Living in intensified urban environments: residential self-selection and travel behaviour

January 2012

Carolyn O'Fallon, Pinnacle Research & Policy Ltd, Wellington

Ian Wallis, Ian Wallis Associates Ltd, Wellington

NZ Transport Agency research report 468

ISBN 978-0-478-38091-0 (print)
ISBN 978-0-478-38092-7 (electronic)
ISSN 1173-3756 (print)
ISSN 1173-3764 (electronic)

NZ Transport Agency
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
research@nzta.govt.nz
www.nzta.govt.nz

O'Fallon, C and I Wallis (2012) Living in intensified urban environments: residential self-selection and travel behaviour. *NZ Transport Agency research report 468.* 188pp.

Carolyn O'Fallon, Pinnacle Research & Policy Ltd, PO Box 12–483, Thorndon, Wellington
Ian Wallis, Ian Wallis Associates Ltd, PO Box 11-785, Wellington

Keywords: attitudes, built environment, central city, density, intensification, neighbourhood preferences, New Zealand, public transport use, residential self-selection, travel behaviour; travel patterns, VKT, walking.

An important note for the reader

The NZ Transport Agency is a Crown entity established under the Land Transport Management Act 2003. The objective of the Agency is to undertake its functions in a way that contributes to an affordable, integrated, safe, responsive and sustainable land transport system. Each year, the NZ Transport Agency funds innovative and relevant research that contributes to this objective.

The views expressed in research reports are the outcomes of the independent research, and should not be regarded as being the opinion or responsibility of the NZ Transport Agency. The material contained in the reports should not be construed in any way as policy adopted by the NZ Transport Agency or indeed any agency of the NZ Government. The reports may, however, be used by NZ Government agencies as a reference in the development of policy.

While research reports are believed to be correct at the time of their preparation, the NZ Transport Agency and agents involved in their preparation and publication do not accept any liability for use of the research. People using the research, whether directly or indirectly, should apply and rely on their own skill and judgement. They should not rely on the contents of the research reports in isolation from other sources of advice and information. If necessary, they should seek appropriate legal or other expert advice.

Acknowledgements

The authors gratefully acknowledge the funding provided by the NZ Transport Agency, without which this research project could not have been undertaken.

We appreciate the expert guidance on scoping the study, as well as the helpful comments/feedback on the draft report from our peer reviewers, Professor Robert Cervero (Department of City and Regional Planning, University of California, Berkeley) and Todd Litman (Director, Victoria Transport Policy Institute, Canada).

We would also like to recognise the individuals in our steering group whose input and comments helped us to focus the output from this project into the areas of greatest interest and usefulness to them: Evelyn Légaré (Senior Corporate Policy Officer, VicRoads); Anna Sunter-Daniels (NZTA); Haobo Wong (Ministry of Transport) and Anna Percy of the Office of the President, Republic of Kiribati (formerly Organisational Strategy Manager of Auckland Regional Transport Authority).

Important technical support came from a variety of sources, including: Philip Corr (PermissionCorp/ SmileCity – transferring survey to internet, managing sampling and data collection); Lynley Povey (Ministry of Transport – NZ Household Travel Survey); Dean Edwards (Statistics New Zealand – additional variables created from 2006 NZ Census); Karen Witten (Massey University – New Zealand-based walkability/accessibility indices); Erel Avineri and Thomas Calvert (Centre for Transport & Society, University of West England – fieldwork design, subsequent data analysis and interpretation) and Heather Carew (NZ Transport Agency editor). Our research and report are the better for your role in it.

Abbreviations and acronyms

A/SA	agree/strongly agree
A/W	Auckland/Wellington
AKL	Auckland
CAU	census area unit
CBD	central business district
D/SD	disagree/strongly disagree
MV	motor vehicle
NZ	New Zealand
NZTA	New Zealand Transport Agency
RSS	residential self-selection
VKT	vehicle kilometres travelled
VMT	vehicle miles travelled
WLG	Wellington

Contents

Executive summary

In New Zealand, the largest cities have experienced significant growth in inner city residential populations over the last 15 years, partially as a direct result of local authority planning changes attempting to curb urban sprawl and to integrate land use and transport. It is widely held that encouraging people to live in intensified housing situations will provide transport and other benefits, including encouraging the use of environmentally friendly transport modes and reducing the need to own and use a passenger car.

In this research project we focused on the inner city experience of urban intensification in New Zealand to ascertain its impact on people's travel behaviour, mode choice and household vehicle ownership. We explored the roles of different aspects of the built environment and compact development, residential self-selection (neighbourhood preferences as well as the effect of shifting from one type of neighbourhood to another) and attitudes that affected travel patterns and vehicle ownership.

Methodology

The methodology utilised a combination of an international and New Zealand-based literature review; an analysis of secondary data and accessibility and land-use indices; and an online survey of inner city and non-inner city residents in Auckland and Wellington to gather primary research data.

Key findings

Inner city residents do more walking for transport

A core finding from our fieldwork and analysis of existing datasets was that inner city residents were more likely to walk and less likely to drive for any trip purpose than residents living elsewhere in Auckland/Wellington cities and metropolitan areas. Based on our examination of the accessibility and land-use indices, we surmised this was largely because more potential destinations were within walking distance. We found that walking and/or public transport use was substituted for driving trips for work, study and supermarket shopping in inner city Auckland/Wellington, compared with lower density Auckland/Wellington cities and metropolitan areas. We suspected this would have an impact on overall vehicle kilometres travelled, but did not measure it in our study.

In line with the literature review findings, there was no notable difference in the amount of walking and cycling for recreation, sport, exercise or leisure between inner city Auckland/Wellington residents and other areas in our sample population.

Inner city residents own fewer household vehicles

No matter how measured, whether by the number of vehicles per household, by the ratio of vehicle:adults, or by age group, inner city residents had demonstrably fewer vehicles per household in our sample and in the 2006 Census. In our study population, the median increased from 0.5 vehicles per adult in the inner city to 0.67 in the Auckland and Wellington cities and 1.0 in the Auckland and Wellington metropolitan areas.

Fewer vehicles led to greater walking, particularly in areas with a good walkability and destination accessibility. Sixty percent of inner city Auckland and Wellington households with zero vehicles walked for transport at least 10 minutes at a time on five to seven days compared with 31% of inner city households with one or more vehicles per adult.

Effect of built environment and density

Our analysis of 2006 Census data indicated that, *on their own*, neither the population nor employment density of major New Zealand cities appeared directly correlated with the choice of mode for the *journey to work*.

As suggested through our review of the international literature, we consider that density works in conjunction with the mix of activities/destinations in an area and destination accessibility to affect travel patterns and vehicle ownership. The indices we reviewed (Walkability Index, Neighbourhood Destination Accessibility Index, and Walk Score) all confirmed Auckland and Wellington inner city areas are highly accessible and walkable, particularly when compared with surrounding suburbs or ones located further away.

Effect of preferences and attitudes

We found the attitudes of respondents to our survey mirrored their revealed mode use and choice of residential neighbourhoods. Dissonant Suburbanites (who would prefer to live in the inner city but lived in the metropolitan area) drove less frequently, and walked and used public transport more often than the True Suburbanite respondents (who preferred to live and actually did live in suburban metropolitan areas). Similarly, Pro-Green Travellers reported travel behaviours that one might expect from an environmentally minded population segment; they drove vehicles far less often to the supermarket and to work/study, and generally drove less than Committed Drivers, irrespective of where they lived.

Thus, while inner city residents in our dataset definitely drove less and walked or used public transport more often than Auckland and Wellington city or metropolitan area residents, population segments who shared the same neighbourhood preference for inner city living and/or environmental attitudes (ie Pro-Green Travellers, True Urbanites and Dissonant Suburbanites) – *irrespective of where they lived* – exhibited travel behaviours and vehicle ownership patterns very similar to those actually living in the inner city.

It could be said that their attitudes are an important determinant of their mode use, rather than the built environment, although the built environment *facilitates* residents to actively demonstrate their favoured travel and vehicle ownership behaviours.

Policy implications

We found that density on its own was insufficient to explain the travel behaviour and vehicle ownership patterns of inner city residents. However, we observed that inner city Auckland and Wellington residents in mixed-use settings with many destinations nearby tended to walk far more and drive less than when they lived or if they lived in (lower density) suburbs with fewer destinations and lower destination accessibility. This has potential benefits for society, such as improved public health (and reduced health care costs) from a more active lifestyle, opportunities for creating more vibrant urban districts as an economic stimulus, building social capital and natural surveillance through having ‘eyes on the street’, mobility benefits from less road expansion and land conservation due to urban sprawl abatement.

Our fieldwork suggested that attitudes towards the environment and different modes (eg walking and driving) and neighbourhood preferences also played an important role in determining travel behaviour and vehicle ownership patterns. We found that largely exogenous factors, ie not having to do with neighbourhood attributes, explained residential shifts. Proportionately more respondents were Dissonant Suburbanites than Dissonant Urbanites, implying a latent demand for residential locations with suitable

housing options and greater destination accessibility (that would in turn facilitate walking, cycling and public transport use over driving).

As a caveat, it should be recalled that the overwhelming majority of those whose residential preferences could be classified were True Suburbanites, who did not want to live in the inner city, preferred living in a suburb, and were quite content to drive to their destinations.

Taken together, all of these factors suggest inner city – and the immediately surrounding suburbs – planning and policy should focus less on creating density and more on targeting inner city housing and location opportunities to the kinds of market niches drawn to these settings. The current population mix living in these areas in Auckland and Wellington, ie 'generation-Xers' (students and young professionals) and 'empty-nesters' (middle-aged and older people, without young children), suggest possible niche markets for whom neighbourhood attributes apparently do not weigh heavily in relocation decisions to the central city. Planning and policy development could take the form of changing building and zoning codes in order to build the type of accommodation that appeals to these niches or to attract/maintain a high level of destination accessibility (eg more retail, educational, recreational, entertainment, workplace and other destinations) in inner city locations. Car-sharing could be promoted and increased to provide flexible access to a car on an as-need basis to central city households to serve those without cars and those who may wish to reduce car ownership. This might mean facilitating the re-location of 'destinations' from suburbs to central city residential districts that are accessible by walking, cycling or public transport. Environmentally friendly mobility (particularly driving less and walking more) thus happens to be a fortunate by-product for both those making the move and for the city as a whole.

Abstract

In this research project we used a combination of a literature review; an analysis of secondary data and accessibility indices; and an online survey of inner city and non-inner city residents in Auckland and Wellington to examine the impact of urban intensification on people's travel behaviour, mode choice and household vehicle ownership.

A core finding was that inner city residents were more likely to walk and less likely to drive, for any trip purpose, than residents living elsewhere in Auckland/Wellington cities and metropolitan areas. Inner city residents also had demonstrably fewer vehicles per adult in the household.

Our analysis of 2006 Census data indicated that, on their own, neither the population nor employment density of major New Zealand cities appeared directly correlated with the choice of mode for the journey to work. Rather, our review and primary data analysis determined that density worked in conjunction with the mix of activities/destinations in an area and destination accessibility to affect travel patterns and vehicle ownership. In addition, we found that attitudes and neighbourhood preferences (self-selection) were important determinants of mode use, rather than the built environment, although the built environment facilitated residents to actively demonstrate their favoured travel and vehicle ownership behaviours.

1 Overview

1.1 Background

In New Zealand, the largest cities have experienced significant growth in inner city residential populations over the last 15 years, partially as a direct result of local authority planning changes attempting to curb urban sprawl and to integrate land use and transport. It is widely held (see for example PHAC 2010; Litman 2004 and 2011) that encouraging people to live in intensified housing situations will provide transport and other benefits, including:

- encouraging the use of environmentally friendly transport modes
- increased levels of physical activity
- reducing the need to own and use a private motor vehicle
- reducing public infrastructure and service costs by providing savings on roads, school transportation, delivery services and parking facilities, as well as water, sewage, rubbish collection and utilities
- improved health and well-being. A recent Public Health Advisory Committee (PHAC 2010) review found evidence to suggest people become more isolated in low density development (where typically more time is spent in cars and less is spent walking); less time is spent in 'civic engagement' and there is a weakened sense of community. People are more prone to social exclusion, particularly where they do not have access to a car. In communities with greater social cohesion, people tend to have better cardiovascular and psychological health and live longer
- better air quality (as a result of reduced emissions to air and atmosphere) and better water quality due to less runoff.

However, there has been little evidence to support these suppositions in New Zealand, and indeed some suspicion that, while they may be succeeding in providing high density accommodation, local authorities are not achieving the desired transport outcomes (Percy pers comm 3 March 2008). For example, recent work in New Zealand (Syme et al 2005) considered the wider social implications of housing intensification in the Auckland region, including 'access to service and amenities', providing qualitative evidence to suggest that people living in intensified areas valued the proximity and ease of access to services and facilities. However, the research did not consider the impact on overall car use and ownership and mode choice (walking was a preferred mode), and found that 'there is large body of literature and much contentious debate about the effect of urban form on passenger transport use (and travel patterns generally)'.

Thus, although people clearly value the proximity to services and facilities that arises from inner city living, not much is known about the people who live in these intensified areas (apart from some of the more common demographic characteristics), and whether or how their travel behaviour is actually different than it would be if they lived elsewhere. Nor do we know it they are committed to the inner city lifestyle, or if it is a temporary residential location until they can afford a house in the suburbs.

While there are broader questions around the contribution of urban intensification to sustainability, in this research project we focused on its impact on people's travel behaviour and mode choice. Hence, in the proposal the stated purpose of the fieldwork was to draw on the inner city experience of urban intensification in New Zealand to ascertain:

- How would people's travel behaviour differ if they lived in a suburb? (eg would they drive or use public transport instead of walking?)
- Does living in inner city areas affect people's car ownership and car use?
- Are people choosing to live in intensified areas more 'self-selected' (eg in terms of their attitudes/ lifestyle aspirations/life-stage) than those who choose to live in a suburb? Would they choose to live in a suburb in the future? What factor(s) would cause them to shift – are any of them transport related?
- Do people live where they work and play? Do residents 'reverse travel' to other city centres or suburbs for work, recreation, etc?
- Do people use public transport or are there other reasons for locating in the inner city?
- Do different kinds of inner city developments (eg apartment towers vs low-rise developments with some landscaping) impact differently on transport use?

To address these questions, we planned to:

- conduct a review of international and New Zealand-based research on urban intensification (also known as smart growth), particularly examining the effect on travel behaviour and the transport system and information about the types of people who live in intensified environments
- analyse existing data, eg 2006 Census for journey to work, Auckland and Wellington household interview survey and/or New Zealand Household Travel Survey (NZHTS) data, as appropriate, to identify underlying trip-making patterns and mode choice of inner city residents
- undertake primary research (fieldwork), involving inner city residents, to explore underlying causes (eg attitudes, life stage) of their travel behaviour and how it would be affected if they located elsewhere.

1.2 Structure

This paper is structured as follows:

- Chapter 2 outlines the research methodology for this project.
- Chapter 3 summarises the findings from our review of international and New Zealand-based research on urban intensification, the built environment, residential self-selection and travel behaviour.
- Chapter 4 presents the analysis of existing datasets.
- Chapter 5 examines some land-use indices and mapping for Auckland and Wellington.
- Chapter 6 analyses the data collected from the online survey of Auckland and Wellington residents conducted for this project.
- Chapter 7 discusses the combined results of the various research strands and our conclusions.

The report also contains five appendices including a glossary.

2 Methodology

The methodology utilised a combination of literature review, quantitative analysis of secondary data, and an online survey of inner city and non-inner city residents in Auckland and Wellington to gather primary research data.

2.1 Literature review

We conducted an extensive literature review incorporating terms such as urban intensification, (residential and population) density, reverse commuting and reverse travel, residential self-selection, built environment, smart growth, vehicle ownership and so on. The search incorporated English language electronic databases (including TRIS Online, Google, Google Scholar, etc), transport-related websites, online bibliographies (such as Victoria Transport Policy Institute TDM Encyclopaedia), reference lists in documents/publications/reports, references held by our peer reviewers, and Pinnacle Research & Policy Ltd and Ian Wallis Associates' archives of published and unpublished documents and reports. Within the search, we sought, among other things:

- evidence of causality (as opposed to correlation) and its 'direction', eg whether neighbourhood or suburb characteristics, such as density, mix of land use and street connectivity influence travel behaviour or whether travel preferences influence the choice of neighbourhood
- specific reference to the effect on travel behaviour (mode use and/or share, trip frequency, trip length, etc) and/or the transport system
- information about the 'types' of people, based on demographics, attitudes, beliefs and behaviour, who live in intensified environments.

We also contacted known experts in the field for access to unpublished research, clarification, etc. We prepared a synthesis of literature review, which is found in chapter 3. A summary of the key articles reviewed (and those specifically excluded) is attached as appendix B.

2.2 Analysis of existing datasets

We originally proposed to analyse existing datasets, such as 2006 Census data (which includes data on the 'main means of travel to work'; and regional or national travel data from Auckland and Wellington surveys and the NZHTS, to identify underlying trip patterns and mode choice and to identify possible population segments (households) for the fieldwork phase of the project.

To this end, we investigated three different travel survey datasets for their potential to analyse underlying trip patterns and mode choice, namely the NZHTS – July 2003 to June 2008 data, Auckland Household Travel Survey (collected in 2006) and the Greater Wellington Household Interview Survey (collected in 2001). Ideally, we wanted to be able to compare inner city household travel patterns with those of people living in the suburbs of each particular city. Unfortunately, even adopting the broad definition of 'inner city' used by Statistics NZ in its apartment dweller analysis (see below), there were insufficient sample sizes in any of the datasets:

- The NZHTS in years 2003–2008 included fewer than 25 households total in the inner cities of Auckland, Wellington and Christchurch.
- The Auckland Household Travel Survey included 11 households in the Central Auckland area. We considered including households from other city centres, such as Takapuna, North Shore City and Henderson, Waitakere City, which had 41 and 103, respectively in the survey. However, according to ARTA (2006), these areas could not be considered 'intensified' in the same way as Auckland central because they had much lower population densities. Auckland city central business district (CBD) had 211 persons per hectare net, compared with Henderson (15 persons per hectare net) and Takapuna (18 per hectare net).
- The Greater Wellington Household Interview Survey included 24 households living in the inner city area.

The 2006 Census of Population and Dwellings data proved to be a better source of information regarding the inner city areas of Auckland, Wellington and Christchurch, particularly as Statistics NZ has prepared several relevant reports (eg Statistics NZ 2010, 2009a–c; Goodyear 2008). The 2010 report, *Apartment dwellers: 2006 Census*, compares and contrasts the characteristics of inner city and non-inner city apartment dwellers in the three main cities of New Zealand (Auckland, Wellington and Christchurch). It updates an earlier report (Statistics NZ 2006) based on the 2001 Census. Travel behaviour data is very limited: apart from journey to work and motor vehicle ownership data, the census did not collect any information regarding trip patterns or mode choice. However, it does provide demographic descriptions of households and individuals living in the (broadly defined) inner city areas of Wellington, Auckland and Christchurch. Highlights from the Statistics NZ report are discussed in section 4.2 along with some additional analysis we completed using the 2006 Census data.

We also accessed Auckland primary, intermediate and secondary school roll survey data, gathered from schools which had developed and implemented school travel plans, in an attempt to compare the travel patterns of students attending Auckland inner city schools with those attending schools outside the area we defined as central Auckland. The outcome of this analysis is reported in section 4.3.

2.3 Analysis of walkability and accessibility

As part of our preparation for the fieldwork, we intended to perform land-use analysis of the case study areas to rate land-use mix, the qualities of 'walkability' and, if feasible, 'cyclability', and other factors considered to affect multi-modal accessibility. To this end, we were able to draw on recently completed research by Mavoa et al (2009) who constructed three neighbourhood-level indices (Walkability Index, Neighbourhood Destinations Accessibility Index, and Land-use and Public Transport Accessibility Index) for four New Zealand cities, including Wellington city.

We also assessed the 'walk score' using the publicly accessible www.walkscore.com website, which calculates the walkability of an address based on the distance from the residence to nearby amenities, assigning a score between 0 and 100.

We had proposed to undertake regression analysis to isolate the effects of each factor on walking and cycling accessibility, if feasible, but the lack of modal use data for the inner city pre-empted this.

