, both higher density participants); and 0% usage (n=2; two lower density participant). The number of trips made for activities and the number of destinations reached within the tracking period was also assessed.

All interviews were transcribed verbatim and imported into NVivo 9 (QSR 2010). The transcripts were manually coded for: 1) relevance to, and analysis of participants’ mobility needs; and 2) the accessibility of the community environment.
4.4.5 Results

GPS data

The GPS data not only allows estimation of the amount of out-of-home travel, but also the use of various transport options, the number of trips made, and the destinations reached for out-of-home activities. The measurement of time spent for activities gives an indication of the involvement of older people within their community.

Travel behaviour

The GPS data showed that the car was the most used transport option for most participants, but that the amount of kilometres travelled varied widely for each participant (see Table 13). Overall, it was found that lower and higher density participants travelled about the same number of kilometres. However, participants from lower density environments travelled more kilometres (median 16.1 kilometres) by car than those living in higher density environments (median 11.4 kilometres). Participants who did not drive themselves (P9, P10) still travelled the most kilometres by car as passengers of family and friends.
<table>
<thead>
<tr>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
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<tbody>
<tr>
<td>Participants low-density</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>37.3</td>
<td>66.8</td>
<td>16.1</td>
<td>13.6</td>
</tr>
<tr>
<td>P2</td>
<td>41.1</td>
<td>18.4</td>
<td>7.8</td>
<td>8.7</td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td>24.1</td>
<td>13.6</td>
<td>9.5</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>P7</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>P8</td>
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<td>P9</td>
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<td>0</td>
<td>0.2</td>
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<tr>
<td>P11</td>
<td></td>
<td>1.6</td>
<td>0.2</td>
<td>2.4</td>
</tr>
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<td>P12</td>
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<td>24.8</td>
<td>6.3</td>
<td>0</td>
</tr>
<tr>
<td>P13</td>
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<td>0</td>
</tr>
<tr>
<td>Average daily kilometres travelled by transport option</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>37.3</td>
<td>41.1</td>
<td>66.8</td>
<td>16.1</td>
</tr>
<tr>
<td>Public Transport</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Active Transport</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SUM daily average kilometres travelled by transport option</td>
<td>37.3</td>
<td>41.1</td>
<td>66.8</td>
<td>16.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>72-83%</th>
<th>39-41%</th>
</tr>
</thead>
<tbody>
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<td>Participants higher density</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P14</td>
<td>9.3</td>
<td>18.6</td>
<td>46.9</td>
<td>44.2</td>
</tr>
<tr>
<td>P15</td>
<td>5.2</td>
<td>13.4</td>
<td>9.1</td>
<td>7.6</td>
</tr>
<tr>
<td>P16</td>
<td>21.7</td>
<td>4.2</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>P17</td>
<td></td>
<td>11.9</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>P18</td>
<td></td>
<td>1.8</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>P19</td>
<td></td>
<td>0.2</td>
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<tr>
<td>P20</td>
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<td>0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>P21</td>
<td></td>
<td>0</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>P22</td>
<td></td>
<td>0</td>
<td>0</td>
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<tr>
<td>P23</td>
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<td></td>
</tr>
<tr>
<td>Average daily kilometres travelled by transport option</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>9.3</td>
<td>19.9</td>
<td>47.9</td>
<td>18.6</td>
</tr>
<tr>
<td>Public Transport</td>
<td>5.2</td>
<td>11.1</td>
<td>19.5</td>
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</tr>
<tr>
<td>Active Transport</td>
<td>21.7</td>
<td>45.4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>SUM daily average kilometres travelled by transport option</td>
<td>9.3</td>
<td>5.2</td>
<td>21.7</td>
<td>19.9</td>
</tr>
</tbody>
</table>

Fifteen participants used active transport modes such as walking and cycling; eight of those participants lived in lower density environments and seven in higher density environments. Participants who used active transportation for more than 2 kilometres of their daily travel had made a deliberate choice to use this option. While affordability played a deciding role for P12 who could not afford a car, for example, P22 used active transportation to keep fit for his recreational cycling activities. P13 had no access to a car temporarily, and disliked public transportation. Public transport was a central transport option for P12 only; however, P12 combined cycling with public transportation for work-related trips.
Number of trips, destinations, and time spend outside home

Participants from lower and higher density environments made approximately the same number of daily trips (median: 1.5 trips per day), and visited approximately the same number of destinations (median: 2 destinations per day) (see Table 14). One participant (P14) who lived in a higher density environment left the house only a few times a week because of health and mobility issues.

Table 14 Number of trips, destinations, and time spent outside home

<table>
<thead>
<tr>
<th>Participants low-density</th>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>P1</td>
<td>P2</td>
<td>P3</td>
<td>P4</td>
<td>P5</td>
</tr>
<tr>
<td>Daily average nr of trips</td>
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<td>1.7</td>
<td>2</td>
<td>0.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Daily average nr of destinations reached</td>
<td>2</td>
<td>2.7</td>
<td>1.9</td>
<td>3.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Average time spent for activity in hours</td>
<td>3.7</td>
<td>3.4</td>
<td>5.9</td>
<td>4.2</td>
<td>2.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participants higher density</th>
<th>% kilometres travelled by car</th>
<th>100%</th>
<th>90-99%</th>
<th>72-83%</th>
<th>39-41%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>P14</td>
<td>P15</td>
<td>P16</td>
<td>P17</td>
<td>P18</td>
</tr>
<tr>
<td>Daily average nr of trips</td>
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<td>0.6</td>
<td>1.4</td>
<td>1.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Daily average nr of destinations reached</td>
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<td>1</td>
<td>1.7</td>
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<td>2.7</td>
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<tr>
<td>Average time spent for activity in hours</td>
<td>0.6</td>
<td>2.6</td>
<td>2.5</td>
<td>3.6</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Travel for out-of-home activities

All participants travelled to reach destinations for social activities, and all but one travelled to reach destinations needed for daily life activities; however, participants living in lower density environments (see Table 15) tended to travel further than higher density participants for social activities such as
meeting family and friends. Higher density participants (see Table 14) engaged more in volunteering activities or meetings of social clubs. Three participants, one in a lower (P3) and two in higher density environments (P18 and P19), travelled on average more than 36 kilometres to reach destinations for social activities. These trips were necessary either to visit family and friends (P3 and P18) or to attend a meeting (P19).

Table 15 Kilometres travelled for activities

<table>
<thead>
<tr>
<th>Kilometres travelled for activity</th>
<th>Participants low-density</th>
<th>100%</th>
<th>90-99%</th>
<th>75-77%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13</td>
<td>7.8 18.1 65.3 16.6 9.3 5.1 9.2 2 13.6 7.6 1 4.7 2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily life</td>
<td></td>
<td>29.5 15.2 1 17 5.7 6.7 10.6 6.1 0.5 3 4.7 1.8 3.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational</td>
<td></td>
<td>0.4 2.9 2.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td></td>
<td>1.8 3.7 54.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unspecific activities</td>
<td></td>
<td>7.8 0.1 1.1 12.4 0.5 0.5 4.3 0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kilometres travelled for activity</th>
<th>Participants higher density</th>
<th>100%</th>
<th>90-99%</th>
<th>72-83%</th>
<th>39-41%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>P14 P15 P16 P17 P18 P19 P20 P21 P22 P23</td>
<td>8.2 3.7 9.9 11 38 36.8 3.8 0.4 4.6 0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily life</td>
<td></td>
<td>1.5 9.9 8.7 9 8.1 8 7.3 3.5 2.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational</td>
<td></td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Work</td>
<td></td>
<td>2.4 18.9 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unspecific activities</td>
<td></td>
<td>1.1 1.8 0.1 0.5 1.1 0.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On comparing the median for travel for daily life activities, it was found that the lower density participants travelled less (median: 5.7 kilometres) than the higher density participants (median: 8.0 kilometres). Three residents from the lower density environments travelled more than 15 kilometres for daily life
activities. P1 was travelling to specialist shops to gather material for her hobby, while P2 and P4 lived further away from shopping and health facilities and, consequently, needed to travel greater distances.

Recreational walking or cycling was only undertaken by a few participants in both groups, and was mostly necessitated either by owning a dog (P10), or by having a special interest in fitness (P3, P11, P22).

**Interview responses**

This section discusses the mobility experiences of older participants living in suburban and urban environments. The focus of the thematic analysis is on participation in out-of-home activities and the accessibility of the community environment.

*Experiences common to both environments*

Participants from both environments generally found that mobility within the community was difficult without a car, as they experienced difficulties with both public and active transportation. Some participants thought they would use public transportation if they could no longer drive; however, as a lack of available walkways already limits pedestrian mobility within the community, the distance to and from public transport is another issue that would impede this use of public transport. Additionally, bus routes often require a change of services at different arrival and departure points within
the city, further creating impediments to the use of these services. Furthermore, transport vehicle design can create accessibility issues for older people: *I can get on a bus, but I can’t get off the bus* (P14).

*Lower density environments*

Most participants living in lower density environments had no satisfactory public transportation or facilities for active transportation within their community. For example, a lack of well-maintained walkways and bikeways meant that participants were highly dependent on the car as their main transport option. While that was not an issue for most participants if they were able to drive, they were aware that they could face mobility issues if this were not the case, and might eventually have to move to an area that provided better mobility: *We are very definitely committed to being close to a railway line in future* (P7).

Other participants stated that they already relied on family members and friends for mobility needs, or could have to do so in future: *Oh, my daughters would see to it and I have got friends in here who would pick me up, if I need milk or something like that* (P9).

*Higher density environments*

Participants living in higher density environments were mostly living in relatively new apartment blocks and had made a conscious decision to move
into those environments: *We decided, no, we want to come into a city where we can get to things very easily. We deliberately looked for something in the central area and this was a place we were shown. We liked it very much* (P19).

Participants living in these environments generally had a wider range of transport options at hand. While living close to the river made travel by ferry attractive, usage was also dependent on the availability and ease of pedestrian access; for example, the distance between ferry points and shops and facilities, and the sometimes hilly environments created problems for older people: *The City Cat is good in that it’s, you know, it’s available and cheap for seniors but when you come to the city, where do you finish up?* (P8). Taxis were seen as good alternative to buses and trains, especially when travelling for smaller distances within the city; nevertheless, participants from higher density environments were dependent on the car as the main transport option: *You still need a car. ...Public transport doesn’t always go where you want to go* (P6).

**Access to activities**

For very different reasons, participants from both low and higher density environments did not use the car to participate in activities within the inner city. Higher density dwellers (closer to the CBD) did not find the car necessary: *I’m not bothered with it. Wouldn’t consider it, bringing a car into the city; not where we live. There’s no reason to do it* (P23). Parking difficulties and
costs were reasons for suburban residents to seek out other transport to reach the CBD: I leave my car there [at my friends place] and I go to town with them and then I catch the bus out (P7); If we want to come into the city, we’ll go down and catch the train and come in, just like we did today (P2).

Social activities

Participants from both environments were very dependent on the car for their social activities; having family and friends all over the city resulted in travelling longer distances for these activities. Participants who assisted or volunteered within the community relied on the car as their main transport option for this activity as they often had to transport other people and goods: When I am picking the boys up, the distance you will find most of those trips were [at] a distance (P6). However, participants who reported smaller social networks within the city participated in more formal social groups, or volunteered. Therefore, flexible transportation was important for all participants, regardless of the environment they lived in: We need to be able to get all over Brisbane (P7).

While most participants living in higher density areas reported pleasant environments for recreational walking, they also experienced problems with their use; for example, some participants reported that a lack of seating and shade created difficulties. However, the main issue was that most
recreational areas are designed as shared space, and are planned to accommodate a range of users and activities. Participants, who walked, for example, did not feel safe because of often unfriendly joggers and speeding bike riders: *One, it’s shared with pushbikes, shared with joggers; very rude people* (P8). Some of those participants developed strategies to avoid having too much contact with ‘cyclist traffic’: *Well, I guess we tend to sort of walk in the non-peak hours [for cyclists], as such, but if I am coming over to the city - got to be careful, yes* (P23). On the other hand, participants who rode bikes complained about the inattentive behaviour of walkers who do not keep on their side of the shared space, thus creating unsafe conditions for both walkers and bikers.

**Daily activities**

Participants living in both environments mostly accessed life activities such as shopping, health and other services by car. However, participants were also conscious of how they used their car, saying that they strategically planned most of their out-of-home activities in the same areas: *So if I am going to visit somebody, then I will shop* (P21).

Participants also reported that they liked to visit shopping centres as they provided them with a range of shopping possibilities, the best bargains and other activities: *Yes, because there’s bigger range. Not only that, you can get a nice*
cup of coffee (P4). However, such facilities are mostly difficult to reach by public transport and require the use of a car: [Better off to go to the shopping centre], While I can still use a car, yeah (P15). Use of public transportation for shopping was also seen as difficult because of the walking that is needed to and from the transport: But it’s the walk up the hill and I just don’t think I’d ever fancy carrying very much shopping (P7).

Older people who are more fragile due to health conditions can have out-of-home mobility difficulties, regardless of where they live: [I used to drive there] Now I’m grounded (P13). This fact is especially pertinent as older people have to travel to health services more often, and are therefore dependent on family or friends: My daughter could take me but that’s sort of to do it well, I need to go at least three days a week and that’s, you know [a bit too much to ask] (P14).

4.4.6 Discussion

This qualitative research used different methods of data collection in combination: travel diaries (with questionnaire), interviews, and real time measurement of out-of-home activities using GPS technology. The data provides a snapshot of the mobility and community engagement of older people living in different urban settings; it also reveals their reasons for, and perceptions of mobility in relation to out-of-home activities. This research provides significant insights into the effects of lower and higher density
environments on mobility in older age. Three key findings warrant specific attention.

Firstly, community environments seem to create car dependency in older age, irrespective of their proximity to the city. Brisbane is a city with a predominance of sprawling, low-density suburbs, with pockets of higher density developments in the form of high-rise apartment buildings. Higher density development areas can be found within a radius of 6 kilometre distance to the CBD. Participants living in these developments decided to move there primarily because they wanted to be close to the city centre, with easy access to services and facilities. While European studies describe walkability and access to public transportation and services and facilities as encouraging the use of active and public transportation modes in older age (Fobker & Grotz 2006), this study shows that living closer to the city centre does not necessarily result in greater use of active and public transportation. Older people have individual interests and different motives for travelling to various destinations; this makes them prone to use the car as their main transport option as the car provides the most flexibility.

Secondly, it appears that the expectation of a change in transportation modes from vehicle driving to using active and/or public transportation in older age is unrealistic, as most participants reported difficulties with these alternative transportation modes. While some did still think them an option if, or when,
they could no longer drive, research shows that older people are more likely to be able to drive themselves than to use active and public transportation (Rosenbloom 1999b; Rosenbloom 2003). Age-related health issues, for example, can prohibit older people from accessing public transportation due to the distances they need to walk to and from the transport, and/or an inhospitable walking environment. Public transportation within Brisbane is centered on the use of buses; however, various issues that facilitate or hinder their usage by older people (such as those mentioned above) need to be considered (Broome et al. 2010).

In terms of environmental sustainability, it is critical not to underestimate the rising numbers of older drivers in an ageing population (Rosenbloom 2001); this is especially critical for Australia, as its population is not only ageing, but increasing (Commonwealth of Australia 2010). It is of interest for Australian communities to aim for a shift in urban and transportation planning towards less car dependency, more densification of dwellings, and the decentralization of services. However, the focus on age-friendly design is also critical, so that older people are able to engage with their community, whether they are drivers or non-drivers.

Thirdly, when older people plan their travel activities, they aim to be economical in their use of both time and money. Having the control and the freedom to make their own, independent decisions about their daily mobility
and activity can have a positive impact on their quality of life. While it is an established concept that mobility (generally speaking) has an impact on quality of life (Metz 2000; Bowling et al. 2002), this aspect of independence is not yet considered and integrated into the concept. Our findings suggest that older people (especially) who are dependent on others not only lose their independence, but can experience problems in accessing the necessary health and recovery services.

The provision of facilities and services within the community is critical. Affordable, flexible and tailored transport options for older people (with and without health issues) need to be a central component of such services. Additionally, the combination of daily life and health services and facilities within the same precincts could create better accessibility for older people, and facilitate the organization of their daily travel. This might even make it easier for non-drivers to ask a driver for a lift, knowing that the latter could also attend to their own needs at the same time within the same precinct.

Finally, the findings from this study cannot be generalized, as it is a qualitative study with a small sample size within a specific Australian subtropical urban context with a hilly topography. Nevertheless, this study does provide a detailed picture of the travel behaviour and engagement in out-of-home activities of older people living in different urban settings within this context. The mixed method approach of data collection not only
illustrates real-time engagement in the out-of-home travel and activities of older people, but also ventures beyond the raw GPS data to expose older people’s perceptions of their community environment and activities. More research with larger samples and a longitudinal design could be very insightful and lead to a better understanding of repetitive travel behaviour and activities in older age, and changes in these over time.

### 4.4.7 Conclusion

Australia’s cities face major changes due to population growth and population ageing within the next decades (Commonwealth of Australia 2010). While densification is inescapable for the future of Australian cities (Randolph 2006), it will not necessarily reduce car dependency in older age. New approaches to sustainable transportation, which consider the ageing population’s need for mobility will be a major challenge for urban and transportation planners and designers.