2.4 Exploratory fieldwork

2.4.1 Source of data: online survey panel

We originally proposed to undertake in-depth interviews with 30 to 36 selected households in Auckland and Wellington. However, given the lack of data to undertake comparisons between inner city residents' and suburban residents' travel patterns and mode use, we revised our methodology to incorporate an online self-completion survey, with a target sample size of 600 respondents, with a minimum of 120 of these recruited from the inner cities of Auckland and Wellington and the remainder from the greater metropolitan areas of Wellington and Auckland. While still exploratory in nature, the online survey could provide a greater insight into distinctions between those living in intensified areas and those not. To allay a concern expressed by the steering group that relying on an online survey might result in a bias in the sample towards those who were more comfortable with electronic media (eg younger tertiary students or professionals on a higher income), we were able to compare our respondent sample with 2006 Census data to ascertain how representative it was of the wider population in the inner city and metropolitan areas.

The online survey was hosted and conducted by PermissionCorp, using its research panel SmileCity, which is considered to be representative of the New Zealand population and have good response rates. SmileCity fully complies with ESOMAR, the international research organisation, standards and principles in the conduct of online market and social research, as well as with the ISO 20252 Market and Social Research Standard.

Further to the concern regarding possible bias in the online sample, we noted that a recent survey suggested home-based internet access had become the 'norm' in New Zealand: some 80% of households in Auckland and Wellington regions had access to the internet *at home* in 2009 (Statistics NZ 2010)[1]. If access to the internet at work or other locations was included, this figure would be much higher. Indeed, 80% of all New Zealanders aged 15+ reported having used the internet at least once in the last 12 months. The older age groups (aged 65+) showed a much lower propensity to use the internet, but as the focus of the study was primarily on those working or studying, and who were most likely to be younger than age 65, this was not considered too great an issue.

2.4.2 Development and content of online survey

While the development of the online survey took into account the findings of the international and New Zealand literature review, we were particularly cognisant of the qualitative research project that took place in Auckland in 2008 where Carroll et al (2011) conducted in-depth face-to-face interviews with 11 families in inner city Auckland. The study objectives included understanding the 'everyday experiences of parents and children living in apartments in inner city Auckland' and to identify the factors that supported family life (eg dwelling and/or neighbourhood characteristics) and to evaluate whether or not inner city apartment living in Auckland was a feasible long-term solution for families. While the total number of families interviewed was very small (and could in no way be considered representative of either families or the more general population of Auckland's

[1] The Household Use of Information and Communication Technology (ICT) Survey collected information from New Zealand households and individuals about access to, and use of, computers, the internet and mobile phones. The survey was carried out from October 2009 to January 2010 (the December 2009 quarter) via personal and telephone interviews, achieving a response rate of 80%, which represented 13,713 households.

inner city)[2], the discursive nature of the interviews allowed a reasonable amount of information to be gathered on the families' travel behaviour while living in the inner city.

For example, Carroll et al (2011) found that interviewees had moved to the inner city to reduce transport costs, to be close to work, schools, shopping, and other amenities or services, even though several of them were paying more for their housing. In 10 of the 11 families, the move was regarded as temporary, with the goal to be living in a house in the suburbs. This raised possible additional questions for exploration in our survey:

- What are other demographic groups' perspectives on living in the inner city? Is it temporary or somewhere they intend to stay? Do people living in other urban areas regard their location as temporary or are they aspiring to live elsewhere?
- Do people change their travel behaviour to fit the environment or will they use the same travel methods no matter where they live?

Following the literature review, we sought input from our external peer reviewers and finalised objectives for the fieldwork (refer to section 3.8.3) and the questionnaire (available in appendix C).

2.5 Analysis and preparation of final report

On completion of survey data collection, we analysed the data in conjunction with the other secondary data analysis and literature review results. The results of our analysis are presented in this report, which has been externally reviewed and signed off by two peer reviewers and reviewed by our steering group.

[2] From the census, we knew that these people were not 'representative' of most inner-city dwellers (who are 20 to 29 years old, and more likely to be single and/or students).

3 Literature review: urban intensification, self-selection and travel behaviour

3.1 Overview

We inspected more than 200 studies relating to the built environment or compact development, density, and/or self-selection and travel behaviour. Over half were excluded from further analysis for various reasons, most notably that the content was 'out of scope' for this project.

We found that many studies (particularly those using complex models) simply did not provide enough information to judge whether their results were statistically valid. We join Brownstone (2008) in exhorting editors and referees to require more thorough description of model output.

Ninety-eight were finally included in the analysis. Of these, 11 were New Zealand-based studies comprising descriptive analysis, and a further 22 were largely descriptive reviews of earlier studies (as opposed to a meta-analysis). A handful contained interesting points or background data but were not 'case studies'. Appendix A contains a table summarising the key attributes of the remaining 58 empirical studies and meta-analyses included in the literature review, ie it outlines the primary factors examined, the data type, study site, data (usually the sample size) analytical method(s) employed, and any factors controlled for, particularly residential self-selection. Where an empirical study controls for other factors, it reduces the likelihood of spurious and confounded inferences. Most studies employed cross-sectional data. Two-thirds (66%) of the studies did not control for self-selection and 36% did not control for other factors.

A synthesis of the study and review findings are reported in the following sections, while a brief summary of each document is provided in appendix B.

3.2 Factors affecting transport-related walking and vehicle kilometres travelled

We use the terms 'compact development' and 'built environment' to distinguish them from residential or employment 'density'. Compact development (also known as new urbanism or smart growth) is associated with regional accessibility, mixed use, transport system diversity, and/or parking management and, sometimes, density. The built environment particularly refers to factors such as street connectivity, accessibility, pedestrian/cycling facilities, and availability of public transport (eg stops or stations, frequency and routing of services, transit-oriented development). Clearly there is overlap between built environment and compact development factors, hence we have considered them together.

3.2.1 Compact development/built environment

Overall, urban environments, where land use is a 'mix' of shops, services (including transport facilities), places of employment and residences so that shops, services and places of employment are in reasonably close proximity to residential areas (usually within a 0.4 to 0.8km radius), encourage transport-related walking trips (Handy and Clifton 2001; Cao et al 2005a, 2005b and 2009; Handy et al 2006; Cao 2006; Frank et al, 2005; Lund 2001; Saelens and Papadopolous 2008; Saelens and Handy 2008; Lee and Moudon

2006). In Auckland, New Zealand, living close to place of employment decreased vehicle commuting and increased walking (Badland 2007).

In 2003, Holden (2007) conducted a survey of individuals (aged 17+) residing in eight residential areas in Oslo, Norway. Questions were asked about the consumption of energy and transport. Holden reported the distance to the city centre and proximity to private and public services affected energy consumption for everyday travel (living further away engendered the use of more energy), and density, distance and local mix of services were strongly correlated. Holden suggested high density, close proximity to the centre, and good/high local mix of services (ie compact development) should be combined to reduce energy consumption in transport.

Recreational walking trips do not appear to be affected by the built environment: Lund (2001) and Lee and Moudon (2006) found no strong relationship between the frequency of 'strolling' walk trips and the built environment. Lund reported the top two reasons for strolling were to get exercise/fresh air/relax and to walk children or dogs. Cao et al (2005a) also found having a pet to walk was the most prevalent factor affecting the frequency of strolling walk trips. More recently, Saelens and Handy (2008) reviewed 13 reviews published between 2002 and 2006, along with 29 original studies published in 2005 and 2006, to consider the evidence of built environment correlates and walking for transport or recreational walking. While there were positive relationships established for density, land-use mix, connectivity and transport-related walking, the results for recreational walking were equivocal.

With specific reference to cycling and pedestrian facilities or networks, Krizek et al (2009) published a comprehensive review of international walking and cycling literature prepared for the Victoria Department of Transport, Australia. The project team reviewed over 300 articles, papers and reports with the specific aim of providing professionals and other researchers with an understanding of the barriers to walking and cycling, as well as the infrastructure and policy supports for non-motorised transportation. They observed that street patterns (eg connectivity, pedestrian facilities, footpaths) were important in some studies and not in others. Krizek et al (2009) concluded this might be a measurement issue or it may be due to the use of space (for instance in suburban areas pedestrians may cut through large blocks on paths not identified in the data collection nor known in most network measures). Infrastructure such as sidewalks and lighting was considered to have some importance in travel walking but merely building a sidewalk would not make an environment walkable. Related to this, in The Netherlands Snellen (1999) found having local facilities was no guarantor that they would be the destination of inhabitants, who chose to use the car to travel further afield.

More recently, Ewing and Cervero (2010) completed a meta-analysis involving more than 200 studies of the built environment and travel behaviour. Where there was good data on travel choices, they quantified the effect sizes on travel behaviour, while controlling statistically for confounding influences (particularly demographics). In total the data in 50 studies was analysed in this way. Ewing and Cervero found street connectivity and percent of four-way intersections (with a weighted average elasticity of -0.12) were much more relevant to vehicle kilometres travelled (VKT) than either employment or residential density. Similarly, the meta-analysis pointed out impacts of mixed-use were mainly through the shortening of travel distances, which reduced job accessibility by auto (-0.20) and distance to downtown (-0.22). Shortening travel distances and the distance to downtown reduced VKT, the strongest correlate of resource consumption in the urban transport sector. The propensity to walk was most strongly influenced by street connectivity (0.39 – increased connectivity increased the amount of walking); the distance to a shop (0.25) and the jobs-housing balance (0.19).

Goldberg et al (2007) found respondents traded off living in a walkable built environment against affordability, school quality and perception of crime (personal safety).

3.2.2 Employment and residential density

Cervero and Murakami (2010) examined assembled data from 370 urbanised areas in the USA, and found doubling population density was associated with a 60% decline in vehicle miles travelled (VMT) per capita. However, this was tempered by positive indirect effects (higher road infrastructure density, greater local retail accessibility and urbanised area size), yielding a net, or total, elasticity of -0.381 (meaning that a 1% increase in density resulted in a 0.381% decline in VMT). In a different literature review, Litman (2010) found a 1% increase in population density was associated with a 0.58% reduction in VKT. Maat and Timmermans (2009) also found that increasing residential density in 57 residential neighbourhoods in The Netherlands resulted in fewer kilometres travelled (by any mode), but this was offset to some degree by an increase in the frequency of trips made for other activities. In California, Chatman (2003) found that increases in either residential or workplace density reduced the likelihood of vehicle commuting, although increased residential density, employment in the retail industry, or employment density within a residential area did not affect the amount of personal commercial travel. Increased workplace density of 1000 employees per square mile decreased vehicle commuting by 3% while increasing residential density by 1000 households per square mile reduced the likelihood of vehicle commuting by 12%.

Several studies concluded that *higher residential density* increased walking for transport (Forsyth et al 2009; Li et al 2005; Saelens and Handy 2008; Naess 2009; Chapman and Frank 2004). Krizek et al (2009) concluded that *overall density*, which is related to the clustering of destinations including other housing units, was associated with travel walking in most, but not all, studies.

Examining aggregate data for 31 cities, Van de Coevering and Schwanen (2006) found residents in higher density cities tended to travel fewer VKT, and population size was positively correlated with the average commuting distance and commuting time. They noted the 'centrality of employment' had an effect, in that the higher the percentage of jobs in the CBD, the lower the distance travelled by car, the shorter the overall commuting distances, the larger the distances travelled by public transport and the longer the commuting times (reflecting that more trips were taken by the slower modes of public transport, walking and cycling). Van de Coevering and Schwanen (2006) found evidence suggesting the proportion of workers within the population influenced mode use, not just urban form.

In their meta-analysis (described in the previous section), Ewing and Cervero (2010) found once other factors were statistically controlled, population and employment densities exerted relatively small impacts on travel. Job density, in fact, was found to have no influence on VKT, although it did positively influence walking and public transport use.

Using longitudinal data from Puget Sound, Washington, USA, Krizek (2003) found reductions in VKT and no change in other mode use where there was greater population density. He posited that the reduction in VKT could occur because in such areas locations might be closer to more destinations, rather than because walking or other mode use was substituted for driving trips. In a Dutch study involving neighbourhoods in nine cities (N=344 households; 586 respondents), Snellen (1999) found density was not an important determinant of mode use. Rather, the availability of a vehicle for use was a strong influence in mode choice, as was distance to facilities such as shops and services (where short distances favoured non-motorised modes.

Examining the effect of density on vehicle trips (rather than VKT) using a subset of data from Canada's 2005 General Social Survey (where the total dataset comprised 19,597 respondents), Turcotte (2008) found only about one-third of residents in very high density neighbourhoods made all their trips by car on the survey day, compared with more than two-thirds of respondents in low density neighbourhoods. Driver behaviour in (medium density) smaller urban areas was more similar to that of lower density suburban areas than to major urban areas (in a New Zealand context, this would be comparing New Plymouth or Tauranga with Auckland or Wellington). However, the overall patterns were very similar in urban areas of all sizes, ie the greater the distance from the city centre, and the greater the prevalence of traditional suburban dwellings and the lower the residential density, the higher the proportion of people who made either some or all of their trips by car as the driver or a passenger.

In the New Zealand context, Norman and Sanderson (2010) examined the relationship between a range of demand variables and the demand for public transport in 18 urban centres and found that on its own, increasing residential density by 7.3 people per hectare raised public transport uptake by one percentage point; however, in a multi-variable model, residential density (and workplace density) is insignificant, possibly because density, public transport use and walking or cycling are interrelated. Analysing the urban centres individually, Norman and Sanderson found that in the Auckland metropolitan area, as residential density (population per hectare) rose, public transport uptake rose and conversely as workplace density (workers per hectare) rose, public transport uptake fell (and active mode use increased). However, in the Wellington metropolitan model (including Kapiti Coast), neither residential nor workplace density were significant.

3.2.3 Street connectivity

Saelens and Handy (2008) reviewed 13 reviews and 29 original studies and found little or no correlation between connectivity and travel behaviour. In a multiple-method study (survey; two methods of self-report and accelerometer-wearing for seven days) of 716 participants in Minnesota, USA, Oakes et al (2007) and Forsyth et al (2009) found neither density nor street connectivity were statistically related to overall mean miles walked per day or increased total physical activity, although higher density was associated with greater walking for transport (compared with walking for leisure/exercise). The 'most obvious' finding was that people without cars walked for transport purposes at higher levels than those with cars.

Tal et al (2010) reviewed selected studies examining the effect of connectivity on VMT and made several pertinent observations, namely that studies:

- used different measures of connectivity, meaning comparability was compromised
- focused on street connectivity (excluding rail)
- focused on *residential* density (generally the origin of a trip), rather than *destination* density, where the latter may be an important factor in overall VMT.

Other studies reported that greater street connectivity, which is often related to higher residential density and mixed land-use areas (in other words, compact development), was correlated with travel behaviour, for example:

- Badland (2007) found more people walked to work in connected areas
- Cao et al (2005) determined that people walked more often to shops

- Frank et al (2005) found connectivity was positively related with the number of minutes of physical activity per week.

Based on reviews of various studies, Litman (2008) concluded a 10% increase in intersection density reduced VKT by 0.5%.

3.2.4 Proximity to public transport

Close proximity to public transport stops or stations is associated with greater public transport use (Cervero 2007). Ewing and Cervero (2010) estimated, through the data available in their meta-analysis, a weighted average elasticity of 0.29 for distance to the nearest public transport stop. The same elasticity was derived for the percentage of four-way intersections in the neighbourhood. As noted above, household/population density and job density exerted relatively modest influences (0.07 and 0.01 respectively) on public transport usage. Maat and Timmermans (2006) also showed increasing residential density and/or workplace density led to increased likelihood of public transport use and lower household vehicle ownership in The Netherlands.

3.3 Factors affecting vehicle ownership rates

Generally speaking, studies based in different countries (USA, The Netherlands and Chile) found household vehicle ownership rates were inversely correlated with residential density and/or mixed land use, so that households living in higher density environments had lower vehicle ownership rates (Maat and Timmermans 2006, 2009; Zegras 2007; Cao 2007; Bhat and Guo 2006). Cao (2006) reached a similar conclusion based on a selected literature review. Unsurprisingly, transport-related walking and cycling was found to increase as vehicle ownership rates declined (Holtzclaw 1994, as reported by Badland and Schofield 2005a).

The reasons for low ownership rates in a high density inner city area were explored by Melia (2007) who identified three groups (car-free choosers, car-free potentials and car limiters) that could be targeted for car-free developments in the UK. Among other things, he posited inner city dwellers could contain high proportions of these target groups and conducted a survey to prove or disprove this theory. Melia's survey of residents living in the high density, inner London borough of Camden found some respondents were 'car-free choosers' (choosing to live without a car by choice) and others were 'car-free potentials' (who had chosen or could choose to not own cars under certain circumstances). Car-free choosers tended to be younger in age, more commonly were single and had significantly higher incomes than other non-car owners. The reasons for their choices varied: most of the 118 respondents with zero cars in their household selected 'no need for a car' (87% gave this as their first or second reason) when asked 'What are the reasons why you live without a car?'; 'cost' was the second most common reason (83%). Sixty-five percent of the respondents without household cars had never owned a car and 30% had owned cars prior to living in London. Three-quarters (75%) lived without a car by choice. Half of those who owned cars were unwilling to give them up for any reason.

Intuitively, it would seem other built environment factors would also affect vehicle ownership rates: for example, higher density neighbourhoods tend to have better public transport access, better street connectivity, higher employment densities and better pedestrian environments, all of which may contribute to a reduced need for vehicle ownership. This was found to be the case in apartment-based living and living within 500m of an urban rail stop, which were associated with lower vehicle ownership rates per household in Santiago, Chile (Zegras 2007).

Cao (2007) found in California that those who owned fewer vehicles were more likely to live in 'high accessible' situations, including being close to transit services, having complete sidewalks and bike routes, easy access to the workplace and to a regional mall.

In The Netherlands, Maat and Timmermans (2006) found the higher the residential density and the closer to a rail station a household lived, the higher the probability that the household did not own a car. However, if there were two income earners present, the household was more likely to have at least one car.

Cao (2006) reviewed selected literature and concluded the available evidence suggested that households living in single-family dwellings, homogeneous and/or suburban types of neighbourhoods, typically located farther away from employment sites, tended to own more vehicles (and use them more often) than households living in denser neighbourhoods and/or closer to the CBD.

Similar to Maat and Timmermans (2006) and Zegras (2007), Litman (2010) reviewed selected studies finding that vehicle ownership rates and vehicle-miles travelled declined in households living within public transport zones (labelled 'transit zones' – areas within half a mile of a transit station).

Applying cluster analysis to Scottish Household Travel Survey data, Ryley (2005) posited that life stage not only may be correlated with residential density and vehicle ownership rates, it could be a causative factor. In Edinburgh, he observed that households with younger adults and no children were more likely to be located in higher density neighbourhoods located close to the city centre, own fewer vehicles and walk or cycle to work. As noted in section 3.3, Melia (2007) reported a similar finding for an inner city London borough. Ryley (2005) reported Edinburgh households with older adults and children in lower density residential areas (away from the city centre), had higher vehicle ownership rates, and adults tended to drive to work. Similarly, Bagley and Mokhtarian (2002) found increases in age, household size, the number of children and number of household vehicles, were negatively associated with living in high density Californian neighbourhoods.

While not providing any insight into vehicle ownership, Morrison and McMurray (1999) interviewed 67 Wellington, New Zealand, inner city apartment purchasers and found inner city buyers tended to be either younger, single, with no children, or to be older, in a relationship, with no children, than purchasers of single detached suburban properties elsewhere in the city. Over 60% of those in inner city apartments walked to work, compared with 10.5% of suburban dwellers.

We explored the relationship between demographic characteristics (particularly household size, age and life stage) and vehicle ownership rates of people living in higher density New Zealand neighbourhoods compared with lower density ones, working with Statistics NZ to extract information on this from the 2006 Census data. The results of this analysis are reported in section 4.2.3.

3.4 Effects of residential self-selection on travel behaviour

Cao et al (2009) reviewed 38 cross-sectional studies[3] which tested whether observed patterns of travel behaviour could be attributed to the residential built environment itself, as opposed to attitude-induced residential self-selection. Almost all of the 38 studies found a statistically significant influence of the built environment on travel behaviour remaining even after residential self-selection was accounted for. The influence of built environment diminished once residential self-selection was taken into account (hence if

[3] Cao et al (2009) noted that a few also adopted quasi-longitudinal designs.

residential self-selection was ignored, built environment effects would be over-estimated). Cao et al stated that it was unclear how big the 'true influence' of the built environment on travel behaviour was, speculating it was relatively small compared with socio-demographic and unmeasured variables.

Cao et al (2009) also found that it was not possible to specify the nature and extent of the causality between built environment and travel behaviour, particularly since the relationship appeared to vary by mode, trip purpose and population segment, and depended on what elements of the built environment were being captured (eg neighbourhood-specific characteristics such as density and land use mix versus regional location).