Research from Northern America (Rosenbloom 2003) provides some idea of the challenges a car-dependent environment faces in providing mobility for older people. European research is also important in providing recommendations for environments that foster mobility through means of both active and public transportation. However, the findings of this research show that it is necessary to investigate the specific regional factors affecting older people’s mobility. Only in this way, can we develop approaches to age-
friendly environments that are tailored to a specific local environment and its particular future challenges.
Participation in activities outside home is believed to be a key factor for healthy ageing, with mobility being essential for older people’s ability to engage in activities within the community; this engagement, in turn, fosters quality of life in older age. Theoretical approaches which conceptualise mobility in older age are diverse, and focus on quality of life, impacts on movement within the community, and the disabling effect of a non-fit between environmental demands and personal capabilities. However, this thesis illustrates that the link between participation in out-of-home activities and mobility is still not fully understood; this lack of understanding makes it difficult to evaluate the effect of mobility on opportunities for active ageing.

Mobility within the community is dependent on access to transportation. This research has provided much needed insight into why older people travel the way they do, their transport choices, the critical factors within the community that impact on these choices and, finally, the impact of these choices on their out-of-home activity. Not only will this research inform strategies for age-friendly community design; this design, in turn, will enhance older people’s chances of staying engaged in the activities they wish to participate in.
This doctoral research project investigated two research questions: *What impact does the community environment have on the choice of transport options in older age?* and *What impact do transport options have on participation within the community?* To address these questions, the following objectives were set: To explore how low density suburban environments impact on the use of different transport options in older age, and the consequences for active ageing; to explore how transportation choices and practices influence social participation and the daily lives of older suburban residents; and to analyse the effect of suburban and urban environments on the mobility and participation of the older age group within the Australian urban context.

This research used an innovative qualitative mixed methods approach, which included the recording of travel behaviour through travel diaries (including questionnaires), GPS tracking, and in-depth interviews which investigated older people’s perceptions and experiences. A major innovation of this research was the use of person-based GPS tracking. The use of portable GPS devices to investigate older people’s mobility has, to date, only been used in a small number of studies, and the method still needs development (Frignani et al. 2010; Shoval et al. 2010; Hanson & Hildebrand 2011; Boruff et al. 2012). This was also the first study to use this method within a subtropical climate.
This chapter draws together the main findings from each of the four articles presented, and outlines their theoretical contributions to an enhanced understanding of the impact of the community environment on transportation choice, and the impact of this choice on community participation. It also explores the link between the frameworks of active ageing and mobility. It further discusses how the research findings could influence policies and interventions, and the directions which future research could take. The methodological contributions of the research are presented through a discussion of the methodology’s strengths and limitations, of the lessons learned, and of its application to further research.

5.1 Theoretical contribution

This research gives new insights into older people’s mobility and how it is related to the community environment and community participation. This section is organised in three main parts: The impact of the community environment on the choice of transportation; the impact of transportation on participation; and active ageing and mobility.

- The impact of the community environment on the choice of transportation

  This section specifically provides new insights into the impact of the community environment on the choice of transportation in older age,
with a focus on travelling by car, public transportation, and active transport modes.

- **The impact of transportation on participation**

  This section explores the link between older people’s transportation use and their participation in social and daily life activities within the community. In particular, it provides new insights into the specific attributes of car transportation in relation to participation in out-of-home activities; to date, this has not been included in the discourse on older people’s mobility.

- **Active ageing and mobility**

  Finally, this research develops the argument for acknowledging mobility as a key area of active ageing, and presents four key strategies to optimize mobility options within the community.

### 5.1.1 The impact of the community environment on choice of transportation

This study investigated the choice of transportation and the travel behaviour of people living in low (Articles 1-4) and high-density (Article 4) environments. Findings from this research (Articles 1, 2 and 4) indicate that the community environment impacts on the choice of transportation used by older people. Specifically, it highlights how – contrary to current and dominant policy and planning dogma – older residents in more dense urban
environments are not more likely than their suburban counterparts to make active and sustainable transport choices. The role of the built environment, as well as the unique characteristics defining the older population (such as lifelong dependency on the car, safety concerns, and health considerations) are identified as critical factors in facilitating a transition from car-dependence to other transport options.

The car

In line with findings from other studies (Lord et al. 2011; Lord et al. 2009; Lord & Luxembourg 2007), findings of this research suggest that low-density suburban environments, in particular, create a special dependency on the car as the main transport option (Article 2).

Findings from this research also suggest, however, that older people living in higher density environments are also very dependent on the car as their main transport option, and that this environment did not impact on their travel behaviour in terms of lower car dependency (Article 4). This is contrary to other research findings which state that people living in higher density environments are more likely to use more active transportation modes than those living in suburban or rural areas (Scheiner 2010). It was found that environmental circumstances which created accessibility issues with public transportation (e.g. walkability in hilly environments), and the lack of transportation alternatives (e.g. no public transportation to particular
destinations) were factors in the choice of the car as the main transport option in higher density environments (Article 4).

Like the current literature, current transport policy also argues that denser urban environments can provide better access to transport alternatives and reduce car dependency (Metz 2011). On the contrary, findings from this research indicate that, within the case study area (Brisbane), all urban environments seem to foster car dependency among older residents. This finding is critical for local policy makers and city and transportation planners, as it indicates that more consideration should be given to the mobility of older people, particularly when planning higher density environments with the aim of reducing car dependency.

It is unrealistic to expect older drivers to convert to using active and public transportation. This research found that the environment the participants lived in created car dependency, and made active and public transportation options impractical for older people. This contradicts the general belief that public transportation and walking can become more important, especially when driving abilities decrease (Su & Bell 2009). While older drivers are concerned about the impact that driving cessation would have on their independent living within the community, they do not plan for this event (Liddle et al. 2004). They are not informed about transportation alternatives within their community, and might also have no experience in using them.
There was a strong fear of using public transportation, and a reluctance to try something new at *this stage of their lives.*

In purely pragmatic terms this research confirms that (especially for car-dependent environments) it is important to keep older people driving for as long as possible, as this can be the most realistic option to provide them with the mobility they need (Rosenbloom 2009). At the same time, if we wish to foster more sustainable and active transportation choices, there is a clear need to engage and educate older residents about non-car mobility options in their neighbourhood.

The relationship between community environmental circumstances and the use of the car as the main transport options is not straightforward. Regardless of where people live, older people are increasingly using the car as their main transport option (Rosenbloom 2001). The high reliance on the car might well be a reflection of their lifelong habit of being a driver (Hjorthol et al. 2010). At the same time, Australian cities – like American cities – are very car-dependent because they are typically dispersed; this dispersion creates greater travel distances and a relatively poor public transportation system (Dodson & Sipe 2008a; Dodson & Sipe 2008b).

Results of this research show that the urban and suburban environments of the case study area do not provide older people with many opportunities to use transport options other than the car. This might be due to a focus on car-
orientated transportation planning (Butler 2008; DeGood 2011), or to a lack of consideration of older people’s needs in terms of using active and public transportation.

**Public transportation**

The availability and accessibility of public transportation provides alternatives to transportation by car. This research indicates that public transportation was available within walking distance for most of the participants; for these participants, buses were the main transportation option available. The lack of sufficient scheduling of buses out of business hours, however, was found to be inconvenient for the participants (Articles 1 and 2). This research and that of Broome et al. (2010), shows that this lack of availability is a barrier to the use of public transportation. Even if public transportation is available, it might not be tailored to older people’s specific travel needs (Burkhardt 2003); thus, it is a less desirable transport option than the private car.

Especially critically is the non-walkability of the community environment for the uptake of public transportation. The case study area (Brisbane, Australia) is providing an increasing network of bus services, and also provides train and ferry transport options. While distance to the transportation stops might be walkable, the pedestrian infrastructure was described as very poor (Articles 1, 2 and 4). Findings from this research support other studies which
found that insufficient pedestrian infrastructure can discourage older people from using public transportation (Broome et al. 2010). Suburban environments especially were found to provide insufficient pedestrian infrastructure; paved walkways were often unavailable, and there were difficulties in trying to safely cross roads.

This research also concurs with other research (Gilhooly et al. 2002) which indicates a lack of consideration for older people as passengers. Not only did transport vehicle design create problems for older people in boarding and disembarking the vehicle, the sourcing of information on time scheduling and routes was also difficult for those without internet access.

It is critical for communities to focus on providing public transportation that is tailored to older people’s travel needs. Not only is it necessary to focus on the provision of specialised transport options throughout the day (Rosenbloom 2009), it is also necessary to provide seamless movement within the community (Alsnih & Hensher 2005).

**Active transportation**

There is a strong relationship between the uptake of active transportation modes and the pedestrian infrastructure within the community. Participants living within suburban and urban environments reported inadequate pedestrian infrastructure. Main issues were the lack of dedicated walkways and poor walkway maintenance; this creates barriers for the uptake of active
transportation. Corresponding with the findings of other research (Badland & Schofield 2005), low-density was also found to have a negative impact on the uptake of active transportation.

Findings from this research support Ståhl et al.’s (2008) proposal that pedestrian environments need to be more tailored to the needs of older pedestrians, and Bentley, Jolley and Kavanagh’s (2010) contention that urban design plays a vital role in the uptake of physical activity. Older people, for example, are more likely to have functional limitations, or might need to use mobility devices; these factors make them more sensitive to barriers within their pedestrian environment (Wennberg et al. 2009). For the suburban areas investigated in this research, this would indicate that barrier-free pedestrian environments need to be provided, and that walkways need to be paved, shaded, and equipped with resting points. Pedestrian environments should also be wide enough for people to walk side by side, and allow for the use of a mobility device.

Urban leisure environments were especially found to promote shared space. As older people do not perceive these shared arrangements as safe, however, it is necessary to ensure that pedestrian areas are retained for pedestrians only and not shared with other transport options such as bikes (Wennberg et al. 2009). These simple strategies can provide older people with walking
environments which positively influence their walking behaviour (Berke et al. 2007b).

Environments which encourage walking for active transportation can have different requirements than environments that encourage walking for recreational activities. Most participants used active transportation modes for a small percentage of their daily kilometres travelled, and indicated that the community environment is not adequate in terms of pedestrian infrastructure (Articles 1, 2, and 4).

These findings are critical for local policy makers and city and transportation planners, who seek to encourage the uptake of active transportation to foster healthy and active ageing processes. Research shows that walkability has a positive effect on older people’s walking activities (Berke et al. 2007b; Berke et al. 2007a), and that physical barriers have a critical impact on walking in older age (Wennberg et al. 2009). The current car-orientated planning approaches create a lack of attention to the walking environment (Butler 2008).

Therefore, if active transportation is to be fostered within the case study area, a new approach towards providing pedestrian infrastructure that enables older people to actively commute should be considered. Critically, although this should address the unique needs of older people (a significantly growing
proportion of the population), a better designed urban infrastructure would also help foster active transportation behaviours among all residents. This would have subsequent physical and mental health benefits, and reduce the strain on busy roads.

Participants who engaged in recreational activities chose walking environments such as parks, golf courses and recreational areas along the river. While they mostly enjoyed those places, they also identified difficulties, especially with spaces shared by pedestrians and cyclists (see Article 4). Recreational walking was found to be linked to the use of parks or car-free environments. This suggests that the availability of these environments fosters older people’s engagement in recreational physical activity and provides subsequent health benefits (Takano et al. 2002).

The research on active transportation in older age reviewed for this thesis did not, for the most part, differentiate between recreational physical activities and active commuting. However, findings from this study suggest that it is necessary to distinguish between the two as they are undertaken for different reasons and require different environmental conditions.

It is also necessary to investigate walkability in the context of local climatic conditions. While, in countries where there is snow in winter, it is well understood that weather negatively influences walkability (Wennberg et al. 2009), it is less understood how subtropical or tropical environments
influence walkability in older age. Nevertheless, it can be anticipated that older people might experience barriers to walking or biking because of a lack of shade and resting points (Vine et al. 2012). Developing age-friendly approaches for the community context is necessary so as to enable older people to incorporate physical activity into daily life by using walking as an active transport mode. This would involve the planning of shady walking environments with shaded resting points.

Further research is required in this area to develop approaches to pedestrian environments that consider older people’s needs in subtropical environments. Research could specifically focus on climate issues related to active transportation in older age. This research could use GPS tracking at different times throughout the year, and direct observation by walking with participants in their neighbourhoods.

Summary
This research found that the built environment impacts on the choice of transportation used by older people. It indicates that the current focus on car-orientated transportation planning within the study area (Butler 2008) creates accessibility and usability issues for other transport options. The car, therefore, provides the most convenient transport option for the older person; this is not only unsustainable (Rosenbloom 2001), but also creates the risk of social exclusion (Engels & Liu 2011) and economic vulnerability
(Dodson & Sipe 2007; Dodson & Sipe 2008a; Dodson & Sipe 2008b; Dodson, Li & Sipe 2010). It is critical that community environments enhance the use of a range of transport options to provide accessibility to the community.

5.1.2 The impact of transportation on participation

Older people not only engage within their closer community environment, but continue to participate in activities all over the city (Articles 2, 3 and 4); they make deliberate choices about where they want to go and their purpose for going. Private transportation gives them this flexibility to travel within the broader community (Articles 3 and 4).

Research indicates that people’s preferred transport options and their decisions about where they want to live are related (Chatman 2009). However, the findings of this research indicate that even older people who decide to live in more dense environments might still prefer the car for most of their travel. This could indicate that local transport facilities are not adequate, and that older people are deciding to travel longer distances by car. However, it also indicates that older people, especially those who are able to drive themselves, are free to travel to destinations of their choosing.

Lifestyle clearly has an impact on older people’s travel behaviour and on the activities they participate in (Haustein 2012; Hildebrand 2003). Mobility itself has an impact on quality of life in older age (Metz 2000; Musselwhite &
Haddad 2010). Thus, travelling longer distances for necessary travel – such as shopping – might not only be undertaken because of the greater range of goods and services available, but also for other positive advantages, such as meeting affective and aesthetic travel needs (Musselwhite & Haddad 2010).

This realisation is critical to the understanding of the relationship between mobility and engagement in activities in older age. While a local community that provides accessible and attractive services and facilities is important in facilitating active lifestyles in older age (Fobker & Grotz 2006), it is also necessary to provide a safe travel environment throughout the wider community to allow older people to reach facilities and destinations of their choice.

**Transporting goods and other people**

It is important for older people to be able to transport goods and other people, and this is an advantage of transportation by car. Independent and self-determined living in older age implies that older people can continue to reach health appointments, shopping facilities and social destinations (Articles 3 and 4). Public and active transportation, however, lacks the car’s specific ability to carry goods and people over long distances without physical effort.

Transportation by car thus allows older people to continue to engage in activities that involve transportation of goods (for example, shopping) or
other people, even if their health is declining. Thus, the private car provides older people with special mobility benefits (Metz 2000; Musselwhite & Haddad 2010). The ability to transport goods and other people can be related to independence and autonomy (Ziegler & Schwanen 2011), and also addresses the utilitarian and affective travel needs (Musselwhite & Haddad 2010) of individuals within personal social networks.

These aspects of car use are currently not considered in mobility theories. It is critical that future research further exposes the car’s special function of transporting goods and other people in terms of older people’s mobility needs and quality of life.

Flexible trip-chaining throughout the city

Older people organise their travel in trip chains in order to minimise out-of-home trips. The destinations they reach are distributed all over the city, and they organise their travel in order to save kilometres and fuel. The car was found to be the most suitable transport option to engage in these trip-chaining activities.

Trip chaining by using public transportation is deemed impractical, as public transportation does not provide seamless transportation throughout the city (Alsnih & Hensher 2005; Buys & Miller 2011). This makes it more difficult to actually organise the travel necessary to reach a range of different destinations within one trip. Schmöcker, Su, and Noland (2010) even suggest
that, because of the use of mobile phones in older age, older people’s travel might become even more complex in the future.

Increasing age can also be linked to a decrease in trip chaining (Golob & Hensher 2007), and to an increase of ride shares with others. Also, the likelihood of using public transportation decreases with older age, especially for daily life trips (Kim 2004).

These factors make it critical to develop approaches for public and special transportation for older people which allow older non-drivers easy and convenient access to the whole community (An improvement in the transportation system would of course benefit all residents, regardless of age or mobility).

The role of transportation access in social network membership

The ability to drive empowers older people not only to independently engage in social and daily life activities, but also to support others within this network and their community. Therefore, as long as older people can drive safely, they can provide a valuable contribution to other people’s mobility, independent living and engagement in social contacts.

As identified earlier, transport by car has a significant advantage in that it facilitates the flexible transport of goods and other people; this is important to the ability to assist others or to volunteer within the community, and
places additional focus on the importance of keeping older people driving for as long as possible. It is also known that driving cessation can have a negative impact on the social inclusion of older people (Mezuk & Rebok 2008). It is further believed that keeping older people driving for as long as possible can minimize the burden of families and communities in organising their mobility (Whelan et al. 2006).

To date, it has not been clearly understood what impact driving cessation has on the immediate social network in terms of lost mobility and transportation for those who benefit from older people’s driving capabilities. This research clearly indicates, however, that older people who drive are essential in providing others’ access to transportation and activities. Therefore, the loss of driving capabilities might not only negatively affect the quality of life of the driver (Banister & Bowling 2004; Marottoli et al. 2000; Liddle et al. 2004), but also the quality of life of those within his/her social network.

**Summary**

This research indicates that the use of transport options has an impact on participation in older age. The car provides mobility attributes which foster participation, and which are currently not met by other transport options (Figure 13). These attributes include: flexibility and freedom; the ability to transport goods and other people; the opportunity to provide assistance to others; and the ability to plan activities and to trip-chain in relation to
personal preferences (see Figure 13). The car provides the flexible and seamless travel which is required for modern active lifestyles in older age (Hjorthol et al. 2010; Miranda-Moreno & Lee-Gosselin 2008). In brief, older people prefer transportation which is flexible and which gives them the freedom to choose where they want to go to.