Krizek (2003) conducted one of the few longitudinal studies examined in this literature review, involving a panel of 6144 households in the Puget Sound, Washington, USA. Using a subset of 430 households who had shifted between different panel years, and after controlling for self-selection, Krizek found that 'neighbourhood accessibility' (measured as a combination of the three factors of density, number of employees for neighbourhood retail businesses, and block area), baseline travel behaviour, and baseline socio-demographic characteristics (income, number of vehicles, number of adults/children/employees) were all significant factors affecting travel behaviour, although the greatest influence was baseline travel behaviour. A neighbourhood with higher accessibility meant that residents were more likely to decrease VMT and personal miles travelled and to do more tours (home-destination-home) in a day. A household with higher VMT at baseline was more likely to reduce VMT when shifting residence.

In a cross-sectional study involving 999 San Diego and San Francisco residents, Chatman (2005) found that preferences for particular modes (eg choosing to live in a neighbourhood with good walking and cycling access to shops or other destinations) influenced travel behaviour (eg such households made fewer non-work car trips than the base population), thus reducing the size of estimated relationships between the built environment and non-work travel. However, following further analysis of the same datasets, Chatman (2009) reversed his finding and determined that the residential self-selection process did not strongly affect estimates of the built environment's effects on travel behaviour. To the extent that it did, the bias resulted in both underestimates and overestimates of the built environment's effects.

Examples of the effects of the relationship between self-selection, built environment and travel behaviour include:

- Schwanen and Mokhtarian (2007) found that people who valued commuting by modes other than private car tended to live in a neighbourhood with better accessibility to such modes. Households with fewer cars tended to live in higher density areas, closer to the CBD; those who valued their car as something more than a means of transport tended to live further away, where they could display their 'status symbol'.

- In other analyses of the same data, Schwanen and Mokhtarian (2005a and 2005b) found commute mode choice was affected when respondents resided in areas that were mismatched with their preferred neighbourhood type (eg preferring high density living but actually living in a suburb). For example, if residents preferred suburban neighbourhoods while living in an inner city one, they were more likely to drive a car to work than those who preferred and lived in the inner city (the latter were more likely to walk, cycle or use public transport). Schwanen and Mokhtarian noted about one-quarter of their sample (based in San Francisco neighbourhoods) was mismatched with their neighbourhood, suggesting a viable policy option for changing travel behaviour could be to improve the matching.

- In an Atlanta Georgia study involving two surveys, one about preferences and the other a trip diary, Frank et al (2007) found that individuals who preferred and lived in a walkable neighbourhood walked

most (33.9% walked) and drove 25.8 miles (41.5km) per day on average. Individuals who preferred and lived in car dependent neighbourhoods drove the most (43 miles/69km per day) and walked the least (3.3%). Participants drove less when located in more walkable environments regardless of their demographic characteristics, the importance of the selection factors tested and preferences for neighbourhood type.

- Modelling individual travel mode choices in a revealed preference survey, Braun (2009) found the more an individual (verbally) preferred good public transport access and city lifestyle, the higher the public transport and walk utility with respect to car, both as driver and passenger, and bicycle.

Van Wee (2009) agreed that understanding self-selection choices provided a greater insight into people's travel behaviour and the external effects of transport. However, van Wee argued that self-selection occurred in 'many more' ways than residential choice, including self-selecting for proximity to locations and activities (eg work or residential location, non-work destinations); availability of particular travel behaviour (mode choice, travel frequency, travel time, travel distances) or driver behaviour preferences; based on potential exposure to transport externalities (congestion, safety/risk, noise); and preferred vehicle choice. He argued that 'ignoring self-selection [in its broad sense] generally (but certainly not always) led to an overestimation of the importance of variables included in models for location choice and travel behaviour' (p290).

3.5 Attitudes and neighbourhood preferences

Handy et al (2005), conducting two different analyses in the same population area, reached somewhat contradicting conclusions. Through a multivariate analysis of cross-sectional data, they found the differences in travel behaviour between suburban and 'traditional' (high density, mixed use) neighbourhoods were largely explained by attitudes. The factor for car dependent attitude (perceived need for a car) had the highest standardised coefficient; and other attitudes were also significant: pro-bike or walk and pro-transit attitudes were negatively associated with driving, and the safety of car attitude and a preference for outdoor spaciousness were positively associated with driving. Based on the multivariate analysis, they concluded: 'With these attitudes accounted for, no measures of the actual built environment – neither accessibility measures nor perceived characteristics – were significant' (p439). However, a further quasi-longitudinal analysis of changes in driving and changes in the built environment (done by measuring changes for people shifting residence in the past year and comparing them with non-movers) showed significant associations between the built environment and travel behaviour, even after taking attitudes into account. Essentially, they concluded that residing closer to destinations and having available alternatives to driving was associated with a decrease in driving, even after taking neighbourhood preferences and travel attitudes into account.

Bagley and Mokhtarian (2002) developed a number of population segments based on preferences for neighbourhoods, travel and attitudes among other things. They found people classified as culture lovers, outdoor enthusiasts, pro-alternatives (to travel), pro-growth (of cities), pro-pricing (of travel), time satisfied, work driven, or pro-high density living were most likely to live (or want to live) in a high density or traditional neighbourhood. By contrast, those people labelled as adventurer, homebody, nest builder, relaxer, pro-drive alone or pro-driving had positive associations with low density or suburban neighbourhoods.

3.6 Do inner city residents live where they work and play?

We examined the available literature to ascertain whether or not inner city residents lived, worked and played in the inner city area they lived in.

3.6.1 Reverse commuting: where do they work?

The primary focus of research on the topic of reverse commuting has been on the creation of job access and reverse commute programmes in the USA, where there are areas with substantial inner city 'ghettos'. In this context, reverse commuting programmes aim to increase the accessibility and affordability of commuting to jobs located outside the central city area (Roberto 2008).

Little research attention has been paid to reverse commuting by people choosing to live in re-vitalised central city areas, although it has been acknowledged to occur (eg Project for Public Spaces Inc 1998; Cervero 2002). Cervero (2002), in examining the market demand characteristics of reverse commuting, found about 10% of all commutes in California's four largest metropolitan areas (Los Angeles, San Francisco-Oakland, San Diego and Sacramento) occurred in the reverse direction (eg central city to suburbs in the mornings); among low income workers, the share is closer to 20%. Ninety-five percent of the reverse commute trips were estimated to be by car.

Research in New Zealand has found the prevailing situation for inner city dwellers is to live and work in the same area: Morrison and McMurray (1999), while not specifically stating where the workplace was located, found that more than 60% of the 67 Wellington inner city apartment dwellers responding to their survey walked to work, with the mean journey taking 10.5 minutes. In a survey of people living in the central city area, Wellington City Council (2009) found the majority of respondents (73%) worked (in their main work) or studied in the central city area.

3.6.2 Reverse travel: where do they play?

Greenaway et al (2008) investigated the importance and meaning of social and recreational travel for all members of 12 Auckland households, a few of which were located in the Auckland central city area. Nine full days of trip-making by each household member were recorded in diaries prior to 25 in-depth interviews to discuss the importance of their social and recreational trips recorded during the nine-day period. Greenaway et al found participants highlighted the importance of social and recreational travel – much of which was conducted using a private motor vehicle – for maintaining family and social relationships (social cohesion) and for mental and physical health and well-being. They observed 'the importance of face-to-face personal contact meant that participants could not envisage any alternative forms of communication that could provide an adequate substitute' (p509) for many of the trips. This was true of all households interviewed, irrespective of where they lived.

Based on their analysis, Greenaway et al (2008) suggested a commonly held belief that if people can 'live, work and play' in the same neighbourhood, they will decrease their private motor vehicle use overall, may not be accurate given the 'essential nature' of social and recreational trips in people's everyday lives. From the resident's point of view, these trips may be difficult to forego or even substitute by different travel methods.

In the same Norwegian study discussed earlier, Holden (2007) explored the use of transport (and its energy consumption) during leisure time. Holden found density and access to a private garden (eg front or back yard) were highly correlated (in different directions) to airplane and motor vehicle travel during leisure time. People living in higher density situations tended to travel more frequently by plane for

leisure. At the same time, having access to a private garden reduced the desire to travel by plane or motor vehicle, reducing their overall energy consumption.

Holden also found, while having a 'green attitude' was a clear predictor of everyday mode use being environmentally friendly (eg walking, cycling and taking public transport), such an attitude did not seem to affect people's travelling for leisure activities as measured by long-distance leisure-time travel by airplane.

Snellen (2001) had similar findings to those of Holden (2007). Snellen conducted a study involving 355 households in 19 selected neighbourhoods in nine Dutch cities and found the potential of urban design measures to reduce trips made and overall kilometres travelled, and to induce a shift in the modal split, was limited. While differences in travel distance on weekdays were determined to be rather sizable for certain urban form characteristics (in combination with some socio-economic characteristics), there was strong evidence that these effects disappeared when weekend travel behaviour was taken into account.

3.7 New Zealand-based studies

3.7.1 Wellington

3.7.1.1 Morrison and McMurray (1999)

Morrison and McMurray (1999, p378) aimed to 'describe and account for the growth of the central city apartment block as it has emerged in New Zealand's capital Wellington'. As such, they provided a comprehensive description of the Wellington housing market and the inner city 'apartment boom' in the 1980s and 1990s. While not focusing on travel behaviour, they sought to answer the question:

> *Is this new and growing market for the downtown apartment simply an extension of the demand for the stock of single unit dwellings still physically close to the city or do the purchasers of inner city apartments differ in measurable ways?* (p378)

A survey of recent buyers of both inner city apartments and single detached suburban properties was conducted, with 67 respondents in the former group and 72 in the latter. Morrison and McMurray (1999) found inner city buyers were more likely to be younger or older than those buying in the suburbs; less likely to have children; more likely to be single if young or to have a partner if older than 45. Of these factors, not having children was found to be an almost 'necessary condition for inner city apartment occupancy', although their presence was not sufficient to require the purchase of a suburban dwelling.

Morrison and McMurray (1999) found the majority of movers, both to the inner city and suburbs (74% and 76% respectively), came from the suburbs within Wellington city – ie they were already living close to the city centre prior to making their recent move. Hence, they concluded 'the inner city apartment emerges as a close substitute for the inner city single dwelling within the city; the two are closely linked in the market, primarily by their sharing of a common quest for easy proximity to the city itself' (p390). Inner city apartments may not be a counter to 'urban sprawl', but rather an expression of a latent demand for residences (whether they were single-unit dwellings or apartments) located in the inner city.

Proximity to work place was established as an important attribute to both apartment and single-unit dwellers. Morrison and McMurray (1999) observed that over 60% of those in apartments walked to work, compared with 10.5% of suburban dwellers, and there was very little difference in the amount of travel time to work: 10.5 minutes for apartment dwellers and 13.6 minutes for suburban ones. Apartment

dwellers said they saved an average of 14.8 minutes travel time compared with single-unit dwellers who saved an average of 1.7 minutes as a result of shifting residence.

3.7.1.2 Wellington City Council (WCC) (2009)

In April–May 2008, Wellington City Council undertook a mail-back/online survey of 'central area' apartment dwellers (as defined in the Wellington City District Plan). The council received 1350 responses out of a possible total of 5500 (25% response rate). The purpose of the survey was to develop an understanding of who lived in the central city; what motivated them to live there and how they found the experience. Only 12% of the respondents lived with children, the remainder were couples (39%), single/one person household (32%) and group/flatmates (15%). Thirty-six percent indicated their previous residence was in 'central Wellington' or an 'inner city'; while 45% had lived 'in the suburbs'. It was not possible to determine, from the survey question, what proportion of people lived and moved within Wellington, other than for those who were specifically in 'another apartment in central Wellington' (24%) as the survey question asked 'in what type of dwelling did you previously live (ie the last place you lived before your current apartment?)' and offered choices such as 'a house in the suburbs'; 'a townhouse in the inner city'; and 'a house on a lifestyle block' among others.

To assess the validity of the survey results, we considered how representative the respondents were of Wellington's inner city population by comparing respondent demographics from this survey with the 2006 Census. Unfortunately, apart from the proportions of households living with children (which were the same in both), differences in questions, survey coding and reporting meant such comparability was limited. However, a couple of items are worth noting: 33% of the respondents to this survey were in the 16 to 34 age group, while the census indicated that 49% were in the 20 to 29 age group. Similarly, according to the census, full-time students formed 22% of the population in Wellington's CBD, while only 5% of the respondents to the Wellington City Council survey identified student as their 'main occupation'. These two points suggest the survey sample is not representative of the whole population.

Nonetheless, it provides some indications as to why respondents live in the inner city and the effect this has on their travel patterns. Respondents were asked to tick their three most important reasons for choosing to live in an apartment from a list of possible reasons. The four most common reasons selected were lifestyle and 'city living' (23%); to be close to work (20%); to be close to shops and cafes (11%); and low maintenance (11%). Affordability (5%) and close to public transport (3%) were only selected in a few cases.

The majority of respondents (73%) worked (in their main work) or studied in the central city area and 12% had work or study outside of the central area. Similarly, 78% of respondents did their grocery shopping in the central area. The most common response to 'what is the main way you usually travel to work' was walking (73%), followed by car (13% – could be driver or passenger) and bus (6%)[4]. The questionnaire asked respondents 'do you own a car?' to which 69% said yes and 31% said no.[5] One-third of the respondents owned bicycles. They were asked 'what would make you consider using your bicycle for

[4] Note that the way this question was asked ('what is the main way you usually travel to work?') gives a very general picture of how people travel to work. No guidance was given to respondents on how to choose 'main way' (eg the mode used for the longest time or longest distance, etc). Also, the categories for selection are somewhat ambiguous (particularly 'car' and 'passenger in a car') – driver is not a clear option and 'car' would be considered by some to exclude vans, motorcycles/scooters, trucks, etc, which perhaps should be included, if they are household vehicles.

[5] This question is ambiguous, as some people live in households which do have a 'car', but they did not personally own it, would quite correctly respond 'no' to this question. The use of the word 'car' potentially precludes ownership of other motor vehicles, such as motorcycles, scooters and vans or SUVs.

regular travel to work?' to which nearly one-half (46%) said 'nothing – I am unlikely to use my bicycle' and 21% said 'better cycle-ways along major roads'.

Respondents were also asked 'when do you usually use your car?' and offered three categories: 'weekdays only', 'weekends only' and 'both'. Forty-six percent said they used their vehicles on weekends only and 5% said they used them on weekdays only, while nearly half (49%) said they used their cars on both weekdays and weekends.

3.7.2 Auckland

3.7.2.1 Carroll et al (2011)

To gain insight into the experiences of families with children living in medium and high-rise apartment blocks in central Auckland, Carroll et al (2011) conducted in-depth semi-structured interviews with 11 parents from 10 households living in the inner city in 2008. Three of the households had no motor vehicle. They were asked about their experiences living with children in the inner city, benefits and drawbacks of apartment living, their social networks and sense of belonging and their ideas for improved family friendly facilities, both within apartment complexes and in the 'neighbourhood'.

When asked about the benefits of apartment living, the participants commented on the convenience of being close to work, schools, study and a range of public facilities and services. Most spoke of the ease of being able to walk everywhere, which contrasted with their former dependence on the car or public transport while living in the suburbs. Many spent less time commuting, which allowed more time with their children. Some participants thought their reduced reliance on car use was good for the environment. Affordability was a key consideration, and most found the higher inner city rents were offset by the much lower transport costs and in some cases, their living costs were lower now than previously.

Eight of the 10 households viewed their sojourn in apartments as temporary, and aspired to living in a house with a backyard.

3.7.2.2 Greenaway et al (2008)

This research was discussed in section 3.6.2.

3.7.2.3 Badland (2007)

Badland (2007) investigated associations between overall physical activity and transport-related physical activity (ie walking and cycling) and perceptions, health outcomes, urban design and socio-demographic variables. In North Shore city, Auckland, Badland (2007) found respondents who lived closer to their place of employment were most likely to engage in walking or cycling for commuting, particularly if the route was through a well-connected street network and was <5km long. Overall, 50% of respondents perceived they could commute by active transport modes for distances less than 5km. Ten percent of the sample actually did this on a regular basis. Those whose travel followed the most connected street networks were more likely to engage in active transport modes compared with those travelling on the least connected street networks.

Badland (2007) also found those who had unrestricted access to a private motor vehicle were less likely to undertake transport-related physical activity trips, although they were more likely to be classified as sufficiently active for health benefits, than those who reported no private automobile availability. Those without access to private motor vehicles were six times more likely to engage in walking or cycling as a

mode of transport to work/study and 10 times more likely to use active transport to their local 'convenience' shop, even though their overall physical activity levels were insufficient to be classified as active.

3.7.2.4 Syme et al (2005)

Syme et al (2005) considered the wider social implications of housing intensification in the Auckland region, including 'access to service and amenities', providing qualitative evidence (based on an analysis of 15 community surveys conducted between 1995 and 2004) to suggest that people living in intensified areas valued the proximity and ease of access to services and facilities. In some cases, this was the most important factor in choosing to live where they did. However, the research did not consider the impact on overall car use and ownership and mode choice (walking was a preferred mode), and found 'There is a large body of literature and much contentious debate about the effect of urban form on passenger transport use (and travel patterns generally)' (p41).

3.7.2.5 DTZ Research (2003)

DTZ Research conducted a survey of residents living in apartments in Auckland's CBD. There were 185 responses to the survey (no information is provided regarding response rate or the survey delivery mechanism). Sixty-seven percent of the respondents were students and the majority had lived for less than two years in their current apartment. Most had moved there from a suburb in the immediate vicinity of the central city area. While less than half (46%) owned cars and 71% walked or jogged to work or study, when asked what features they would like their next apartment to have 53% said one car park and 40% indicated two car parks. Seventy-three percent indicated they would like to have a larger apartment next time.

3.7.3 Christchurch

3.7.3.1 Buchanan et al (2006)

Buchanan et al (2006) explored the relationship between urban form and transport in Christchurch through an analysis of census journey to work data from 1991 to 2001. They found low density suburban areas generated, and received, the greatest proportion of private vehicle trips. A multivariate regression analysis found the key variable determining modal split and trip length was the distance the residence was located from the CBD.

3.7.3.2 Lilley (2006)

Lilley (2006) surveyed residents of medium density housing in Christchurch's inner Living Three ring to ascertain the acceptability and outcome of a development specifically designed to increase residential density. She distributed surveys to 103 units in the development, with 42 surveys being completed (in some cases, more than one respondent per housing unit completed the survey).

Most respondents (n=26) were 15 to 34 years old, with the remainder aged between 35 and 64. Prior to shifting to Living Three zone apartments, most (74%) had lived in detached houses and 43% had lived in outer suburbs. Unfortunately, respondents were not asked about their employment status or their previous mode of travel to work, although Lilley reported that currently 'half of respondents travelled to the central business district for work' (it was actually slightly more than half). Of the 22 workers, 11 travelled to work by car. Few of the households had bicycles and 'generally' they had as many motor vehicles as adults per household. Lilley found convenience of location and accessibility to services was not a strong consideration in the transport decisions of the survey respondents. Rather, she found there was a possible correlation between age groups and their transport choices (eg public transport was preferred by the younger age groups; private motor vehicle by those aged 34+). All age groups favoured shopping in

locations fairly close to their residence, although there was variation (by age group) as to which shopping area was favoured and the mode used to get there. Younger age groups wanted to access shops without having to use a private car. Lilley suggested further investigation of the possible age and transport choice connection.

3.7.4 Summary of New Zealand studies

In general, empirical studies from New Zealand appear to establish associative relationships between density, compact development and travel behaviour, more or less mirroring the broader international literature on built environments and travel. Inner city residents walked to work/studied more frequently than residents elsewhere in the cities, in part due to the high street connectivity and closer proximity of work/study places (Badland 2007; Carroll et al 2011; Syme et al 2005) and because they did not own cars. Some people valued the proximity and ease of access to services and facilities (Syme et al 2005; Carroll et al 2011; WCC 2009; Morrison and McMurray 1999). Lilley (2006) suggested young people in particular preferred walking to using a car in Christchurch.

In addition to the socio-demographics of inner city Auckland and Wellington residents, in chapter 4 we explore their vehicle ownership characteristics, journey-to-work travel, school travel, and whether workers work where they live, using the 2006 New Zealand Census data.

The fieldwork built on the information gathered, as discussed here and in chapter 4, following the objectives outlined in section 3.8.3.

3.8 Discussion and finalisation of fieldwork objectives

3.8.1 Summary of literature review findings

Table 3.1 summarises the factors examined (residential and employment density, destination accessibility (including compact development and built environment), network accessibility and public transport accessibility) in the literature review and how they affect household vehicle ownership, VKT and overall vehicle use, and walking and public transport use.

Table 3.1 Summarising literature review: how factors affect household vehicle ownership, car use (including VKT) and walking and public transport use

Factor	Definition	Travel impacts		
		Household vehicle ownership	**Motor vehicle use**	**Walking and public transport use**
(Higher) residential/ population density	People per unit of land area	• Increased residential density associated with lower household vehicle ownership (Maat and Timmermans 2006; 2009; Zegras 2007; Ryley 2005; Bagley and Mokhtarian 2002; Melia 2007; Cao 2007; Bhat and Guo 2006; and in a selected literature review, Cao 2006) • Snellen (1999) availability of a vehicle for use was a strong influence in mode choice whereas residential density was not an important influence	• Decline in VKT per capita (eg Litman 2010 – based on literature review; Maat and Timmermans 2009) • Small decline in VKT per capita (Ewing and Cervero 2010) • Reported elasticity of -0.381 (meaning that a 1% increase in density results in a 0.381% decline in VMT (Cervero and Murakami 2010) • Reductions in VKT and no change in other mode use (Krizek 2003) • Increasing residential density by 1000 households per square mile reduced likelihood of vehicle commuting by 12%. (Chatman 2003) • Residents in high density neighbourhoods make fewer of their trips by vehicle than residents in low density areas (Turcotte 2008)	• Increases walking for transport (Forsyth et al 2009; Li et al 2005; Saelens and Handy 2008; Naess 2009; Chapman and Frank 2004). • People living in higher density areas, *without a car available in their household*, walked for transport purposes at higher levels than those with cars (Oakes et al 2007; Forsyth et al 2009) • Increasing residential density in New Zealand by 7.3 people per hectare raises public transport uptake by one percentage point (Norman and Sanderson 2010) • Density not statistically related to overall mean miles walked per day (Oakes et al 2007; Forsyth et al 2009) • Density not a determinant of choice in mode use (Krizek 2003; Snellen 1999)
(Higher) employment density	Jobs per unit of land area		• Workplace density (increase of employees by 1000 per square mile) decreased vehicle commuting by 3% (Chatman 2003) • Small decline in VKT per capita (Ewing and Cervero 2010) • The higher the percentage of jobs in the CBD, then the lower the distance travelled by car, the shorter the overall commuting distances, and the larger the distances travelled by public transport (Van de Coevering and Schwanen 2006)	• Increase the likelihood of walking and public transport use (Ewing and Cervero 2010)

Factor	Definition	Travel impacts		
		Household vehicle ownership	**Motor vehicle use**	**Walking and public transport use**
(Better) destination accessibility or compact development	Proximity between different land uses (housing, employment, retail, services)	• Better street connectivity, higher employment densities, close proximity to public transport stops or stations (implying access to good public transport services) associated with lower vehicle ownership rates (eg Zegras 2007; Maat and Timmermans 2006; and following extensive literature review, Cao 2006) • Those who own fewer vehicles are more likely to live in 'high accessible' situations, including being close to transit services, having complete sidewalks and bike routes, easy access to the workplace and to a regional mall (Cao 2007)	• Increased job accessibility by auto (with a weighted average elasticity of -0.20) and reduced distance to downtown (-0.22) both reduce VKT (Ewing and Cervero 2010) • Living close to place of employment decreases vehicle commuting and increases walking (Badland 2007) • Distance to the city centre and proximity to private and public services affected energy consumption for everyday travel (living further away engendered the use of more energy) (Holden 2007) • 'Neighbourhood accessibility', baseline travel behaviour and baseline socio-demographic characteristics were all significant factors affecting travel behaviour, eg moving to neighbourhood with higher accessibility led to reductions in VMT and personal distance travelled (Krizek 2003)	• Having a 'mix' of shops, services (including transport facilities), places of employment and residences, so that shops, services and places of employment are in reasonably close proximity to residential areas (usually within a 0.4 to 0.8km radius of residences) encourages transport-related walking trips (Handy and Clifton 2001; Cao et al 2005a, 2005b and 2009; Handy et al 2006; Cao 2006; Frank et al 2005; Lund 2001; Saelens and Papadopolous 2008; Saelens and Handy 2008; Lee and Moudon 2006; Krizek et al 2009) • Recreation walking not affected by built environment (Lund 2001; Lee and Moudon 2006; Cao et al 2005a; Saelens and Handy 2008) • Snellen (1999) found having local facilities was no guarantor a location would be the destination of inhabitants
(Greater) street connectivity	Degree that walkways and roads are connected		• Street connectivity and percent of four-way intersections (-0.12) were relevant to VKT reduction (Ewing and Cervero 2010) • Based on reviews of various studies, Litman (2008) concluded that a 10% increase in intersection density reduced VKT by 0.5% • Saelens and Handy (2008) reviewing 13 reviews and 29 original studies found little or no correlation between connectivity and travel behaviour	• Krizek et al (2009) – comprehensive review concluded that street patterns (eg connectivity, pedestrian facilities, footpaths) were important in some studies and not others • Street connectivity (elasticity of 0.39), distance to a shop (0.25) and the jobs-housing balance (0.19) all positively increased the amount of walking (Ewing and Cervero 2010) • Oakes et al (2007) and Forsyth et al (2009)

Factor	Definition	Travel impacts		
		Household vehicle ownership	**Motor vehicle use**	**Walking and public transport use**
				found street connectivity was not statistically related to overall mean miles walked per day • Badland (2007) found more people walked to work in connected areas • Cao et al (2005a) determined that people walked more often to shops • Frank et al (2005) found connectivity was positively related with the number of minutes of physical activity per week.
Public transport accessibility	Access from home to public transport to destinations	• Higher residential density in conjunction with highly connected local street networks; apartment-based living and living within 500m of an urban rail stop were associated with lower vehicle ownership rates per household in Santiago, Chile (Zegras 2007). • See bullets under 'destination accessibility'	• Vehicle ownership rates and vehicle-miles travelled declined in households living within public transport zones (conclusions of literature review by Litman 2010)	• Close proximity to public transport stops or stations is associated with greater public transport use (Cervero 2007). • Ewing and Cervero (2010) estimated a weighted average elasticity of 0.29 for distance to the nearest public transport stop and for the percentage of four-way intersections in the neighbourhood. Household or population density and job density exerted relatively modest influences (0.07 and 0.01 respectively) on public transport usage.

Considered separately, the influences of density, compact development (built environment), street connectivity and proximity to public transport on household vehicle ownership, vehicle use, walking and public transport use appear to be somewhat inconclusive. With the exception of public transport accessibility, where a small number of studies report that greater accessibility reduces vehicle ownership, VMT and increases public transport use (and these appear to be confounded by other factors such as residential density and street connectivity), some studies find there is an effect and others report no or little effect. It is unclear whether this is due to the weaknesses of methodology or research design, including not controlling for residential self-selection or other factors such as demographic characteristics and/or attitudes; insufficient sample sizes; insufficient numbers of empirical studies across a broad range of urban environments located in different countries; 'apples-and-oranges' comparisons (eg some studies discuss walking for transport, others walking for leisure or non-work purposes, overall miles walked or number of walking trips) or some combination thereof.

Part of the difficulty lies in the fact that density tends to be accompanied by, and thus interrelated with, the various land-use and transport factors. For example, in higher density central city residential areas, with a greater mix of uses (including employment, retail and services), better street connectivity, walking and cycling facilities, destination accessibility, public transport service quality, traffic congestion and parking pricing all tend to increase together, resulting in reduced vehicle ownership, reduced VKT and increased use of alternative modes. Such higher density areas often have quite different demographics, most notably smaller household sizes comprising younger professionals or students (without children), for whom it is easier to develop lifestyles more suited to walking and cycling. The difficulty researchers have is to isolate the individual factors, which could explain some of the conflicting results reported above.

In the studies, meta-analyses and analytical reviews examined here, it has been agreed that residential self-selection does have an impact on what type of neighbourhood people choose to live in and their resultant travel behaviour, irrespective of how that is measured (eg Krizek 2003; Schwanen and Mokhtarian 2007; Schwanen and Mokhtarian 2005a and 2005b; Frank et al 2007; Braun 2009; Chatman 2009 and Cao et al 2009). Generally speaking, people who value commuting by modes other than private car tend to live in a neighbourhood that has better accessibility to such modes (and by definition often has better street connectivity, more compact development, a better mix of services, retail, etc), while those who value their car as a means of transport tend to live where they can use their car (often further from a city centre, in a lower density area).

Among the researchers who did control for residential self-selection (namely Krizek 2003; Chatman 2009 and Cao et al 2009), there is also agreement that there is a statistically significant influence of the built environment on travel behaviour, even after controlling for residential self-selection. This supports the findings of others (who did not control for self-selection) such as Schwanen and Mokhtarian (2005a and 2005b) who reported commute mode choice was affected where respondents were residing in areas that were mismatched with their preferred neighbourhood type (eg preferring high density living but actually living in a suburb) or Frank et al (2007) who observed participants drove less when located in more walkable environments regardless of their demographic characteristics, the importance of the selection factors tested and preferences for neighbourhood type. However, there is some disagreement on how ignoring such self-selection would affect estimates of the built environment's effects on travel behaviour. Chatman (2009) and van Wee (2009) argued the bias resulted in both underestimates and overestimates of the built environment's effects, while Cao et al (2009) and Krizek (2003) suggested it would result in an overestimate of the built environment's effects on travel behaviour.

3.8.2 Implications for the influence of New Zealand central city intensification on travel

Central city locations tend to be mixed land-use environments with good access to shops and other destinations. Possibly without exception globally, they tend to be denser than their surrounding suburbs and environs, at least in terms of retail, services and employment. In some cases, as in Auckland and Wellington, central city locations have a high residential density.

Mixed land-use environments are often associated with greater levels of walking, cycling and public transport use and lower VKT, if not lower vehicle trips overall, as indicated through the international and New Zealand literature. Thus, it could be concluded that density is an associative feature of active transport and sustainable development patterns.

The literature review findings suggest having higher residential density, or higher employment density, is insufficient in and of itself to create socially desirable travel patterns (eg more active transport and public transport use, and less vehicle use). Central city locations are usually relatively close to a lot of potential out-of-neighbourhood destinations, sometimes within walking distance, other times with good public transport access, all of which drives down VKT. They are also usually denser. In the case of a central city location, such density is probably necessary because the finite supply of central city land requires a better use of space (in the form of taller buildings) and to provide the critical mass of population who work and use the facilities and services available.

Ewing and Cervero (2010) make the point it is *where* the density lies in a metropolitan region, and the relative accessibility of dense nodes to other destinations, that has a big bearing on travel patterns, rather than relying on density alone. Based on their finding that destination accessibility is more strongly related to travel behaviour (vehicle, public transport, walking and cycling kilometres travelled) than density, diversity (mix of uses), network design and distance to transit, they argued 'almost any development in a central location is likely to generate less automobile travel than the best-designed, compact, mixed-use development in a remote location' (p276). Ewing and Cervero (2010) demonstrated that once they controlled for destination accessibility, the influence of density on travel behaviour was less important. Very few of the empirical studies examined here controlled for variables that might be related to destination accessibility, such as neighbourhood, built environment or workplace variables (refer to table A.1 in appendix A).

3.8.3 Finalising the fieldwork objectives

Following the completion of the literature review, we revisited the fieldwork objectives we had originally proposed, and modified them in light of our findings. We also sought input from our external peer reviewers. Table 3.2 outlines the final set of fieldwork objectives, the proposed analysis for each one, and the data collection required to undertake the analysis. Note that for each objective, we compared inner city respondents with metropolitan area respondents and, where relevant and feasible, identified any correlated demographic or other characteristics.

We also developed the fieldwork questionnaire, a copy which is available in appendix C.

Table 3.2 Fieldwork objectives, proposed analysis and data required

Objective	Proposed analysis	Data required
How does inner city mode use vary from that of residents outside the inner city?	• Added due to lack of existing New Zealand-based data to analyse this	• **Mode use for specific trips** (eg to work, supermarket, schools, exercise or sport) • **Mode use generally** – what modes used in a typical week
Understanding interaction between living in intensified environment, travel behaviour and possible external factors (eg changing jobs, health problems)	• If moved residence in last three years, travel behaviour in previous compared with current neighbourhood (where previously not in inner city) • If haven't shifted in last three years or planning to shift in next two, will collect current mode use information • If planning to shift in next two years, future neighbourhood choices and perceived effect on travel behaviour • Explore attitudes: commitment to particular modes (eg no matter where I live, I intend to walk, cycle or use public transport to travel to work or study) and neighbourhoods (eg I prefer living in the inner city to living in a suburb)	• **Mode use for specific trips** (eg to work; supermarket, schools, exercise or sport) in 1) previous residence, 2) now, and 3) anticipated (if moving in next two years) • **Mode use generally** – what modes used in a typical week, are each of these used more/less now than in previous residence • **Reasons for any changes in driving** (more/less) now than in previous residence • **Attitude statements:** 5-point Likert scale (agree/disagree)
Understanding influence of neighbourhood qualities in choosing their current home (are people self-selecting to live in particular neighbourhoods?)	• Explore attitudes towards neighbourhood qualities (availability of modes, inner city vs suburbs) and towards mode use (eg I'd rather live in a neighbourhood where I can walk to some shops, schools and services) • If lived less than three years in current residence: identify the main reasons for shifting; any differences in mode use	• **Attitude statements:** 5-point Likert scale (agree/disagree) • **Characteristics of current residence** (house, unit in low-rise or high-rise building, availability of outdoor space) • What were main reasons for shifting to current residence • **Differences in mode use**: see above
Identifying public transport use	• Explore public transport (and other mode) use of inner city residents compared with those not living in inner city for travelling to different destinations and generally	• **Mode use for specific trips** (eg to work, supermarket, schools, exercise/sport) in 1) previous residence, 2) now, and 3) anticipated (if moving in next two years) • **Mode use generally** – what modes (including public transport) used in a typical week, are each of these used more/less now than in previous residence • **If drive to work or study**: given certain conditions, could public transport be used for commute trip

Objective	Proposed analysis	Data required
Understanding vehicle ownership	• Changes in vehicle ownership rates (vehicle:adult ratio) – 1) previous residence, 2) now, and 3) anticipated (if moving in next two years) • Given young age group (nearly half 20–29), many may never have owned a car – lifestyle choice or temporary phenomenon? • Feasibility of living without a motor vehicle	• **Ratio of vehicles:adults in a household** • 2006 Census data (given smaller household sizes in inner city) • Where previously lived outside the inner city: number of adult residents in household and number of vehicles • If intending to move in next two years – will number of household vehicles change? Number of usual residents? • **Attitudes to vehicle ownership** • Do they have a licence to drive? • Have driver licence and no household vehicle: Do they choose to live without a car or do they want a car? • Have driver licence and household vehicle: would/could they go without? In what situation could they live without one?
Understanding the reasons for living in an intensified environment	• Viewed as a 'stop gap' or temporary location or ongoing lifestyle choice? • Explore attitudes: commitment to particular types of neighbourhoods (eg I prefer living in the inner city to living in a suburb; In the next 10 years, I intend to live in a house with a section in the suburbs.)	• **Attitude statements:** 5-point Likert scale (agree/disagree)
Do they live where they work and play?	• Reverse commuting – census analysis; Wellington City Council survey • Reverse travel: Auckland qualitative study of families; current survey: identify where specific activities are undertaken compared with where they currently live	• **2006 Census** – Commuting patterns in Auckland/ Wellington – commuting destination by city of residence • **Where they live** (inner city vs non-inner city vs other city in metropolitan area) • **Where they conduct specific activities** (central city; another area; don't usually do this) – eg work, their own education, supermarket shopping, eating out, exercise or play sport
Identifying types of people who live in intensified environments	• Statistics NZ 2010 apartment dwellers report provides a good baseline of demographics (age, ethnicity, employment status	• **Underlying demographics**: age, gender employment status (including studying), household composition,

Objective	Proposed analysis	Data required
	(full or part-time employment and/or study), educational attainment, household composition, number of bedrooms in home, journey to work, access to motor vehicle) • Explore attitudes/values, life stage, attitudes to vehicle ownership	holding of driver licence, household vehicles • **Attitude statements:** 5-point Likert scale (agree/disagree) • **Attitudes to vehicle ownership:** see above
Carshare in Auckland	• Given the low household vehicle ownership rates in the inner city one of our peer reviewers proposed exploring the degree that inner city residents participate in the Auckland car-share programme as part of our expanded field work.	• Use and impact of car-share programme: awareness of the service use, and the impact on the household's ownership of vehicles.
Walking and cycling for recreation and transport	• Given that there is some evidence that walking for leisure differs from walking for transport, steering group members suggested adding questions exploring 1) whether these differences existed and 2) if the differences reflected residential location for both walking and cycling	• Modes used for different activities in different locations • Walking and cycling for transport or recreation in last 7 days

4 Analysis of existing datasets

4.1 Overview

As noted in section 2.2, we originally proposed to analyse existing datasets, such as 2006 Census data (which includes data on the 'main means of travel to work' and household vehicle ownership) together with regional or national household travel surveys, to identify underlying trip patterns and mode choice and to identify possible population segments (households) for the fieldwork phase of the project. However, none of the three household travel survey datasets available had sufficient numbers of respondents living within our designated inner city areas. Hence we were limited to considering the 2006 Census which is discussed in the following sections.

4.2 2006 Census

A Statistics NZ (2010) report *Apartment dwellers: 2006 Census* compares the characteristics of those living in apartments in the inner cities of Auckland, Wellington and Christchurch with those living in multi-unit dwellings outside the inner city. 'Inner city apartment dwellers' are defined as those living in dwellings that are structurally or physically attached to at least one other dwelling or unit in Auckland, Wellington and Christchurch CBDs. 'Non-inner city apartment dwellers' include those living in such dwellings outside the CBD in Auckland, Wellington or Christchurch cities. Statistics NZ also provided some broader comparisons, usually with the general New Zealand population. Statistics NZ (2010) compared these populations using common demographics such as age, ethnicity, employment status (full- or part-time employment and/or study, highest educational qualification), household composition, number of bedrooms in home, main method of travel to work and access to a motor vehicle.

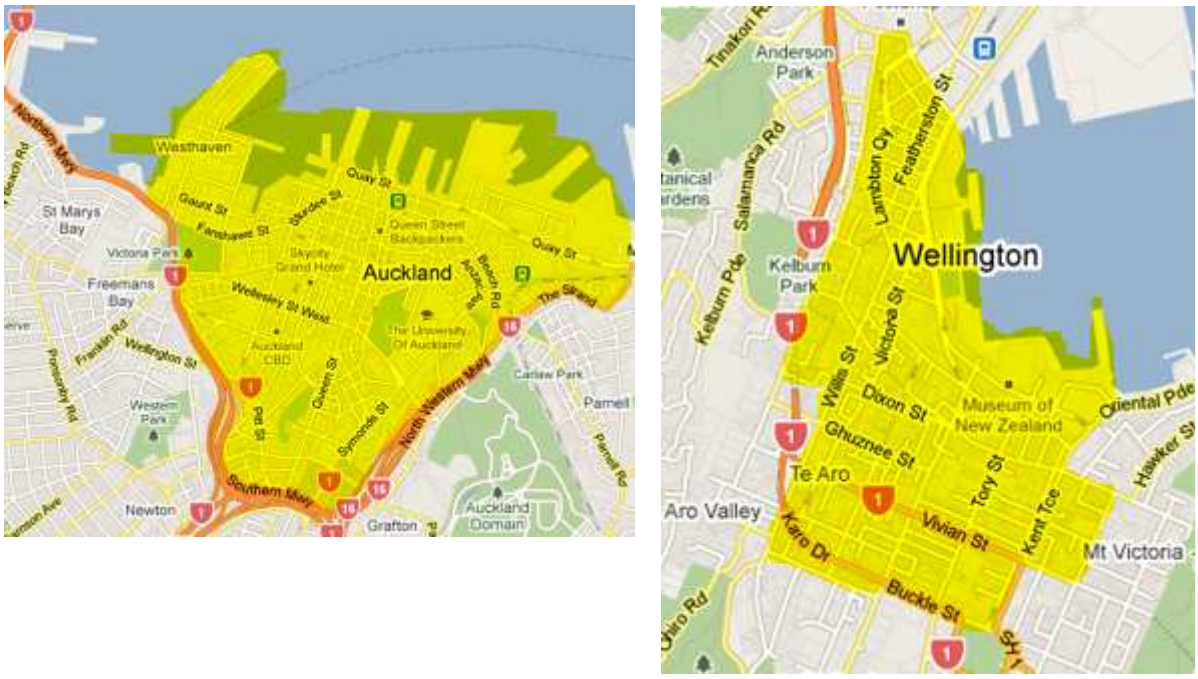
4.2.1 Definition of Auckland and Wellington inner city areas

As defined by Statistics NZ (2010, p23), 'inner city' covered a reasonably large area in all three centres:

- The boundary streets for Auckland's CBD were Mechanics Bay, The Strand, Stanley Street, Grafton Road, Symonds Street, Khyber Pass Road, Upper Queen Street and the western edges of the Southern Motorway to Freemans Bay.
- Wellington's CBD boundary streets were Oriental Parade, Majoribanks Street, Brougham Street, Pirie Street, Kent Terrace, Buckle Street, The Terrace, Bowen Street and Bunny Street.
- In Christchurch, the boundary streets were Moorhouse Avenue, Madras Street, Kilmore Street, Peterborough Street, Durham Street, Salisbury Street, Montreal Street, Bealey Avenue, Park Terrace, The Square, Rolleston Avenue, Hereford Street, Oxford Terrace and Tuam Street.