Figure 13 Transportation attributes related to participation

While it is understood that older people who lose their ability to drive create pressure on their families and the community to provide them with suitable transportation (Whelan et al. 2006), it is less well understood how driving in older age specifically benefits social networks and the community. Frameworks of mobility, for example, fail to include the specific advantages of the private car in relation to community engagement, especially with regard to the link to supporting activities within social networks. The
findings from this study show that transportation planning might need to consider how the advantages of the private car could be translated into other transport options, such as public and specialised services, to make them more attractive to older people.

5.1.3 Active ageing and mobility

Active ageing optimizes opportunities for health, participation and security in order to enhance quality of life as people age (World Health Organization 2002, p. 12). Among other policy proposals, the WHO’s Active Ageing Policy Framework provides concrete suggestions for active ageing policy development, such as: the importance of age-friendly, safe environments; barrier-free living and transportation; and ageing at home and in the community. In relation to the findings presented here, it can be said that these are the areas which are directly linked to mobility in older age.

Mobility is vital to active ageing as it provides access to participation within the wider community (Mollenkopf et al. 1997). However, mobility is dependent on access to transportation which, in turn, is influenced by the capabilities of the individual and their social and built environment (Mollenkopf et al. 2004). Safe, accessible and attractive transportation and built environment is believed to be key in fostering older people’s participation within the community (Beard & Petitot 2010).
This research shows that providing an environment which optimises older people’s mobility and, therefore, their options to participate within the community is a key strategy for active ageing. Central to such an environment is the provision of access to transportation and as a result to mobility within the community. This research shows that access to transportation can be optimized by: 1) providing a variety of transport options within the community; 2) providing walkable community environments; 3) considering older people as customers of public transportation; and 4) by the development of denser environments which are planned to reduce car dependency (see Figure 14). In the following section these points are discussed in more detail.

![Figure 14 Active ageing and mobility](image-url)
Variety of transport options

This research indicates that low density built environment is one factor that impacts older people’s mobility. It creates a dependency on the car as the main transport option, and makes the use of active and public transportation quite infeasible for older people (Article 2, 3, and 4). This is not a problem for older people who are able to drive, as they can still access destinations all over the city; in fact, community design favours this form of transportation (Butler 2008; DeGood 2011). Furthermore, older people who always drive are unlikely to use other transport options, and transportation by car is the most realistic option to keep them mobile (Rosenbloom 2009) for as long as is practically feasible. Most importantly, they do not have difficulties in sustaining their activities within the community.

Car-dependent environments, on the other hand, create accessibility issues for non-drivers and create barriers to their active ageing. Shifting the focus in planning from transportation by car towards the provision of mixed transportation would be beneficial for all citizens. If people are used to a range of transport options, they might be less likely to experience accessibility issues when driving is no longer an option.

Walkable environments

The provision of walkable environments is vital for active ageing. Research shows the positive effect walking has on older people’s health (Patterson &
Chang 1999; Berke et al. 2007a; Takano et al. 2002). The ability to use walking to commute within the community facilitates the inclusion of incidental physical activity in daily activities. However, the conditions of the walking infrastructure play a vital role in older people’s ability to use it (Badland & Schofield 2005; Bentley et al. 2010; Berke et al. 2007b; Wennberg et al. 2009; Li et al. 2005). Environments which impede older people’s engagement in active transportation have implications for active ageing. Not only do they create barriers to physical activity in older age, they can also impede direct contact with and within the immediate neighbourhood (Michael et al. 2006; Alley et al. 2007), and create accessibility issues for public transportation.

**Considering older people as customers**

Policy makers and transportation planners need to focus on increasing older people’s accessibility and usability of public transportation. The development of car-independent transportation within low density environments allows older non-drivers to access activities within the wider community. However, the dispersed structure of low density environments can create difficulties for its provision. It is not feasible to provide public transportation in such areas throughout the day. This creates low frequency scheduling, which also contributes to its non-use by older people (Broome et al. 2010). Transportation should be more specialised with respect to older peoples mobility needs (Rosenbloom 2009).
The availability of public transportation within the community is critical for active ageing. It provides the opportunity for non-drivers to access the whole community. If public transportation is not available older people without access to a private car are excluded from participation within the wider community.

**Denser neighbourhoods which focus on reduced car dependency**

This research indicates that denser community environments need to be planned with a view to reducing car dependency in older age. Creating denser living environments with an integrated public transportation system and attractive shopping and leisure activities within the closer community environment is vital to reducing car dependency in older age. The critical element is to provide accessibility to alternative and attractive transport options and destinations within the closer community environment. Research from Germany shows that the provision of mixed use environments and the availability of public transportation create accessible communities for older people (Fobker & Grotz 2006).

The current planning schemes within Australia, however, are still structured around the car as the main transport option, and this factor is responsible for the dispersed nature of Australian cities (Butler 2008). Car-dependent environments create restricted access to preferred destinations and, as a
result, the risk of shrinking people’s activity space within the community as they age (Lord et al. 2009; Lord et al. 2011). In turn, they are a risk to active ageing as they create accessibility issues for activities of daily and social life within the community.

It is critical to investigate the options for retrofitting and densification within the Australian urban environment. The focus ought to be on the reduction of car dependency and the creation of accessible transportation and environments for older people.

**Summary**

This research shows that mobility is the essential link to participation in social and daily life activities within the community environment and, therefore, essential to healthy and active ageing. Enabling mobility in older age, therefore, could be a key element in enabling older people to age in place, and to stay engaged and to participate as they do so.

A focus on the provision of accessible communities with the provision of a range of transport options which consider needs and accessibility for older people is essential. This research shows that the community environment has an impact on the access to, and use of, transportation options and, therefore, is essential for optimizing opportunities for participation in older age.
5.2 Practical contribution

This research provides important evidence of the need to develop planning and transportation policies which aim to foster active ageing, and provides practical recommendations for policies which facilitate the development of age-friendly transportation. Possible directions for future research are also discussed.

5.2.1 Recommendations for policies and intervention programs

Making recommendations for policies and intervention programs which improve older people’s mobility is not a straightforward process, as recommendations need to be linked to the local context. Australian cities will face rapid change within the next decades as a result of demographic changes (Randolph 2004). The pressing issues of population growth and population ageing create new challenges for town and transportation planning.

Currently, Australia’s planning practices focus on transportation by car, which influences not only transportation planning but also the shape of the dispersed city (Butler 2008). However, car dependency is believed to be unsustainable in the long term because of its environmental impact (Rosenbloom 2001). Furthermore, a dependency on fuel is not an ideal situation, especially for people with low socioeconomic background as they
are vulnerable to pricing issues (Dodson & Sipe 2007; Dodson & Sipe 2008a; Dodson & Sipe 2008b; Dodson et al. 2010). If the current transportation and city planning practice continues in times of intense population growth, car-dependent environments will create congestion, air pollution and social exclusion. This is a critical scenario and leads to further questions about how population growth and population ageing will create even more pressure on the current transportation system.

Policy makers and transportation planners are urged to develop new ways to provide sustainable transportation for all citizens. Policies and intervention programs that aim to improve older people’s mobility need to consider a range of factors: sustainable densification which incorporates the development of local hubs; educational programs for older drivers and non-drivers; specialised transportation that is easily accessible by older people; and the provision of accessible and practical active and public transportation alternatives throughout the city.

Development of sustainable land-use practices

A dispersed city such as Brisbane, which will be challenged by an immense population growth within the next 20 years, needs to develop sustainable land-use practices. Several studies give insights into possible planning directions that could accommodate population growth, and provide better mobility options for older people.
Rosso et al. (2011) found that better mobility outcomes in older age are linked with mixed land use and higher density; these features provide greater street connectivity and, as a result, shorter distances for pedestrians, safer traffic conditions, and proximity to facilities. Fobker & Grotz (2006) further found that the provision of higher density environments which provide services and facilities, and which are serviced by public transportation, can enhance everyday mobility.

In summary, it is recommended that densification should focus on providing a range of facilities and services, walkability, optimal public transportation services, and accessible and inclusive design which accommodates older people’s needs.

**Keeping older people driving**

It is in the best interests of the community to keep older people driving (safely) for as long as possible, especially those who live in low density environments. This study shows that older people who drive have no issue with mobility within car-dependent environments. Indeed, their ability to drive could even last longer than their ability to use other transport options (Rosenbloom 2003). The provision of safe road environments (Oxley et al. 2006; Oxley et al. 2010) and vehicles (Charlton et al. 2002) should be part of policy developments. However, it might be necessary to ensure older
drivers’ safety by developing appropriate licensing procedures, and by testing their driving ability (Whelan et al. 2006).

Educational programs and practical driving courses can be introduced to keep older people up to date with local driving requirements and to maintain their driving abilities (Marottoli et al. 2007). While these programs should be voluntary, they need to be advertised widely, and be provided as a free service to encourage older drivers of all socioeconomic backgrounds to participate in them. These programs could also include information on alternative transportation options that are provided within the community, so that those drivers who are concerned about their abilities can plan for the cessation of driving.