Maps of the Auckland and Wellington inner city areas are shown in figure 4.1.

Figure 4.1 Inner city areas of Auckland and Wellington as defined for this project (source: Google maps)



For comparability of results, we chose to have the same definition of the inner city areas of Auckland and Wellington in our fieldwork, as discussed in chapter 6.

4.2.2 Description of inner city populations

Between the 1996 and 2006 Censuses, the number of people living in inner city apartments in Auckland, Wellington and Christchurch almost quadrupled, from 4974 to 19,020. Seventy percent of this growth occurred in Auckland, where the population grew from 3805 to 13,311. In Wellington, the inner city population more than trebled from 1410 to 4743, while Christchurch experienced a much smaller growth of 27% from 759 to 966 people. These growth rates were much higher than the growth rates for the total populations of these cities (Auckland – 17%, Wellington – 14% and Christchurch – 10%).

Despite the phenomenal growth rate of their populations over the 10-year period, the inner city populations still represent a very minor proportion of the total population in each metropolitan area: in Auckland (population 1,170,861) inner city residents form 1.1%, while in Wellington (population 364,128, excluding Kapiti Coast) they are 1.3% of the total metropolitan area population. Narrowing the comparison to Auckland city or Wellington city boundaries marginally increases the shares to 3.3% and 2.6% respectively.

Inner city residents are highly mobile: very few (8%) of the inner city residents had lived in the inner city at the time of the 2001 Census, compared with 22% of the non-inner city dwellers. More than half (57%) of the inner city dwellers lived elsewhere in New Zealand (65% within the same regional council area) and 36% had lived overseas. Auckland had the highest rate of inner city apartment dwellers who had lived overseas at the prior census (41%, compared with 22% for both Wellington and Christchurch), while Christchurch had the highest proportion (16%, compared with 7% in Auckland and 9% in Wellington) of people residing at the same address for both censuses.

Inner city apartment dwellers were more likely to live in flatting situations (known as 'other multi-person households' in the census) and less likely to live in one-family households than those living outside the city centres. The most common type of one-family household was 'couple without children'. Most inner city dwellers had 'never married' (68% compared with 48% of non-inner city apartment dwellers). Note that this did not preclude them from currently having a de facto relationship.

Overall, it appears apartments generally cater to smaller household sizes: in 2006, 84% of dwellings in the inner cities and 74% of non-inner city apartments had one or two bedrooms. In comparison, nationally just 26% of all dwellings had one or two bedrooms. In the 10 years from the 1996 Census to the 2006 Census, the mean number of bedrooms in inner city apartments decreased.

The mobility of the inner city population is likely to be related to their age and employment status. Nearly half (49%) of inner city apartment dwellers were aged 20 to 29 years in 2006, compared with 24% of non-inner city apartment dwellers. The national figure for population aged 20 to 29 years was 13% in 2006. Auckland and Wellington were the drivers for the 49% population figure; in Christchurch, those aged 20 to 29 years were 30% of the total inner city apartment dwellers, while 15% were people aged 65+ (in Auckland and Wellington this was 2% and 4% respectively). In all three city centres, between 10% and 12% of the population was under 20 years old, which was similar to the national figure of approximately 11%.

In Auckland, 37% of inner city apartment dwellers were of the Asian ethnic group, a proportion similar to the European group. By contrast, in Wellington and Christchurch, 70% and 72% of inner city apartment dwellers, respectively, identified themselves as being of the European ethnic group, with about 18% being Asian. There were no distinguishing gender characteristics worth noting.

Nearly 40% of Auckland's inner city apartment dwellers were in full- or part-time study (32% and 7% respectively). In Wellington, this figure was 30% and in Christchurch 25%. In all cases, lower proportions of non-inner city apartment dwellers were studying either part- or full-time. Nationally, 20% were studying. Just 5% of inner city apartment dwellers had no qualification in 2006, compared with 17% of non-inner city apartment dwellers and 25% of New Zealand adults as a whole.

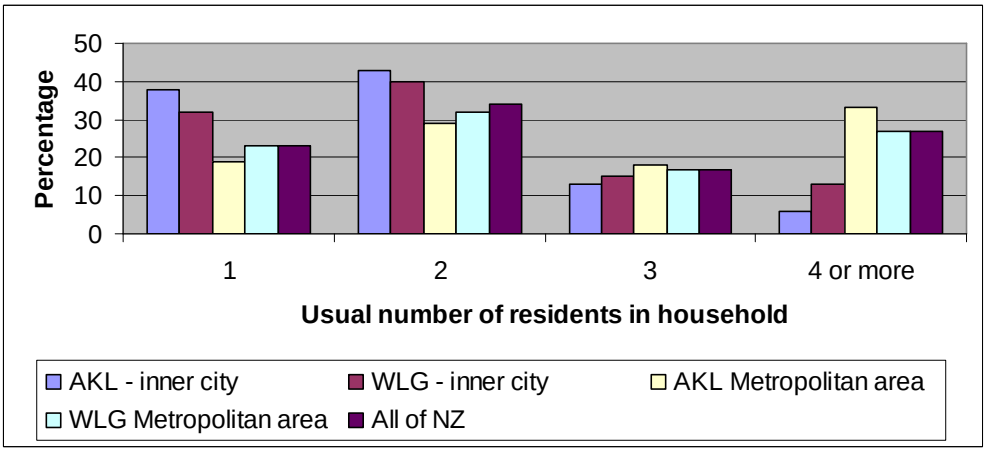
Seventy-three percent of inner city apartment dwellers were in either full- or part-time employment. Just over half of these (55%) worked in the central city, compared with 38% of non-inner city apartment dwellers.

4.2.3 Household vehicle ownership

The Statistics NZ (2010) report did not compare household sizes between areas, although the number of bedrooms and other household composition details were discussed. We obtained the census data (by meshblock,[6] area unit, territorial authority and region) to conduct this analysis. Figure 4.2 shows there are far more one- and two-person households in the inner city areas of Wellington and Auckland (72% and 81% respectively) compared with the metropolitan areas, where around one-half of the households are one- or two-person.

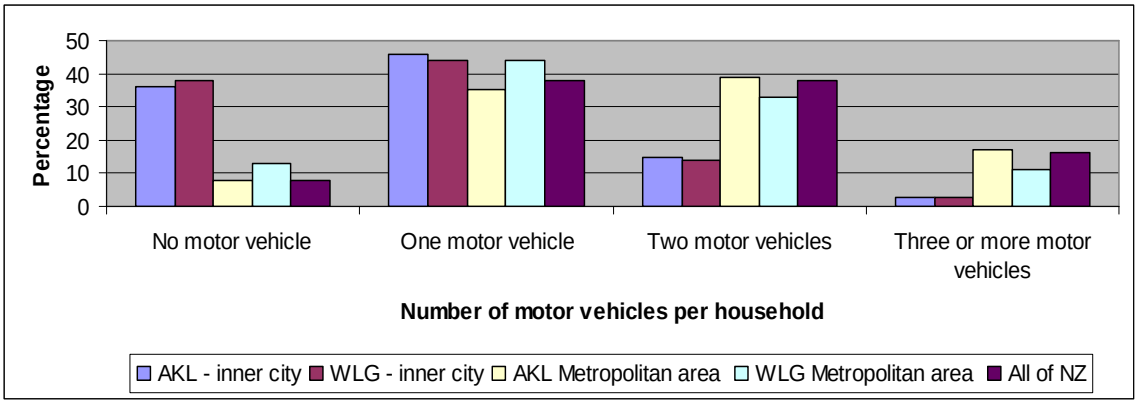
[6]'The meshblock is the smallest geographic unit for which statistical data is collected and processed by Statistics NZ. A meshblock is a defined geographic area, varying in size from part of a city block to large areas of rural land. Each meshblock abuts against another to form a network covering all of New Zealand including coasts and inlets, and extending out to the 200 mile economic zone. Meshblocks are added together to 'build up' larger geographic areas such as area units and urban areas. (www2.stats.govt.nz/domino/external/omni/omni.nsf/wwwglsry/meshblock)

Figure 4.2 Usual number of residents in a household in inner city and metropolitan area as a whole (data source: 2006 Census)



As household sizes in central city areas are smaller, one would logically expect that, on average, households in the inner city would have fewer vehicles – as is indeed illustrated in figure 4.3.

Figure 4.3 Access to motor vehicle by households in inner city and metropolitan area as a whole (data sources: 2006 Census and Statistics NZ 2010)



Clearly many more households do not have access to motor vehicles in the inner city, which seems plausible given the high proportion of adults under 30 years of age who are full-time students. However, due to the significant variation in household size between the inner city and metropolitan areas, figure 4.3 does not reveal the overall pattern of access to motor vehicles. To more fairly assess this, we worked with Statistics NZ to extract further data from the 2006 Census on household motor vehicle ownership rates, in particular, a newly derived variable from the census data 'motor vehicles per adult per household' shown in figure 4.4.

Figure 4.4 Ratio of motor vehicle to adults (aged 18+) in a household in inner city and metropolitan area as a whole (data sources: 2006 Census)

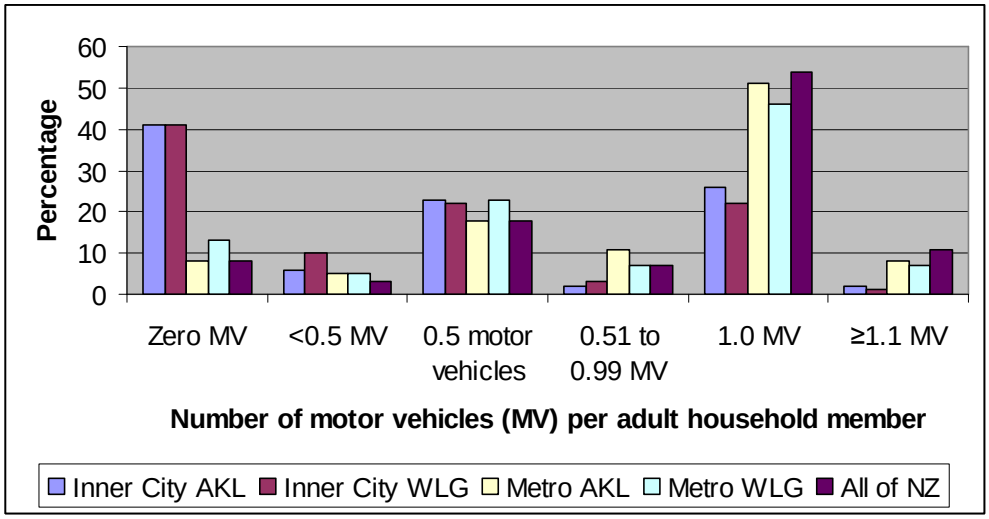


Figure 4.4 confirms there are far more households in the inner city with zero motor vehicles per adult. What it also shows, however, is that ownership proportions are similar for households with 0.5 vehicles per adult household member (around 20% of households in both the inner city and greater metropolitan area) and dramatically different for those with one or more vehicles per adult household member: around 50% of households in the metropolitan area have one or more vehicles per adult household member, compared with 26% in Auckland's inner city and 22% in Wellington's. Note that the figures for the Auckland and Wellington metropolitan areas (51% and 46% respectively) are lower than the national average of 54% for the ratio of one or more vehicles per adult household member.

We have found, in previous investigations analysing the NZHTS data (O'Fallon and Sullivan 2009; Sullivan and O'Fallon 2010), that the ratio of vehicles to adults in a household has a significant effect on individual mode use. Using NZHTS data for Wellington and Auckland metropolitan areas for the years 2003–07,[7] the ratio of vehicles to adults is shown to be correlated with an individual's mode use: individuals in households with one or more vehicles per adult (aged 18+), made far more of their trips as a car driver than those living in households with <0.5 vehicles per adult (74% compared with 22%). The reverse is true for walking and bus and train mode shares, where a lower vehicle:adult ratio contributes to greater walking (44% compared with approximately 12%) and bus and train use (12% compared with less than 2%). Unfortunately, as noted above, we cannot disaggregate these results below territorial authority level (ie to each of the four cities in Auckland and Wellington regions) to discern any particular effects in the denser inner city areas.

[7]The ongoing travel survey was designed to provide annual updates on a three-yearly moving average basis. That is, to examine trends by reporting on the overlapping time periods July 2003 – June 2006, July 2004 – June 2007, July 2005 – June 2008 and so on. We have used the dataset July 2003 – June 2007 as it incorporates the 2006 Census which occurred about the middle of this four-year period.

Table 4.1 Mode use compared with the ratio of vehicles to adults living in a household in Auckland and Wellington metropolitan areas (data source: NZHTS July 2003 – June 2007 – may not add to exactly 100% due to rounding)

	Vehicle:adult ratio in household					Total mode share
	<0.5	0.5	0.51-0.99	1	>1	
Travel mode	**Percent of all trip segments**					
Walk	44	20	21	13	12	17
Vehicle driver	22	52	57	74	74	64
Vehicle passenger	21	21	16	11	12	14
Cycle	1	0	0	0	0	0
Bus and train	12	6	4	2	1	3
Other	1	2	3	1	1	1
Total	100	100	100	100	100	100

We were able to do some further work with Statistics NZ, and obtained data relating the household vehicle:adult ratio to the main means of travel to work as shown in table 4.2. This reveals even where an inner city household has high vehicle availability (ie greater vehicle to adult ratio), the preferred method of travel to work is walking. By contrast, there is a significant drop in those walking to work in the metropolitan areas as soon as there is a vehicle present in the household, irrespective of the vehicle:adult ratio. This implies the built environment (particularly density, street connectivity and/or proximity to work) may exert a stronger influence on mode choice for the journey to work than the availability of a vehicle in the household.

While starting at much lower overall levels, public transport use declined significantly in metropolitan areas as soon as a vehicle was present in the household. For example, in the Auckland metropolitan area 25% of adults aged 18+ used public transport as the main means of travel to work; in the Wellington metropolitan area, this figure was 30% when there were zero vehicles in a household. With between 0.01 and 0.5 motor vehicles per adult household member, the public transport rate declined to 12% and 21% for Auckland and Wellington respectively. At one vehicle per adult, only 3% of Auckland metropolitan residents and 11% of Wellington metropolitan residents used public transport. The pattern was similar in the Auckland inner city (dropping from 19% to 2%). In the Wellington inner city the range was much narrower, from 9% to 4%.

Table 4.2 Ratio of vehicles to adults compared with walking and driving to work by residential location (source: 2006 Census data)

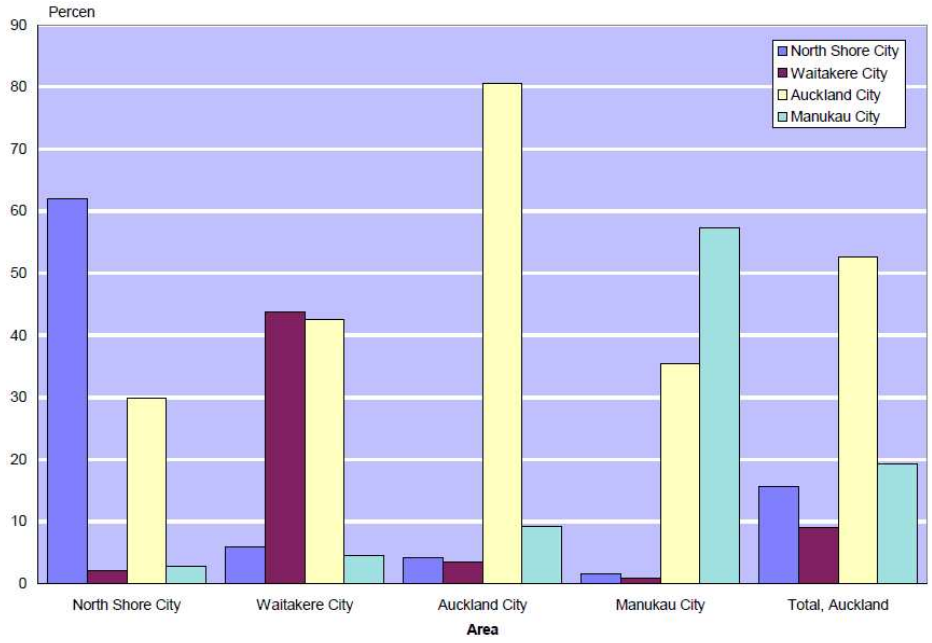
	Inner city				Metropolitan area				All of NZ	
	Auckland		Wellington		Auckland		Wellington			
Number of motor vehicles per adult household member	**Walk**	**Drive**	**Walk**	**Drive**	**Walk**	**Drive**	**Walk**	**Drive**	**Walk**	**Drive**
No motor vehicle	56%	3%	69%	3%	23%	14%	34%	11%	26%	12%
Less than 0.5 motor vehicles	41%	21%	66%	10%	6%	46%	19%	37%	11%	41%
0.5 motor vehicles	42%	27%	60%	18%	6%	53%	12%	45%	8%	49%
0.51 to 0.99 motor vehicles	35%	38%	51%	29%	3%	66%	7%	59%	4%	63%
1 motor vehicle	31%	49%	50%	29%	2%	74%	5%	66%	3%	69%
1.1 or more motor vehicles	29%	53%	44%	20%	1%	76%	3%	72%	2%	69%
Total % using mode	43%	25%	62%	14%	4%	65%	10%	55%	5%	62%

The lower vehicle ownership, particularly the lower likelihood of a household having more than one car in the inner city indicates there could be a market for car-sharing. Experiences in the USA and Europe show many households shed a second car if they have car-sharing options nearby (eg Cervero et al 2007). At the request of one of our peer reviewers, we explored this issue through the online survey. The results are reported in section 6.7.

4.2.4 Do Auckland and Wellington workers work where they live?

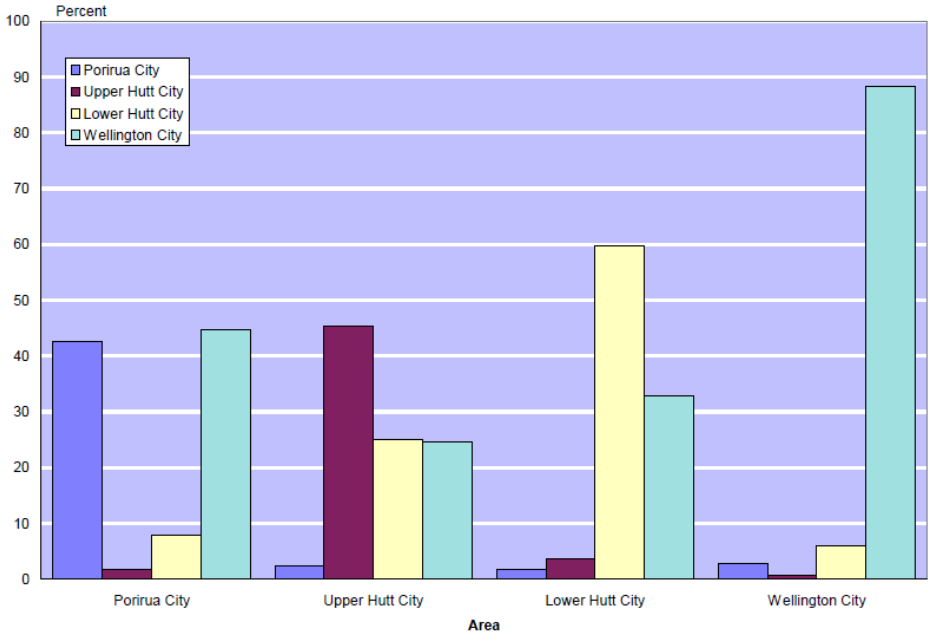
Goodyear (2008) compared the working habits within the Auckland and Wellington metropolitan areas (each metropolitan area comprising four cities). Of the four Auckland cities, Auckland city had the greatest proportion of people (81%) who lived and worked in the same territorial authority. This is in contrast to Waitakere, where only 43% lived and worked in Waitakere as indicated in figure 4.5.