**Development of public transportation that serves older people’s travel needs**

The case study area (Brisbane, Australia) is a dispersed, car-dependent city (Butler 2008). However, it is also the only Australian city (together with the South East Queensland region) which has a public transport network plan that aims to improve service and infrastructure (Mees & Dodson 2011). However, this research shows that public transportation within Brisbane’s suburban and urban environments still needs improvement if it is to satisfy the needs of older users.
It is recommended that the development of public transportation policies focus more on older people’s travel needs, such as: frequent services throughout the day; seamless transportation throughout the city; public transportation stops in close range; and easily accessible vehicles. Furthermore, it might be necessary to develop more specialised transport options that are flexible but still affordable, and to focus on retrofitting those neighbourhoods where more older people age in place (Rosenbloom 2009). Another requirement would be to provide low cost or free parking space along transportation hubs and train stations in order to encourage the public transportation use.

**Creating environments that encourage active transportation**

It is critical to provide safe and connected pedestrian and cycling environments that not only facilitate the use of public transportation, but also encourage older people to adopt active transportation modes. The engagement in active transportation modes for commuting can be the easiest way to include physical activity into daily life and improve health in older age. However, suburban environments can lack sufficient pedestrian and cycling environments. Therefore, a policy priority should be the provision of pedestrian and cycling infrastructure in all areas of the city, whether of low or high-density. However, the design and maintenance of this infrastructure is critical to the uptake of active transportation; they need to be free of
obstacles and well maintained (Wennberg et al. 2009). Within subtropical environments, it is recommended that pedestrian areas are shaded and have resting points, such as benches, available (Vine et al. 2012). Public transportation systems which provide a satisfying service can also relate to an uptake of more active transportation.

5.2.2 Recommendations for future research

It is recommended that future research investigates older people’s mobility in its spatial context. Geographical influences such as topography and climate, for example, need to be included in the investigation of older people’s mobility.

Not every transportation solution that is found to engage older people in more physical activity in daily life is suitable for every environment. Environments that are prone to snow and ice in winter, for example, need to concentrate on areas of concern such as clearing walkways of ice and snow (Wennberg et al. 2009); however, subtropical environments (such as subtropical Brisbane, the case study here) can create a generally more hostile climate for physical activity during the day. This study found that heat and humidity create difficulties for engagement in active transportation, especially if no shade is available.
For local policies and initiatives to be successful, it is necessary to fully understand the specific contextual conditions at play, and to ensure that these are addressed. Therefore, future research should investigate general and local conditions in an effort to encourage a more active lifestyle in older age.

It would also be beneficial to investigate the impact that policy programs and developments have on older people’s mobility within the community. This is especially interesting in light of the concept of ageing as a continuum within the life course (Dannefer 2010), and in light of the tendency for people to maintain their mobility habits as they age. In other words, it is necessary to investigate the role of community and transportation planning in the choice of transportation throughout a lifetime, to enable the development of more sustainable transportation for an ageing population.

5.3 Methodological contribution

This research used a unique mixed methods approach using real time GPS tracking of all modes of transportation, travel diaries (including a questionnaire), external data, and in-depth interviews. The use of GPS tracking in a qualitative research design is a unique research approach, and lessons learned in this research project can inform other research projects in their method development. In this section, the methodology is discussed,
including its strengths and limitations, and lessons learned. The benefits of this research, and its benefits for other research projects, are also discussed.

5.3.1 Strengths
This study used a mixed methods approach. This allowed for the combination of: external community data; quantitative real-time measurement of travel behaviour and active engagement within the community; and participant perceptions of the community environment. Therefore, it was possible to undertake an in-depth investigation of observed travel behaviour in relation to environmental conditions and to older people’s perceptions of the accessibility of the community environment, and the impact of transportation on their participation within the community.

The research method enabled making sense of the GPS data. GPS tracking can provide more accurate and less subjective records of older people’s travel behaviour over a longer period of time (Shoval et al. 2010). However, during this research process, it became apparent that GIS and GPS are naked and do not provide insights into motives for travel or its links to participation within the community. Using mapping or the GPS data alone does not provide insights into the perceptions of, or reasons for, older people’s mobility options. Therefore, the combination of GPS data with qualitative measures and travel diaries is a powerful method of investigating older people’s mobility within the community.
Further, most research projects that investigate older people’s travel behaviour rely on travel diaries and/or interviews. Only a small number of studies have actually used GPS tracking to investigate older people’s mobility (Frignani et al. 2010; Shoval et al. 2010; Hanson & Hildebrand 2011; Boruff et al. 2012). During this research, however, the benefit of using GPS data to obtain exact measurement of travel behaviour became apparent. When compared to the GPS data, for example, the diaries of some participants were found to be incomplete. Furthermore, when older people’s questionnaire responses were compared with their actual measured travel behaviour, it became apparent that their perception of their actual travel behaviour was sometimes misleading. The mapping process revealed any inconsistencies between the GPS data and the travel diaries, and these inconsistencies were addressed during the interviews.

Thus, the use of different data collection methods can minimize errors in the older people’s estimations of their individual travel behaviour. Therefore, this research adds new insights into the use and benefit of GPS tracking within a mixed methods approach to the investigation of older people’s mobility and engagement in out-of-home activities.

5.3.2 Limitations

This study has a qualitative research design, which does not have the capacity to make generalisations across population (Liampittong 2009).
Therefore, the study’s results only reflect the travel behaviour, transportation use, perceptions and experiences of the 23 participants in the study.

This study also used a convenience sample, which only required the following participation criteria: participants being older than 55 years; participants living within the study area; and (ideally) an equal number of male and female participants. Furthermore, the study sample was small, which also indicates that findings are not representative of all people in this age group. While this study enhances our knowledge of older people’s use of transportation and engagement in out-of-home activities, its findings cannot be generalised.

It is critical to take the study’s context into account. The study area has a subtropical environment and hilly topography which can influence active travel behaviour and, in turn, public transportation use. The study is conducted within an Australian urban context, which was found to be different from those of other countries (Randolph 2004). Therefore, it needs to be seen in its spatial context, which can preclude generalisation to other environments.

5.3.3 Lessons learned

From a practical and logistical perspective, the process of GPS coding and analysis is extremely time-intensive. From this perspective, it would be
beneficial to develop new approaches that actually enable a more automated data analysis (Stopher & Greaves 2007; Stopher et al. 2008). Automated analysis approaches, however, can only provide options to investigate kilometres travelled, speed of travel, or time spent out-of-home. They cannot distinguish the transportation options used, or the activities which participants take part in.

On the other hand, automated analysis could still provide insights into the community areas the participants used, and the size of their activity radius within the community. Also, if researchers are only interested in the use of one transportation mode, in-built GPS devices in cars might be useful. However, it seems to be infeasible to ask participants to carry the device only while walking or using public transportation, as this increases the risk of losing travel data. It is recommended that researchers that seek to investigate travel behaviour or choice of travel mode incorporate travel diaries.

While the data analysis was very time-intensive, the process not only displayed how valuable it is to use different instruments for data collection, but also displayed how misleading the mapped data can be. According to the map, for example, one participant was very active, and used a variety of transport options (P10). However, when the GPS data was analysed, it was found that the participants’ active movement was mostly related to recreational activities (walking the dog), and did not account for active
commuting within the community; neither did the data show participation in a range of different activities within the community. Another example is a participant who appeared very active on the map (P4), but travelled mainly for health-related trips with his wife.

In summary, while mapping can show how far from home people would travel to engage in activities, their motives are not clear. The incorporation of travel diaries and interviews is necessary so as to better understand older people’s travel behaviour and their engagement within the community.

### 5.3.4 Using the method for further research

Mixed method approaches combining GPS tracking, travel diaries, and mapping methods with qualitative interviews are beneficial for further research into older people’s mobility. The use of person-based GPS tracking not only facilitates a better understanding of the use of different modes of transport, its combination with qualitative methods also facilitates an in-depth investigation of the relationship between mobility and participation.

This tracking methodology could also be used to investigate out-of-home activity and healthy behaviour in older age. This could be beneficial for health planning, or could be used for health educational purposes; for example, individual GPS-generated maps could be used as the basis for
discussion of an individual’s participation and activity within the community.

While the car was the most used transport option within the research sample, it was still possible to estimate the difficulties older people face in using active and public transportation. Nevertheless, it would be beneficial for future research to specifically investigate the use of public and active transportation by older participants who do use these transport options, using GPS technologies for real-time tracking. This would not only enable investigation of the mobility strategies of these participants, but also investigation of the ways in which the public transportation system actually facilitates their travel needs throughout the city. A mixed methods approach using GPS tracking would lead to more insights into actual use and user experiences, and could further clarify requirements for age-friendly public transportation.

Using this method for larger samples and a longitudinal design could provide feasible data for modelling approaches that investigate older people’s travel behaviour within the spatial context. Conducting this type of research would: 1) Provide a better understanding of what age-friendly community environments need to provide to optimize older people’s ability to stay mobile; and 2) provide a better understanding of future transportation demands within an ageing society.
These understandings, in turn, would inform policy makers and planners in developing tailored approaches to more effective mobility and participation options for older people within the community. The use and further development of automated analysis techniques in combination with qualitative measures would be necessary to make this approach feasible for larger samples, or for data collection over longer periods.

5.4 Conclusion

This thesis provided insights into the mobility of older people and the ways in which this mobility related to their participation within the community. The study’s theoretical framework was based on active ageing and concepts of mobility in older age. It investigated the role of the built environment in the uptake of transportation options in older age, and how this uptake impacts on participation in social and daily life activities within the community.

A clear link was found between the environment and older people’s choice of transportation. The lack of accessibility, usability and practicality of active and public transportation options were the main reasons for the dominance of the car as older people’s main transport option. However, it was also established that transportation by car has specific advantages in enabling
older people to be involved in a range of activities within the whole community.

Finally, the study emphasises that planning approaches that focus on the provision of age-friendly community environments need to include a range of transport options, and the maintenance and enhancement of older drivers’ abilities. The redevelopment of low density environments towards denser, mixed use and serviced communities also needs to be promoted, and the age-friendliness of these higher density environments ensured.
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APPENDIX

Detailed description of GPS device

This section provides a detailed description of the GPS device used for the study and on how the GPS data was prepared and converted into Google Earth (Google 2010a) maps to be used at interview.

The GPS device

Several characteristics were important for the decision on the GPS device to be used: ability to pick up movement within the community using different transport options and accuracy of the data recorded. The participants were older people it was also important to consider that the device was easy to use, small and light in weight.

It was believed that participants would have different technical skills. Therefore, a device was needed that could be preset by the researchers and would not need any configuration by the participants. It is known that battery life can actually influence GPS tracking negatively so the device also needed to be rechargeable over night.

Three light weight devices where tested by members of the research team: 747A+ GPS data logger, Trackstick, EZ23 (analog tracking system). As the price and performance ratio was the best for the 747A+ GPS data logger
it was decided to use this device for further investigations. Cost-performance ratio, weight, dimension, recharge ability and easy handling were deciding factors. The GPS data logger is an all-in-one portable device that allows the logging of routes by setting intervals of time/distance/speed (see Figure 1).

The 747A+ GPS data logger was tested for usability and functionality by three staff members from the Institute of Sustainable Resources (ISR/QUT). The trial participants were asked to take the device with them for three days and leave it switched on. The GPS device was then connected with a PC and the data downloaded using the GPS Photo Tagger, a program that comes with the I-Blue747A+GPS device.
The original format of the data is an *itm* file (GPS Photo Tagger Project File) and displays the data in waypoints and tracks on a Google map (Figure 2). Within this program the tracks are displayed in different colors. The tracks display tracked distances during the time the device was switched on. However, start and end points of the trip displayed don’t relate to actual trips made but to the time and place when the device is switched on and off. New tracks are also displayed if the device could not get a signal for some time.

![Figure 2 Example for GPS Photo Tagger appearance of one of the trials](image)

The different tracks displayed on the map don’t represent single trips a person did but different tracks the GPS device creates due to its
configuration, environmental circumstances and user handling. Therefore, the tracks displayed by the program do not display real start and end-points of trips.

Sometimes the GPS device might have difficulties to determine its position. Firstly, environmental conditions can cause connecting problems if they create a barrier for the GPS to see the sky. Depending on the GPS model, accuracy problems can emerge with trees, high density environments with high rise houses. Indoors GPS devices are generally not able to collect correct positional data. Secondly, the user of the device can also be a factor that can cause incorrect GPS data, for example by not switching on the device as required. Placing the device in a spot where it can't collect waypoints (for example in the glove box), can also lead to losing tracking data. Also, forgetting to recharge the device can lead to a low battery level that can cause problems in logging data.

**Configurations of the GPS device**

Different setups of the device for time intervals for data collection were trialed. As logging travel data every minute was found to be most helpful when different transport options were used, it was decided to configure the device this way (Figure 3). Setting the logging time shorter produced a lot of ‘noise’ within the data, which made it difficult, especially if someone was driving within the city, to estimate the exact route the person took.
The GPS device can also be configured in terms of log settings (Figure 3). The options are general setting, car, bike or walking. For the tracking of humans it is not possible to know what mode of transport this person will take during the tracking period. So it was decided to use the general mode within the GPS tracking device.

The device was also configured to stop logging if its memory becomes full; however, within the study period this was not a case that could happen. With the ability to log up to 125 000 waypoints the device provided a good buffer. Configuration on logging every min would make 1440 waypoints per day or 10 080 per 7 days.

The data logger was also configured with the connection set on auto scan GPS module. Furthermore, the metric system was used for distance units and the time zone was GMT+10:00 (Brisbane, Queensland, Australia). Tracks
were separated when the device lost the signal (or was switched off) and waypoints had a time difference of more than 7 minutes.

**Detailed description of GPS data preparation**

This section will provide information on how the GPS data was prepared so that it could be transferred into Google Earth maps (GIS tool) that were used for the interviews. The Google Earth maps were used to visualize the data and as a GIS tool to assist the interviews.

Preparing the individual maps and finalising the interview material took on average 1.5 days per participant. Within the project the preparation for the data was done in a team of three: two research assistants mapping and one controlling the maps and organising the data packs for the interviews.

**Downloading data from the GPS data logger**

The 747A+ GPS data logger comes with the computer program called GPS Photo Tagger. This program enables visualisation of the collected data and basic functions allow working with the data. The program uses Google maps, therefore, it is recommended to be connected to the internet to access the data. However, this program was not used further than to access the logged data, so there will be no more discussion around functions of this program.

The GPS device can be easily connected to the computer by a USB cable that comes with it. Once it is connected to the computer the GPS Photo Tagger
should be opened and within the file folder the ‘read device log’ button chosen. When program then asks to select tracks, all tracks were selected. The tracks are now displayed in different colors on Google maps (Figure 2). To ensure that the original data file is available throughout the project the data is best to be saved as a new project into the participant’s folder as an itm file.

To be able to work with the GPS data in Microsoft Office Excel 2007 the data needs to be converted into csv files. Under File, the function Export Tracks can be used and the data format csv chosen. To save the data in csv files is also important for converting the data later into Google Earth files, as csv files are the supported format. After converting the data to csv files the complete GPS data recorded for one participant is displayed within an Excel chart. The distinctions between different tracks, as they were displayed by phototagger, are not visual in this file format.

For the ease of data analysis, the data was to be split up into single day files. The data for the local date and local time are the parameters used when cutting the whole csv file into single day data files. These were named and saved into the participants data file.

**Converting data to Google Earth files**
To produce the Google Earth files \((kmz\ files^2)\) a free online converter program\(^3\) called GPS Visualizer (Schneider 2003) was used. It allows the user to upload \(csv\) data files containing GPS information and convert them to \(kmz\) files, which display the GPS data in Google Earth and visualise it within satellite images of the environment the person travelled.

The GPS Visualizer can be accessed online. The program gives many different possibilities to work with GPS data. For this project the function ‘Convert your GPS data for use in Google Earth’ (see Figure 4) was used. A \(kmz\) file was created after pressing the button: ‘Create \(kmz\) file’. It then was named and saved in the participant’s folder.

\(^2\) zipped kml file

\(^3\) http://www.gpsvisualizer.com/
The GPS Visualizer mask was customised to display the GPS data in a way that was decided to be shown for this research (see Figure 4). It was decided that way points (GPS data for time and location) was ‘named with time stamps’ and that the tracks were coloured according to a colour coding scheme (see Table 5) to display the transport option used. The csv file that should be displayed at a map was chosen by browsing the different participant’s files. The option of opening the kmz file in a different window was chosen, and the file saved in the participant’s folder.

Displaying information on map

Different information can be drawn out of the collected GPS data that is visualized. Therefore, a decision needs to be made as to what should be displayed on the map so that the data can be organized. For this research it
was aimed to create an easily usable and clear map that could be used as an interactive tool at the interview. The GPS data itself displays time and location but needs treatment.

Activities of the participant can be also marked on the map using ‘place marks’ in Google Earth. Within each Google Earth file, a hierarchy of folders (layers) was established to separate the information that was displayed separately. The layers can be turned off and on by the user.

**Identifying different tracks**

To identify different transport modes and activities the information in the diaries is vital. The daily entries on used transport options, departure and arrival time and purpose/activity enabled the researcher to develop the Google Earth maps and to display used transport options and activities within the Google Earth maps. Differentiating the transport option used with GPS data alone would not have been possible.

A colour scheme was developed to colour code and display the different days (see Table 1) and different transport options (see Table 2) within Google Earth.