Figure 4.5 Commuting patterns within Auckland four cities, 2006 Census (source: Goodyear 2008)



In the Wellington metropolitan area, Wellington city had the greatest labour force attraction: 88% of employed people residing within Wellington city also worked within Wellington city. By contrast, figure 4.6 shows that Porirua city had more of its residents working in Wellington city than in its own city.

Figure 4.6 Commuting patterns within Wellington four cities, 2006 Census (source: Goodyear 2008)



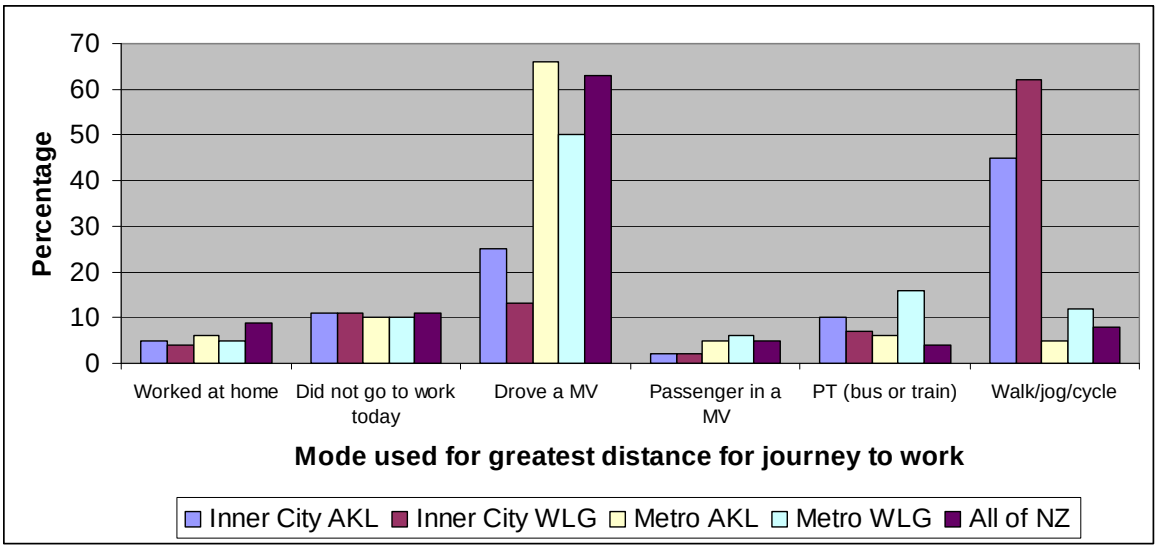
4.2.5 Main means of travel to work

In the 2004–09 NZHTS dataset, approximately 24% of all tours (travelling from home to work to home, sometimes with stops for other activities) have the main purpose 'work' (O'Fallon and Sullivan 2009). This implies the journey to work comprises about 12% of all trips made from home to work.

The 2006 Census asked the New Zealand population: 'On Tuesday 7 March, what was the one main way you travelled to work – that is, the one you used for the greatest distance?' As figure 4.7 shows, walking, jogging or cycling to work on Census day 2006 was the most common mode of transport in inner city Auckland and Wellington. Wellington had the highest proportion of inner city apartment dwellers who walked to work (62%), followed by Auckland (45%) and Christchurch (35%). By contrast, in metropolitan Auckland, 66% used a motor vehicle, 5% walked, jogged or cycled, and 6% used public transport. In the Wellington metropolitan area, 50% used a motor vehicle, 12% walked, jogged or cycled, and 16% travelled by public transport. These figures were very similar to what Morrison and McMurray (1999) observed in their study of home shifters in Wellington.

Of course, the benefits of mixed-use, pedestrian friendly designs were likely to be as pronounced for non-work purposes (eg shopping, eating and socialising) than for work. The data collected through the online survey confirms the differences for other trip purposes, as reported in section 6.4.2.

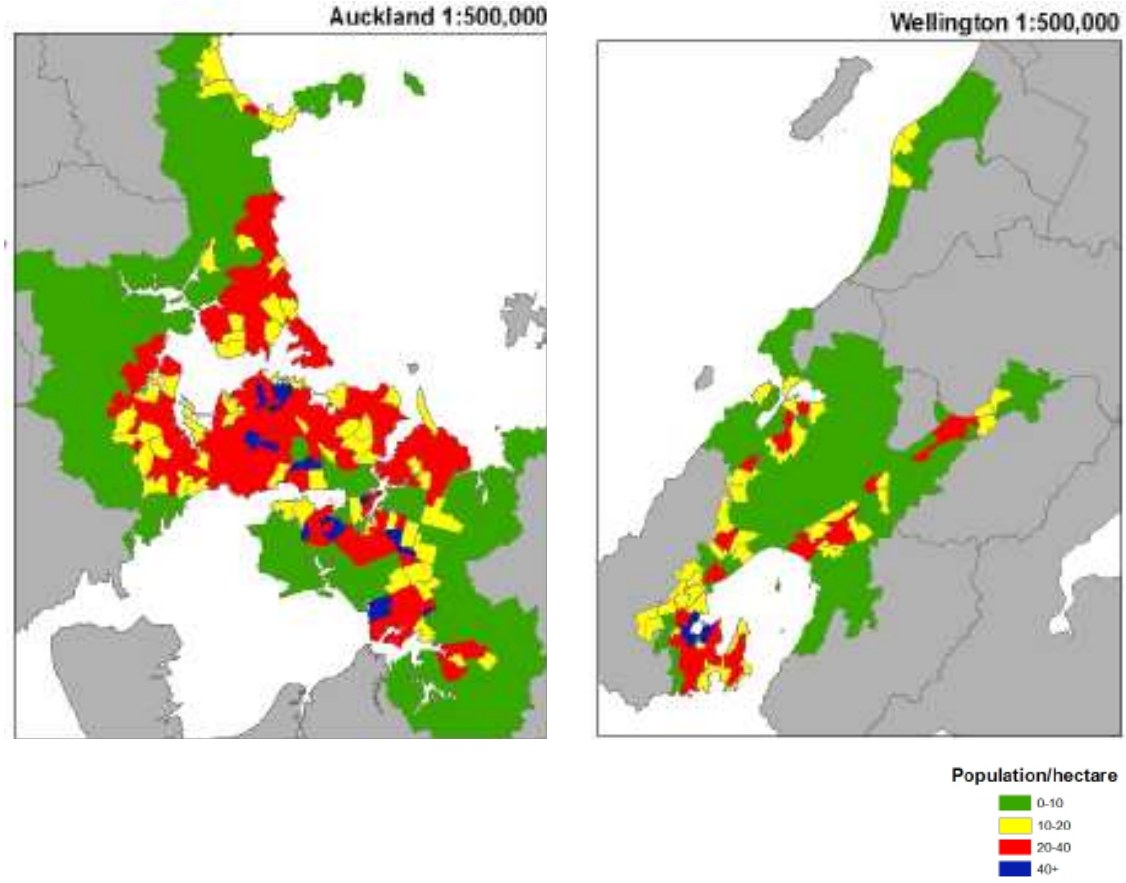
Figure 4.7 Employed population by main means of travel to work in inner city and metropolitan area as a whole (data source: 2006 Census)



4.2.5.1 Influence of population and employment density on main means of travel to work

Figure 4.8 shows the population density of the metropolitan areas of Auckland and Wellington based on the 2006 Census. Note that there are 100 hectares to a square kilometre. There are very few neighbourhoods of high density population (40+ people per hectare/4000 people per km^2). In Wellington, three inner city neighbourhoods have a high density population (Lambton Quay, Mt Victoria West and Mt Cook), while the high density population neighbourhoods are scattered around the Auckland metropolitan area, with only one in the inner city.

Figure 4.8 Wellington and Auckland metropolitan areas population densities 2006 (source: Norman and Sanderson 2010)

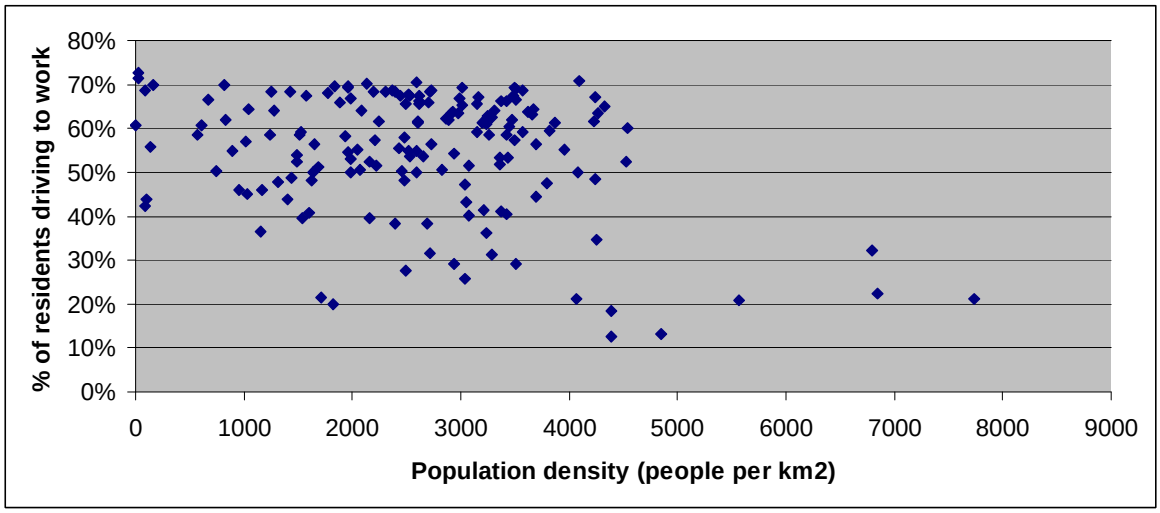


Given the relatively small proportion of the geographical area in the Wellington metropolitan area that has moderate to high population densities compared with the proportions in the Auckland metropolitan area, it is perhaps surprising to recall Wellington metropolitan residents drive less, and walk and use public transport at much higher rates than do Auckland metropolitan residents (refer figure 4.7). Indeed, table 4.3 shows the two most densely populated cities, North Shore and Hamilton, with mean densities of nearly 1600 and over 1300 people/km^2 (ie 16 and 13 people/hectare), have amongst the lowest walking and public transport use rates. Wellington city, with a mean population density of 618 people/km^2 has the highest, followed by Lower Hutt city, which has one of the lowest mean densities (259 people/km^2).

We created a scatterplot of the proportion of people driving to work compared with the density of the census area unit (CAU)[8], which is the rough equivalent to a neighbourhood. As can be seen in figure 4.9, no definitive relationship can be identified (the best fit equation had an r^2 value of approximately 0.1).

[8] Census area units are aggregations of meshblocks with unique names. They are non-administrative areas intermediate between meshblocks and territorial authorities. Area units must either define or aggregate to define urban areas, rural centres, statistical areas, territorial authorities and regional councils. Area units within urban areas normally contain 3000–5000 population. (www2.stats.govt.nz/domino/external/omni/omni.nsf/wwwglsry/Area+Unit)

Figure 4.9 Scatterplot comparing driving to work and population density by CAU for Auckland and Wellington cities (data source: 2006 Census)

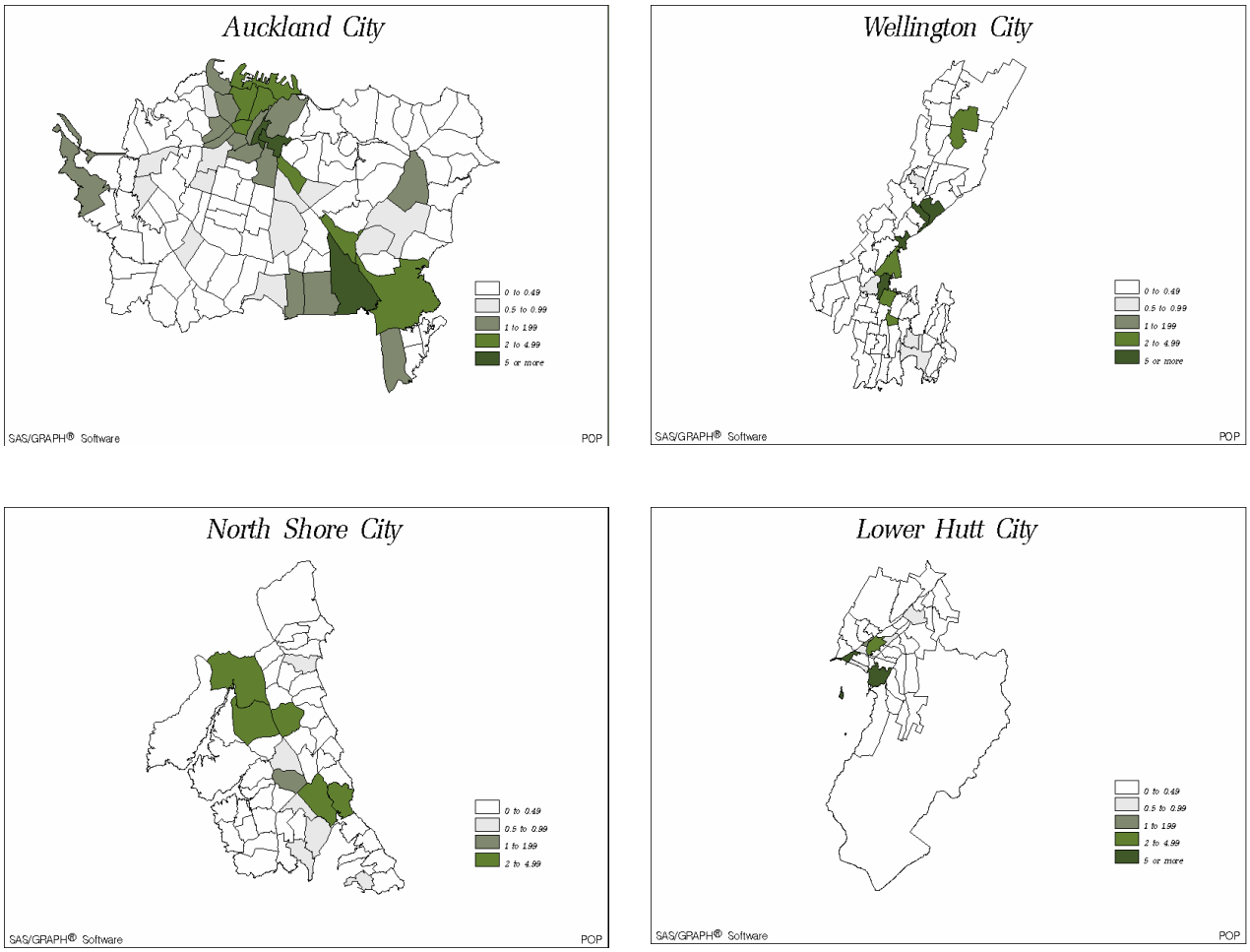


Goodyear (2008) used the 2006 Census to derive *employment* density maps, where the employment density is equal to the ratio of the number of people that specified a workplace address in a CAU to the number of New Zealand adults usually resident in that CAU.[9] As can be seen in figure 4.10, the highest employment density in Auckland city is in the Penrose – Mt Wellington area not the inner city, whereas in Wellington the highest employment densities are in the inner city (Lambton Quay has the highest employed population of any area in New Zealand), as well as two areas north of the city centre. Lower Hutt city also has two high employment density (five or more workers to one adult resident) CAUs. By contrast, North Shore city, which has the highest mean population density of any city in New Zealand, has low employment densities.

The size of the geographical area having a higher population density does not appear to be related to mode choice for the journey to work. Examining the density of the CAUs within the cities, we found a larger area of Hamilton city, comprising 62% of its CAUs, had a population density of greater than 2000 people/km^2, compared with 32% of CAUs in Wellington city. Sixteen CAUs (46% of all CAUs in Wellington city) had population densities of <1000 people/km^2. Six CAUs (17%) in Wellington city exceeded 3500 people/ km^2 (the maximum density in Hamilton city), including two CAUs that form the inner city of Wellington.

[9] A more commonly used measure of employment density is workers/km^2 or hectare; however, this information is not readily available across New Zealand cities, using a consistent set of data and assumptions.

Figure 4.10 Employment density in Auckland, North Shore, Wellington and Lower Hutt cities, 2006 Census (source: Goodyear 2008)



It might be thought the high employment density in the central city areas of Wellington city and Lower Hutt is a factor in the commuting patterns of residents (less driving and more public transport use and walking), or the lower employment density of inner city Auckland influences the mode use for journey to work, given the low-to-medium mean population densities of the cities. However, table 4.3 reveals the main means of travel to work for 12 major New Zealand cities is not solely influenced by the population and/or employment density, irrespective of whether driving, public transport use or walking is examined. The cities with the highest employment densities in their central areas (Wellington, Christchurch, Manukau and Lower Hutt) have quite low mean population densities (226 to 618 people/km2), and the proportions of people driving to work vary from 41% to 67%, while the proportions of those using public transport vary from 3% to 17%.

Table 4.3 Main means of travel to work compared with population density for major New Zealand cities (source: 2006 Census data)

Area	Usually resident population	Mean population density (people/km^2)	Employment density in central area (workers/ adult resident)	Drove (incl motorcycle)	Public transport (bus or train)	Walk
North Shore city (Akl)	205,608	1597.6	2–4.99	64%	6%	3%
Hamilton city	129,249	1319.1		65%	2%	5%
Wellington city	179,466	618.5	5+	41%	17%	15%
Tauranga city	103,635	615.9		66%	1%	3%
Auckland city	404,658	609.5	2–4.99	58%	8%	7%
Napier city	55,359	524.2		64%	1%	5%
Waitakere city (Akl)	186,444	507.4	1–4.99	66%	5%	2%
Manukau city (Akl)	328,968	481.8	5+	67%	3%	2%
Porirua city (Wlg)	48,546	266.1		55%	11%	3%
Lower Hutt city (Wlg)	97,701	259.4	5+	55%	13%	4%
Christchurch city	348,435	226.2	5+	61%	4%	5%
Upper Hutt city (Wlg)	38,415	71.2		59%	11%	3%

We examined the results by metropolitan area and found in Wellington, where the greatest employment density is in the inner city, large proportions of workers from Lower and Upper Hutt and Porirua commuted to downtown Wellington for work. The public transport is well oriented to servicing these commuters, hence the high percentages using it. In Auckland region, there is not the same focused employment centre, and the relatively fragmented public transport network reflects this.

While the residential density of Wellington city is not particularly high, the CBD is a sufficient attractor for workers, permitting those on the fringe to walk to work while those further away can use public transport relatively easily. Ewing and Cervero (2010) concluded that where density lies in a region and the region's accessibility as a destination has a big bearing on motorised and non-motorised travel outcomes. They wrote that 'almost any development in a central location is likely to generate less automobile travel than the best-designed, compact, mixed-use development in a remote location'.

4.3 Auckland-based school travel data

In the Auckland region, roll surveys monitoring students' mode use for travelling to and from school are conducted in most of the 145+ schools which have completed and implemented a school travel plan.[10] We thought the roll survey data might be used to compare 'inner city' Auckland primary schools with other

[10] An Excel-workbook-based master roll survey template is sent to schools so they can place students' names, addresses, year level, room, or form class into the form. On the set day, teachers within each class record in the appropriate column of the table, at roll call, how children got to school that day and how they anticipate they will be travelling home. Copies of the survey form are then collected and returned to the lead travel teacher, and subsequently to the school travel planner for analysis (Hinckson et al 2007).

Auckland-based primary schools to discern any differences in mode use that might be attributed, at least in part, to living in an intensified area. We considered public primary schools as the children attending these schools tend to be from the 'local' neighbourhood much more so than in either private primary schools or in both public or private intermediate schools and colleges, which commonly rely on several suburbs for their student roll.

None of the Auckland public primary schools (or intermediate schools and colleges) is physically located within the area defined as the Auckland 'inner city' for this project. The two public primary schools outside but closest to this area, Newton Central School and Freemans Bay School, have quite distinctive mode shares for the morning journey to school as illustrated by table 4.4, so that nothing meaningful can be concluded with respect to (near) inner city schools. The mean mode shares for all Auckland city and Auckland metropolitan area primary schools participating in the school travel plan programme/roll surveys reveal that Auckland city primary school students are somewhat more likely to walk or scooter to school (and less likely to be driven) than are primary students in the metropolitan area as a whole.