<table>
<thead>
<tr>
<th>All tracks for</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole week</td>
<td>Magenta</td>
</tr>
<tr>
<td>First day</td>
<td>Red</td>
</tr>
<tr>
<td>Second day</td>
<td>Orange</td>
</tr>
<tr>
<td>Third day</td>
<td>Yellow</td>
</tr>
<tr>
<td>Day</td>
<td>Colour</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
</tr>
<tr>
<td>Fourth day</td>
<td>Green</td>
</tr>
<tr>
<td>Fifth day</td>
<td>Cyan</td>
</tr>
<tr>
<td>Sixth day</td>
<td>Blue</td>
</tr>
<tr>
<td>Seventh day</td>
<td>Violet</td>
</tr>
</tbody>
</table>

Table 2 Colour codes on map for transport option

<table>
<thead>
<tr>
<th>Transport option</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car – self driven</td>
<td>Red</td>
</tr>
<tr>
<td>Car – driven by others</td>
<td>Orange</td>
</tr>
<tr>
<td>Food</td>
<td>Blue</td>
</tr>
<tr>
<td>Bike</td>
<td>Green</td>
</tr>
<tr>
<td>Bus</td>
<td>Yellow</td>
</tr>
<tr>
<td>Train</td>
<td>Blue</td>
</tr>
<tr>
<td>Taxi</td>
<td>Violet</td>
</tr>
<tr>
<td>Ferry</td>
<td>Pink</td>
</tr>
</tbody>
</table>

**Example case - That displays the steps**

To understand the travelling schedule of a participant csv data files for the whole week of tracking and the single days tracked were converted to kmz files via GPS Visualizer. The data was displayed on Google Earth to work with (see Figure 5).
To display the real time engagement in out of home travel and activities in Google Earth, the individual diary is necessary to cross-reference and work out what the participant did. This information enabled the researcher to identify individual tracks and activities and color code them with the color coding scheme described previously.

The csv files were divided at the time points that corresponded to the information in the diary and to the actual map that displayed the GPS data (see Figure 6). Information provided by the participants in the diary about departure and arrival times is mostly not exact, but helps the mapping process in defining locations and estimating the right times.

To map the data accurately, decisions need to be made about where a trip ends and where it starts. It was decided to do this visually by comparing the waypoints displayed on the map to the diary entries.

*Information from diary:* Diary Participant went by foot around 17:30 to around 18:00 to a lesion of karate.
The beginning and ending of a trip was defined as the nearest point to departure or destination plus one more waypoint for each clearly defined track of movement.

**Producing a Google Earth map as a GIS tool for interviews**

To use GPS data for interviews it is vital to structure the layers of the map in a way that makes it easy to work with the interactive maps even if participants do not have too much knowledge on reading a map or using this kind of interactive map. Therefore, a hierarchy of layers that should be displayed and could be switched off and on was defined as (Figure 7):

- When the map opens up only the home of the participant is displayed.
- Second layer is an uncut version of the whole week’s movement of the participant.
- Third layer gives the opportunity to show individual days. The days are colour coded as discussed.
- The fourth layer is the transportation and activity layer. It allows displaying transportation and activities for single days or the whole week at once. Single tracks could be also displayed as well as activities. Information like individual tracks, or place marks could be switched on separately if required. Transport options were coded following the colour coding scheme.
• The fifth layer gave the interviewer the possibility to make changes or notes during the interview.

Google Earth also provides layers that can be useful during an interview like the road layers or borders and labels. These layers were helpful for orientation for the participant and the interviewer within the displayed map.

Preparing data for analysis
The Google Earth files were created as visual ‘tools’ for the interviews. To analyse the data, further information was drawn from the data in terms of usage of transport options (type of transportation, km travelled by transport option, time of day, duration), time spent and nature of activities.

*Preparing GPS data for analysis*

The 747A+ GPS data logger records a index number for the data points, UTC Date, UTC time, Local Date (needs to be set when configuration the GPS device), Local Time, Latitude, N/S, Longitude, E/W, Altitude and Speed (Figure 8).

![Figure 8 Example of csv spreadsheet showing the parameters of the GPS records](image)

The data files need preparation so that they can be analysed. To transfer the data into Google Earth it was important that the data was stored in *csv* files. However, for further analysis the files need to be converted to *xls* format (Excel work book), as the *csv* format does not enable the user to use colours to work with the data as it was required for the method used.
Colour coding files

To work with the Excel files of the GPS data for further analysis the research team decided to combine the information’s provided by the diaries and maps, interviews and post interview maps. If questions arose during this process they were clarified by searching the interviews transcripts for further information.

Within the Excel files episodes within the data stream that represented activities and travelling were coded in a pre defined colour scheme (Figure 9).

Categories of activities were developed by grouping different activities that took place during the tracking according to general categories (Table 3). Some categories got developed at a later stage after discussing the data. Furthermore, the estimate of time spent was calculated and displayed in the data tables produced for the analysis. Notes were made if necessary for
clarity of what the activity was, or explaining any error or inconsistency in the data.

Table 3 Coding scheme for activities

<table>
<thead>
<tr>
<th>Coded activity</th>
<th>Colour used for coding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socialising</td>
<td>Light green</td>
<td>Any activity outside home with purpose of social interaction</td>
</tr>
<tr>
<td>Volunteering</td>
<td>Dark green</td>
<td>Time spent volunteering</td>
</tr>
<tr>
<td>Assistance for family member or friend</td>
<td>Previously mostly collared as health</td>
<td>Time spent to assist family member or friend outside home</td>
</tr>
<tr>
<td>Education</td>
<td>Blue</td>
<td>Time spent in libraries, seminars, public lectures, schools or universities where specific purpose is to further their education in one or more areas</td>
</tr>
<tr>
<td>Worship/ Spiritual</td>
<td>Dark violet</td>
<td>Activities external to Home of spiritual nature</td>
</tr>
<tr>
<td>Leisure</td>
<td>Yellow</td>
<td>Any activity external to home which is undertaken for a leisurely purpose</td>
</tr>
<tr>
<td>Daily life activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shopping</td>
<td>Pink</td>
<td>Activity where the main purpose is to purchase goods or services</td>
</tr>
<tr>
<td>Health</td>
<td>Red</td>
<td>Activities external to home which are specifically related to the health of the participant (doctor, physiotherapy…)</td>
</tr>
<tr>
<td>Services</td>
<td>Aqua</td>
<td>Any activity external to home which includes the use of public utilities or public/private services</td>
</tr>
<tr>
<td>Commuting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commuting</td>
<td>Not collared</td>
<td>Travelling to and from location for another reason than pleasure or leisure</td>
</tr>
<tr>
<td>Active commuting</td>
<td>Orange</td>
<td>Time spent commute active to defined activities by foot or bike.</td>
</tr>
<tr>
<td>Waiting for public transport</td>
<td>Light violet</td>
<td>Time spent waiting for public transport</td>
</tr>
<tr>
<td>Work</td>
<td>Grey</td>
<td>Time spent for paid work</td>
</tr>
<tr>
<td>Biking and selling big issue</td>
<td></td>
<td>Activity where it was not sure if participant was biking or selling the big issue</td>
</tr>
<tr>
<td>Other activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational walking or biking</td>
<td>Orange</td>
<td>Any leisure activity external to home that involves physical activity</td>
</tr>
<tr>
<td>Unspecified activity in known multi optional environment</td>
<td>Previously colour coded brown as unknown activity</td>
<td>Activities that take place in a multi optional environment,</td>
</tr>
<tr>
<td>Unspecified activity</td>
<td>Brown</td>
<td>Activities outside home with the purpose not to be identified</td>
</tr>
<tr>
<td>At home</td>
<td>Light blue</td>
<td>Time spent at home as identified via cross referencing with diary and map</td>
</tr>
</tbody>
</table>
Definition of a trip was defined within this research project the time and distance travelled from home to home within the same day. Within this research project the distinction is made between single trips and multi destination trips to recognize the difference. Single trips are characterized by travelling to one destination for some action and then driving home. Even within areas where multiple activities could take place like the big shopping centres, a trip with this one destination would be still a single trip. However, a trip from home to different destinations and then home again is called trip chaining, and defined as a multi destination trip (Figure 10).

![Diagram](image.png)

*Figure 10 Scheme to calculate distances travelled for different activities*

The transport option someone used to undertake the trip was mapped, distance and time calculated per use per transport option. Diary entries, the maps and information from the interviews were used to clarify what transport options were used.
**Calculating distances**

The raw data does not contain information on the distance that was travelled but displays waypoints that mark where the device recorded a satellite connection. Google Earth is also not able to detect and/or display the length of a single trip. The GPS device was configured to record a waypoint every min.

The GPS data is providing waypoints in Longitudes and Latitudes. The GPS waypoints are the reference points for the travelled distance. The distance travelled can be calculated by the distance between two points *as the crow flies*. As the earth is a *sphere* all lines of Longitudes are Great Circles, while the Equator is the only Latitudinal Great Circle. Therefore, to calculate the distance between two points needs this *curve* to be incorporated. Cartography and mathematics provide a formula to calculate this *crow flies* as a Great Circle Distance. The spherical central angle between the two points is calculated and then multiplied by the radius of the earth. Following the instructions of Person (2009) the distance between the waypoints was calculated in the Excel files.