Table 4.4 Mode share of children travelling to school at schools near inner city Auckland (data source: roll surveys for 2010 collected by Auckland Transport)

	Walk + walking school bus + scooter	Cycle	Bus	Driven by friends/family (incl park & walk)	Total
Newton Central School	36%	4%	3%	57%	100%
Freemans Bay School	51%	1%	4%	46%	100%
Mean – Auckland city	47%	2%	1%	50%	100%
Mean - all Auckland metropolitan area primary schools	40%	2%	3%	55%	100%

5 Accessibility and land-use indices

5.1 Overview

As part of our preparation for the fieldwork, we intended to perform land-use analysis of the case study areas to rate land-use mix, the qualities of 'walkability' and, if feasible, 'cyclability' and other factors considered to affect multi-modal accessibility. To this end, we were able to draw on recently completed research by Mavoa et al (2009) who constructed three neighbourhood-level indices (Walkability Index, Neighbourhood Destinations Accessibility Index, and Land Use and Public Transport Accessibility Index) for four New Zealand cities, including Wellington city. We have drawn on a report (Norman and Sanderson 2010) which examined public transport use and urban form in New Zealand, using 2006 Census meshblock data to map such information as population density (discussed in section 4.2.5.1), personal income, share of population aged 15–24, and active mode use for Auckland, Wellington and Christchurch metropolitan areas and New Plymouth. In reporting here, we have focused on information from Auckland and Wellington.

We had proposed to undertake regression analysis to isolate the effects of each factor on walking and cycling accessibility, if feasible, but the lack of modal-use data for the inner city pre-empted this.

There has been very little research into how well walkability indices predict or explain observed walking behaviour and/or mode use in a given neighbourhood, although they have been 'successful' in *describing* the walking environment (Manaugh and El-Geneidy 2011).

5.2 Destination and pedestrian/cyclist accessibility

The three neighbourhood-level indices constructed by Mavoa et al (2009) (see section 5.1) are discussed below.

5.2.1 Walkability Index

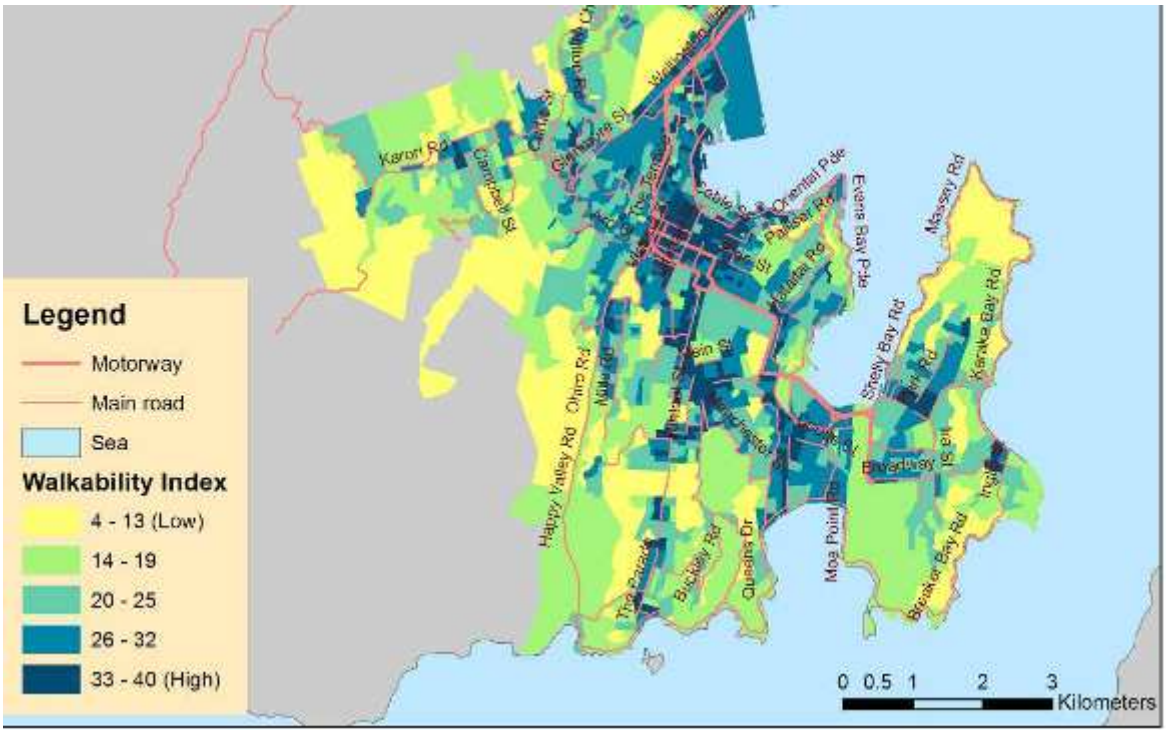
The Walkability Index combines four built environment measures:

- street connectivity – estimated by calculating the intersection density
- dwelling density – estimated by using meshblock data for the occupied private dwellings count from the 2006 Census
- mixed-land use – land use within each meshblock was categorised into residential, industrial, open space, commercial and other use and the mix calculated using an entropy index
- retail floor area ratio – calculated based on building outline data from local councils, the net retail area was determined by dividing the retail floor area by the total retail parcel area within each meshblock.

In creating the index, each component variable was given a score out of 10 for every urban meshblock in the city; hence the maximum score for a given meshblock was 40. Further information on how the Walkability Index was constructed is available in Mavoa et al (2009).

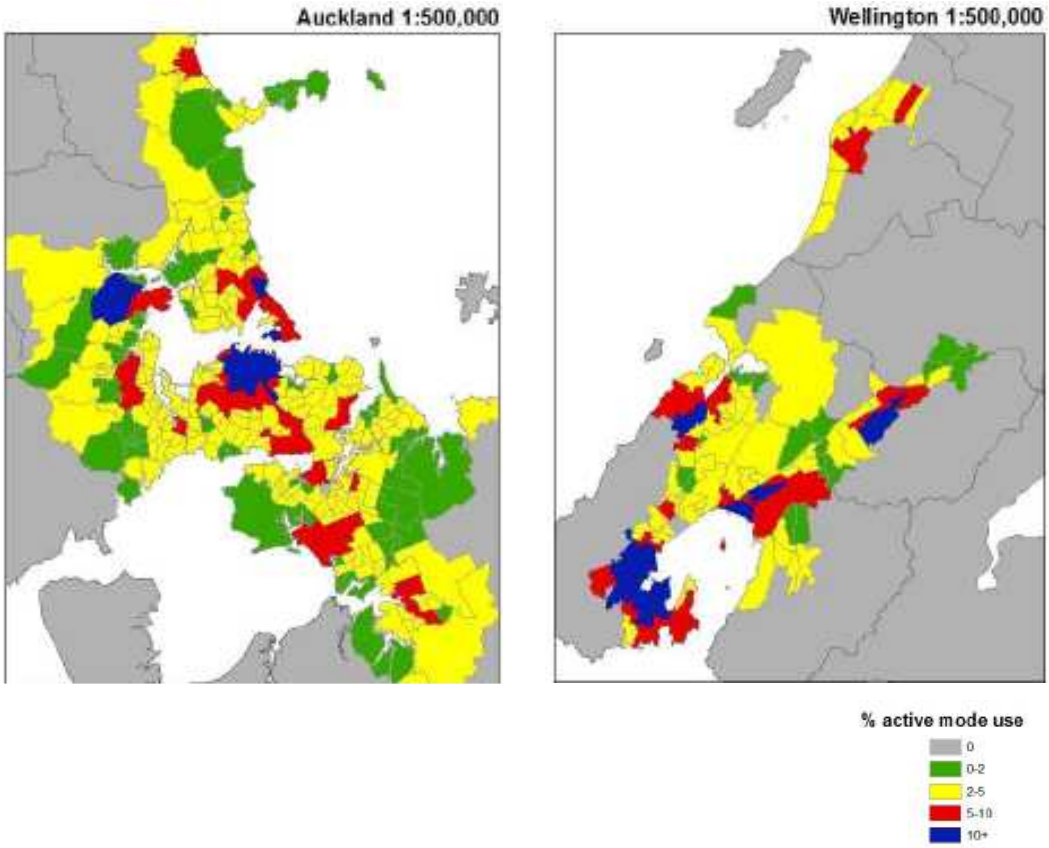
The Walkability Index for Wellington is shown in figure 5.1. Not surprisingly, much of the central city area has a high walkability value (ranging from 26–40), although The Terrace area is more moderate (20–32). In suburbs outside of the central city area, some of the larger suburbs (eg Kilbirnie and Newtown) maintain high walkability values of 26–40 over a large part of the suburb, with the medium-to-moderate (14–25) range being the far more common value for most suburbs.

Figure 5.1 Walkability Index for Wellington central city and environs (source: Mavoa et al 2009)



Norman and Sanderson (2010) maps for Auckland and Wellington show those using 'active modes' (walking and cycling) as their main method for travelling to work. As can be seen in figure 5.2, the areas with the greatest walkability also have the highest active mode use for the journey to work. Norman and Sanderson's analysis draws a relationship between public transport use for the journey to work and active mode use, noting that active mode use drops away fairly quickly in Wellington moving away from Lambton Quay/Thorndon, to be replaced by public transport use in the northern and southern areas. A similar occurrence is noted in Auckland, where once active modes drop to between 2% and 5% of mode share for journey to work, public transport use remains at between 5% and 10%.

Figure 5.2 Active mode use for the journey to work, 2006 Census (source Norman and Sanderson 2010)



5.2.2 Neighbourhood Destination Accessibility Index

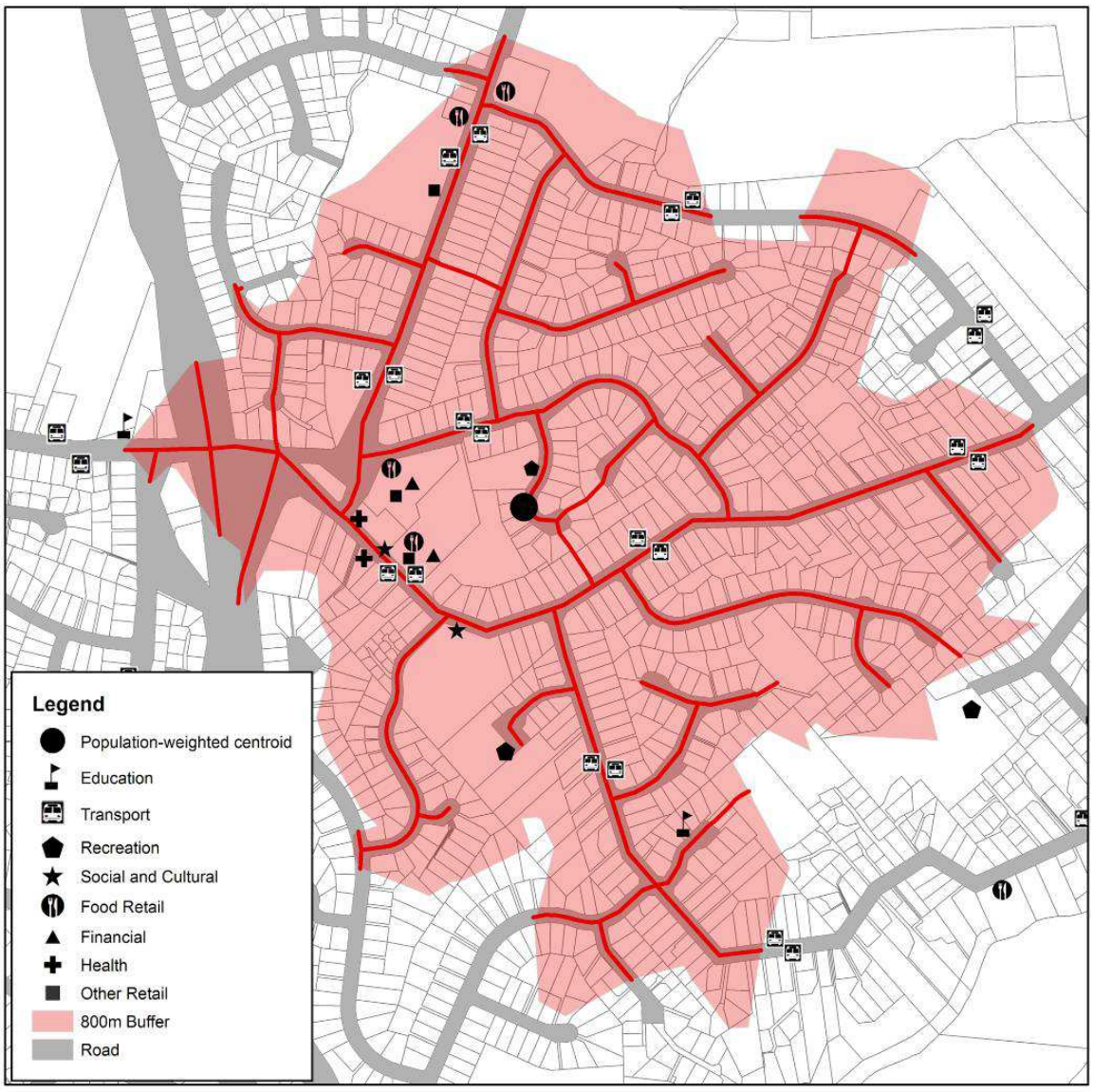
As developed by Mavoa et al (2009) the Neighbourhood Destination Accessibility Index (NDAI) measures access to specific neighbourhood amenities or destinations within a reasonable walking distance (800m) along the local road network from the population centre of each meshblock, including:

- education (preschools and schools from year 1 to 13)
- public transport
- recreation (parks, recreation centres, gyms, beaches)
- social and cultural (museums, libraries, theatre, cinemas, cafes, hotels, etc)
- food retail (supermarkets, bakeries, butcher)
- financial (banks, post offices, automatic teller machines)
- health (Plunket, general practitioners, chemists)
- other retail (video shops, opportunity shops, shopping centres/malls).

An illustration of the 800m road network buffer around the population centre is shown in figure 5.3.

In all, 31 different amenities or destinations are counted. A simple weighting scheme is applied, so that having three primary schools and no socio-cultural amenities will result in one point being awarded, rather than three. The maximum score available is (coincidentally) 31; hence, the range is from zero (low amenity diversity) to 31 (high amenity diversity).

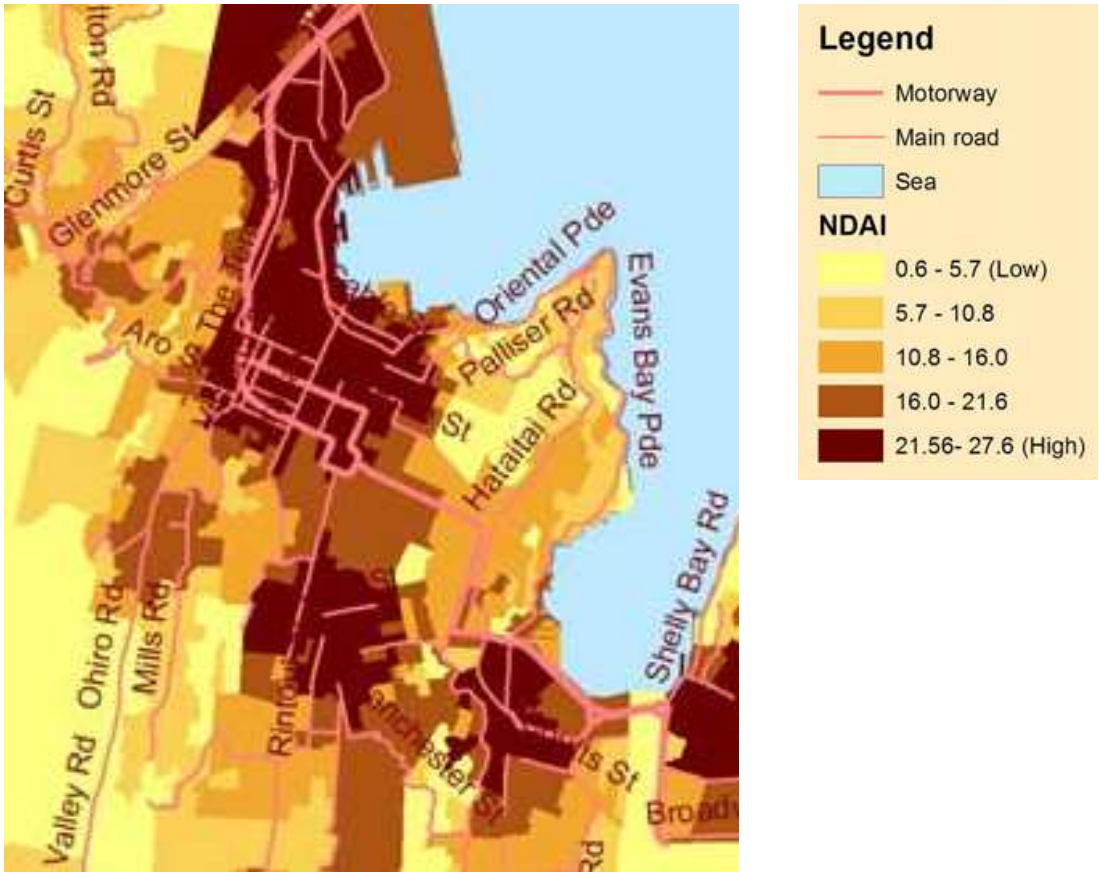
Figure 5.3 800m local road network buffer around population centre ('population-weighted centroid')



The primary difference between the NDAI and the Walkability Index is that the latter includes 'dwelling density'. The 'walkability' features are based on land-use factors (mixed land-use ratios and retail space coverage) and street network configuration, as opposed to the walking distances used in the NDAI. The NDAI measurement framework implicitly includes the street network configuration, insofar as a higher density of streets/walkways, with more intersections, will shorten the access distances.

As can be seen in figure 5.4, the central city area of Wellington city has an overall high amenity diversity rating for most of its area, reflecting good proximity and accessibility to the range of services, amenities and locations under observation. Generally speaking, the NDAI has a high rating for a larger portion of the same inner city area of Wellington and for other major suburban areas such as Newtown and Kilbirnie (located south and east of the inner city) than does the Walkability Index, largely reflecting the fact that dwelling density has been excluded from the calculation.

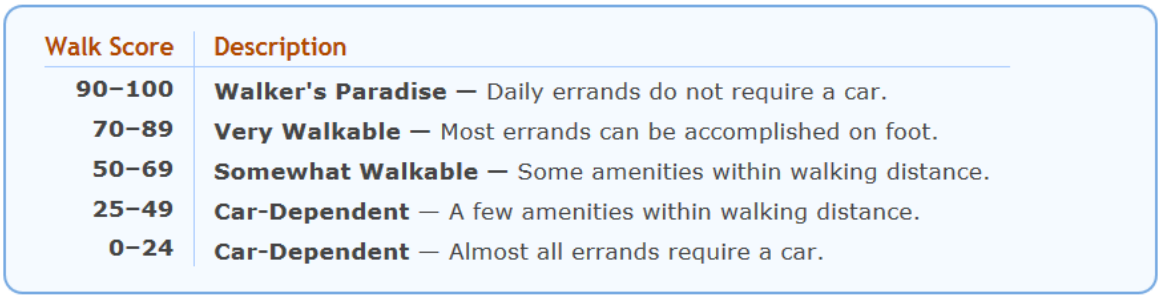
Figure 5.4 Wellington city Neighbourhood Destination Accessibility Index (NDAI) (source: Mavoa et al 2009)



5.2.3 Walk Score (www.walkscore.com)

Walk Score calculates the walkability of an address based on the distance from a residence to nearby amenities, namely restaurants, coffee shops/cafes, supermarkets/food shops, shopping, schools, parks and public places, books, pubs, entertainment (cinemas and theatres) and banking. Walkable neighbourhoods are considered to be those that have a centre (eg main street or public space), mixed income, mixed use, parks and public spaces, schools and workplaces, and streets designed for mixed mode use (walking, cycling, public transport and private vehicles). Each location is given a 'walk score' value of between 0 and 100 that measures the walkability of the location. Walkability is categorised as illustrated in figure 5.5.

Figure 5.5 Walk Score categories (source: www.walkscore.com)



Walk Score	Description
90–100	**Walker's Paradise** — Daily errands do not require a car.
70–89	**Very Walkable** — Most errands can be accomplished on foot.
50–69	**Somewhat Walkable** — Some amenities within walking distance.
25–49	**Car-Dependent** — A few amenities within walking distance.
0–24	**Car-Dependent** — Almost all errands require a car.

A recently released 'beta' Street Smart version measures the Walk Score for each amenity based on actual walking distances (previously this was done using 'as the crow flies'). It also takes into account the average block length as shorter blocks are considered more pedestrian-friendly, the intersection density and the link/node ratio (how many roads go into each intersection – more roads is considered friendlier). This can significantly affect the score of areas: for example, a location in Wadestown Road, Wadestown, Wellington scored 52 using the standard Walk Score measurement, and 36 using the Street Smart version (which we revised to 47 based on local knowledge of the area).

Walk Score does not take into account the perceived or actual safety of the area, the topography or the weather or particular elements of the street design (eg presence or absence of footpaths or pedestrian crossings, traffic speed, street lighting). However, it does provide a basis for consistent comparisons across several different areas as shown in table 5.1. Not surprisingly, both Wellington and Auckland inner cities are rated as 'walker's paradise', although it should be noted there are no public primary or secondary schools in the Auckland inner city, suggesting it is a less family friendly location than other suburbs might be.

Table 5.1 Comparison of walkability scores for selected areas in Wellington and Auckland cities (source: www.walkscore.com)

Locations in:	Score	Category
Inner city, Wellington	90–100	Walker's paradise
Wadestown Suburb of Wellington city, approximately 2km north of the inner city	30s–40s	Car dependent
Khandallah Suburb of Wellington city, approximately 6km north of the inner city	High 40s–50s	Car dependent to somewhat walkable
Karori Suburb of Wellington city, approximately 5–7km west of the inner city	30s–70s	Car dependent to very walkable
Inner city, Auckland	90–100	Walker's paradise
Grey Lynn Suburb of Auckland city, approximately 2km west of the inner city	70s–80s	Very walkable
Remuera Suburb of Auckland city, approximately 6km southeast of the inner city	50s–60s	Somewhat walkable

Full reports from the Walk Score website for the inner cities of Wellington and Auckland and for two suburban areas of each city are found in appendix D. The reports include a map showing the 15 minute walk radius and nearby amenities (refer figure 5.6), a list of amenities by category, the walkable distance and the score for that category, the pedestrian friendliness (average block length and number of intersections) and a graphical representation of the amenity score.

Figure 5.6 Example of Walk Score map showing nearby amenities and 15 minute walking radius

6 Fieldwork

6.1 Introduction

As can be seen in the literature review, a number of studies used what we term 'revealed' residential self-selection (RSS). This is the use of existing data to identify characteristics of residents and their behaviour to reach the conclusion that certain groups of people 'self-select' to live in a given area. While useful, this type of analysis does not disclose whether people's travel behaviour changes based on the neighbourhood (and its built environment characteristics) they select, or whether their travel behaviour would be the same no matter what neighbourhood they live in. Other studies had elements of 'stated' RSS (where the respondents stated how their behaviour had changed or not changed in different circumstances).

Based on revealed RSS, intensified neighbourhoods may look good on paper (lots of people with fewer cars), but these people may have had fewer cars prior to living in the intensified area or they may have the same ratio of vehicles to adults in the household while having fewer vehicles per household (due to the smaller household size). Our fieldwork set out to clarify some of the underlying factors in revealed and stated RSS.

6.2 Background

The data was collected over a two-week period beginning 20 January 2011 via an online survey. The online survey was hosted and conducted by PermissionCorp, using its research panel SmileCity, which is considered to be representative of the New Zealand population and have good response rates. SmileCity fully complies with ESOMAR, the international research organisation, standards and principles in the conduct of online market and social research, as well as with the ISO 20252 Market and Social Research Standard.

The targeted audience was Auckland and Wellington residents, aged 18 and over who were either employed or studying on a full- or part-time basis. There was a quota for respondents who live in the inner city area of Auckland or Wellington. This affected the overall response rate for the survey, as the quota proved a challenge to fill, hardly unexpected given that the inner city areas' population of 18,054 is approximately 1% of the total population of the Auckland and Wellington metropolitan areas combined.

The survey was initially sent to 1595 panel participants, with 605 (38%) completing the survey. At this point, the quota was filled for non-inner city residents, and the focus was on (literally) finding inner city respondents, given that PermissionCorp does not classify its panel members by location apart from city (eg Auckland or Wellington). About 1500 further panel members were contacted, with many screened out based on their residential location, until the quota of 120 inner city respondents was met.

Overall, the response rate for those attempting the survey (n=1698) was good, with 40% fully completing the survey (n=679). Thirteen percent of those attempting the survey were screened out (as not living in Auckland or Wellington) while 44% were screened out as 'quota full' in the effort to obtain inner city respondents. In the process of cleaning the data, 13 respondents and their data were removed as respondents were less than 18 years old. This left a total of 666 respondents, of whom 119 were living in the Auckland or Wellington inner city, 260 were living in Auckland or Wellington city (A/W cities – outside

the central city area) and 287 were living in Auckland or Wellington metropolitan areas (A/W metro – excluding residents of Auckland or Wellington cities and inner city residents).

6.3 Sample profile

Full-time workers formed 50% of the total sample, with part-time workers and students (both full and part time) being 13% and 14% respectively. The respondents were basically evenly split between Auckland and Wellington. The age of the sample was skewed towards the younger adult population (18 to 39 year olds formed 51% of the sample), which is not surprising given the bias created by having a quota for inner city residents, and that the survey was completed online. The most common living arrangements were couple (25%); couple or extended family with some children under age 18 (24%) or adult living with other adults (16%). The mean number of adults (aged 18+) per household was three, irrespective of residential location. Eighty-two percent of respondents held full driver licences, which was lower than the national average of 91% (O'Fallon and Sullivan 2009). Table 6.1 gives a profile of the respondents.

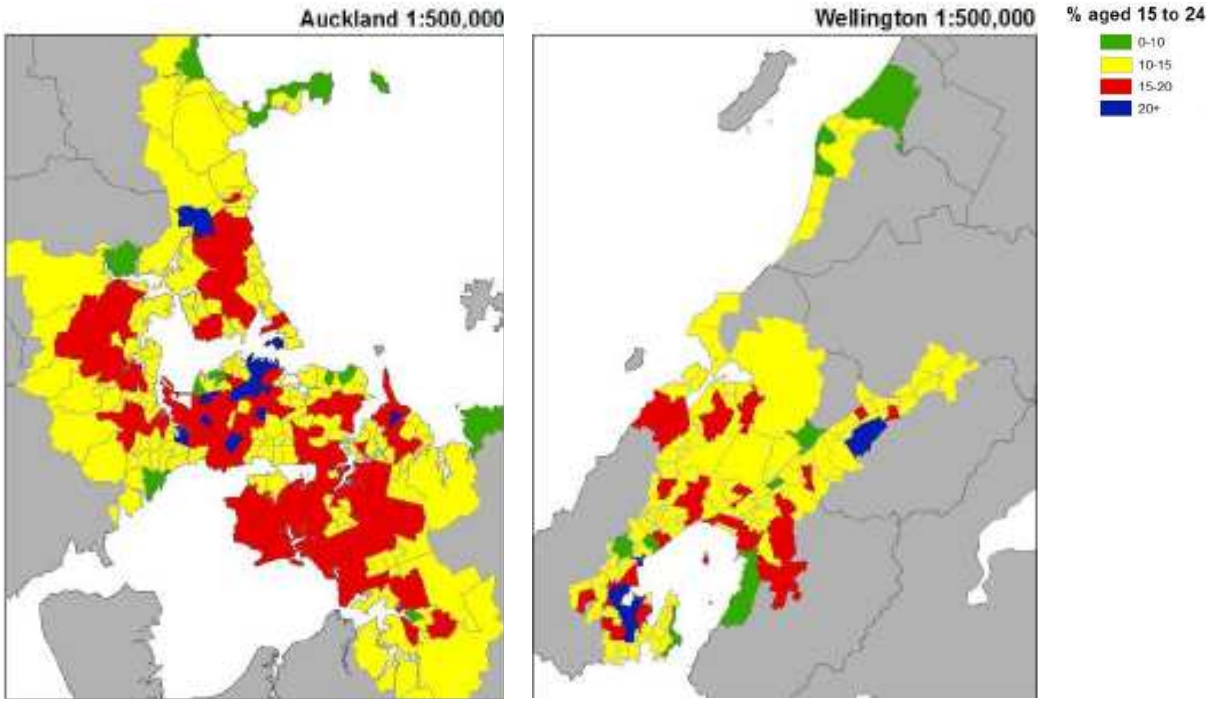
Table 6.1 Profile of respondents

Demographic characteristics		No. of respondents (N)	% of total	% of inner city residents
			N=666	N=119
Which best describes you?	Working full time (30+ hours per week)	335	50	63
	Working part time (less than 30 hours per week)	87	13	8
	Full-time student	77	12	15
	Part-time student	13	2	3
	Looking for work/unemployed	31	5	3
	Looking after home and family	32	5	2
	Retired	59	9	2
	Beneficiary	27	4	3
Which city do you live in?	Auckland	345	52	55
	Wellington	321	48	45
Which area do you live in?	Inner city A/W	119	18	100
	A/W cities	260	39	
	A/W metro	287	43	
Gender	Male	303	45	50
	Female	363	55	50
Which best describes your current household?	Couple living alone	167	25	37
	Couple or extended family living with children, some aged 0–17	163	24	15
	Couple or extended family living with children, all aged 18 years or older	48	7	3
	Single adult living with children, some aged 0–17 years	27	4	3
	Single adult living with children, all aged 18 years or older	16	2	1

Demographic characteristics		No. of respondents (N)	% of total	% of inner city residents
	Adult living alone	93	14	13
	Adult living with other adults	108	16	25
	Living with my parents or guardians	44	7	3
Age group	18–29	204	31	49
	30–39	141	21	28
	40–49	110	17	10
	50–59	109	16	7
	60–69	83	12	4
	70+	19	3	2
Is your current driver licence a...	Learner's licence	70	11	17
	Full or restricted licence	545	82	72
	I don't hold any driver's licence	51	8	11
Household vehicles	None	90	14	35
	1	227	34	36
	2	225	34	22
	3 or more	124	19	7

Given that adult workers and students were targeted, the total sample profile would not be directly comparable to population profiles of Auckland and Wellington (eg the sample had 18% living in the inner city A/W, while the 2006 Census indicated this proportion was 11%). However, comment on the alignment between the 2006 Census and the inner city sample profile was possible due to the Statistics NZ (2010) report. While the overall sample was skewed towards younger respondents, it was representative of inner city dwellers where 49% were aged 20 to 29 years in 2006. Figure 6.1 shows the population aged 15 to 24 was disproportionately higher in the central city compared with other parts of either Auckland or Wellington metropolitan area.

Figure 6.1 Proportion of population aged 15 to 24 in Auckland and Wellington metropolitan area, 2006 (source: Norman and Sanderson 2010)



Similar proportions lived in households comprising unrelated adults ('adult living with other adults'): 28% in the 2006 Census and 25% in the sample, while there were fewer single adult households (19% according to the census and 13% in the sample), which resulted in the sample being slightly more oriented to couples and families with children than was the overall population. Vehicle ownership patterns were similar, as Statistics NZ reported 36% of inner city residents lived in households with no vehicles compared with 35% in the sample.

The labour force participation rate, including both part- and full-time workers, for the inner city sample (71%) was very similar to that reported by Statistics NZ (73%). The sample had fewer part-time workers than what was reported in the census (8% compared with approximately 13%).

It is difficult to compare the study participation rates between the sample here and the census, as the census asked a completely separate question regarding study, which permitted people to be counted both as students and workers, as opposed to the questionnaire used for this study which asked 'which best describes you?' with the option to select a single response. As a result, while 18% of the survey respondents described themselves as full- or part-time students, Statistics NZ reported 39% of Auckland and 30% of Wellington inner city residents were in some form of study.

6.3.1 Household vehicle ownership

Fourteen percent of respondents in the sample lived in households with zero vehicles, with just under one-half (47%) of them living in inner city A/W.

Nearly one-third (31%) of the 90 respondents living in households with zero vehicles did not hold a driver licence, a much higher rate than respondents living in households with one or more vehicles, where only

4% reported not having a licence. Most of the non-licence holders living in households with one or more vehicles were located in A/W cities or A/W metro (17 of 28 respondents).

Melia (2007) posited that higher density residential locations could contain higher proportions of people choosing to live without a car. He found that 87% of respondents in an inner London borough selected 'no need for a car' as the main reason for living without one, while cost was the second most common reason (83%). We asked participants to select up to three responses to the question 'What are the primary reasons that your household does not have any motor vehicles?' While the proportions were smaller than for Melia (2007), the results were similar: in our inner city A/W sample: 52% of respondents stated there was 'No need for a motor vehicle – other transport options available', with 50% giving 'cost' as the second most common reason. Very few (9%) indicated that being without a vehicle was a temporary situation.

Table 6.2 Respondents' main reasons for not having a car in their household (N=90)

Reasons no car in household	% of respondents choosing reason
No. of respondents (N)	90
No one in household is able to drive	23%
Cost of vehicle/driving	50%
No need for a motor vehicle – other transport options available	52%
Health/physical difficulties	8%
Lack of parking spaces	19%
Don't like driving or prefer other means of transport	12%
Environmental reasons	10%
Temporarily without a motor vehicle but will acquire another one shortly	9%
Other	9%

Examining their responses by residential location, there was very little variation in the most commonly cited reasons, although the proportion of respondents selecting each one did differ:

- Inner city (42 respondents): nearly two-thirds selected 'No need for a motor vehicle – other transport options available', followed by 'Cost of vehicle/driving' and/or 'Lack of parking'.
- A/W cities (28 respondents): around one-half selected 'Cost of vehicle/driving' and/or 'No need for a motor vehicle'. About one-fifth selected the third most common reason 'No one in household is able to drive'.
- A/W metro (20 respondents): nearly half selected 'No one in household is able to drive', closely followed by 'Cost of vehicle/driving' and/or 'No need for a motor vehicle'.

Those respondents who had access to at least one vehicle in their household were asked to complete the statement: 'I might be able to live in a household without a motor vehicle if…' from a list of possible responses (see table 6.3). Nearly half (45%) selected: 'I don't believe it is possible for me to live without a motor vehicle', while 30% indicated that public transport services would have to improve. A/W cities and A/W metro respondents were more likely than inner city A/W residents to state they did not believe it was possible to live without a motor vehicle. Younger respondents (18 to 29 year olds) were less likely to state

they did not believe it was possible to live without a motor vehicle than were other age groups, irrespective of where they lived.

Twenty-one respondents (4%) indicated they could choose to give up their motor vehicle at any time without any of their circumstances changing.

Table 6.3 Exploring possibility of living without a motor vehicle (N=576)

I might be able to live in a household without a motor vehicle if…	**No. of respondents (N)**	**Percent**
I moved to a different area	68	12%
I changed jobs or course of study	26	5%
I retired	18	3%
Public transport services improved	170	30%
I don't believe it is possible for me to live without a motor vehicle	257	45%
Car belongs to someone else in household	7	1%
I choose to live with a car, but could change at any time	21	4%
Other	8	1%
Total	576	100%

6.3.2 Ratio of vehicles to adults per household

Note that in the sample, consistent with the 2006 Census (Statistics NZ 2010), significantly more households in the inner city were couples only or 'adults living with other adults' than in A/W cities or A/W metro. Hence, it is probably more relevant on the whole to consider the ratio of vehicles to adults in a household, rather than limit consideration to the number of vehicles in a household. Generally speaking, table 6.4 shows residential location had a demonstrable influence on the ratio of vehicles to adults, which increased from a median of 0.5 vehicles per adult in the inner city to 0.67 in the A/W cities and 1.0 in the A/W metro. The youngest age group (18 to 29 years) showed a similar trend, although their median values of the ratios were smaller (0.33 in the inner city compared with 0.60 and 0.71 in A/W cities and metro, respectively).

Table 6.4 Mean and median vehicle:adult (18+) ratio in households by residential location

Vehicle:adult (18+) ratio in household	Inner city A/W	A/W cities	A/W metro
No. of respondents (N)	119	260	287
Median	.50	.67	1.00
Mean	.47	.73	.83
Standard deviation	.47	.47	.47

Table 6.5 provides further detail into the vehicle ownership patterns. While 35% of households in the inner city had zero vehicles, households across all areas had quite similar proportions with 0.01 to 0.5 vehicles:adult (ranging from 23%–31%). A much lower proportion of inner city respondents had >0.5 vehicles:adult than in A/W cities or A/W metro (34% compared with 60% and 70%, respectively). Nearly half (N=27 or 47%) of those aged 18 to 29 living in the inner city were in households with zero vehicles, compared with 13% and 8% of 18 to 29 year olds living in A/W cities and metro.

Table 6.5 Vehicle:adult (18+) ratio by residential location

	Current residential location			
Vehicle:adult (18+) ratio in household	Inner city A/W	A/W cities)	A/W metro	All areas
0	35%	11%	7%	14%
0. 2–0.49	9%	8%	8%	9%
0.5	22%	21%	15%	19%
0.51–0.99	9%	18%	16%	16%
1	22%	35%	44%	36%
>1	3%	7%	10%	7%
Total	100%	100%	100%	100%

The number of vehicles to adults in the household varied depending on the type of household. We segmented households into 'family' households (comprising one or more adults with some children aged <18 years), 'related adults' (couples or families where everyone in the household was aged 18 years or older) or unrelated households (either 'adult living alone' or 'adult living with other adults'). Unrelated households were far more likely to have zero vehicles per household (24% compared with 7% of families with <18 year olds or 10% of related adult households). Unsurprisingly, the group most likely to have exactly one vehicle per adult was the 'adult living alone'. We had speculated that related adult households might be able to better share cars whereas unrelated adults, eg two independent adults with different jobs and responsibilities, would more likely be individualised in their behaviours and hence, more likely to own his or her own car. Unpredictably, we found households of related adults and family households were much more likely to have ≥1 vehicle per adult (39% and 48% compared with 21% of unrelated adult households).

Households with a ratio of less than one vehicle per adult were more likely to indicate they could live in a household without a motor vehicle if public transport services improved and less likely to state they did not believe it was possible to live without a motor vehicle than those households with ≥1 vehicle:adult, irrespective of where they lived.

6.4 Transport mode use

Respondents were asked about their travel patterns in their current residential location, their previous residential location (if they had shifted residence since 2008) and their future residential location (if they intended to shift within the next two years). In this way we were planning to assess the impact shifting residence might have had (or might have in the future), particularly where the shift entailed moving from either a lower density neighbourhood (A/W cities or A/W metro) to the inner city A/W or vice versa, from a higher density neighbourhood to a lower density one.

In order to get a broad view of their travel patterns, respondents were asked three specific questions (note that the wording varied somewhat depending on whether the current, previous or future residential location was being addressed):

- **In a typical week**, how often did you use each of the following travel methods to get from place to place? Mode choices included: driving a motor vehicle (car, van, truck, motorcycle), passenger in a motor vehicle, walking or jogging, bicycle and public transport (bus, train, ferry). Response choices included: five to seven days a week; three to four days a week; one to two days a week; less than one day a week; and 'not at all'.
- In a typical week, how often did you use each of the following travel methods to **commute to work**? (Students were asked: In a typical week of your most recent term, how often did you use each of the following travel methods to **commute to your study/training**?) The same mode choices and response choices were included as for the general travel question.
- **In your current residence**, how do you or others in your household usually travel to… supermarket, primary school or college, another adult in my household's work/education, your usual place to exercise or play sport. Response choices included: drive a motor vehicle, passenger in a motor vehicle, walk, jog or cycle, public transport (bus, train, ferry), other method, and I/we don't go to this place.

When asking about the previous residential location general mode use, the response choices included 'YOUR work' and 'YOUR education'.

The responses to all of these questions are explored in the following sections.

6.4.1 Mode use in a typical week

Across the whole dataset, over 80% of respondents were vehicle passengers on fewer than two days per week and 95% never or rarely cycled in a typical week, meaning it was not feasible to provide any further comparisons on these methods of travel.

Figures 6.2 and 6.3 show there were significant differences in the reported frequency of driving and walking in a typical week between people in inner city A/W, A/W cities and A/W metro. Given the much lower household vehicle ownership levels in inner city A/W, it is not surprising to find only 35% of these respondents reported driving on three or more days per week, compared with 59% of those in A/W cities and 74% of those in A/W metro. Twenty-seven percent of inner city respondents drove on five to seven days a week, while more than double (59%) of A/W metro respondents did the same. Instead, nearly half (46%) of inner city A/W respondents reported walking for transport on five to seven days a week, compared with the much lower percentages in A/W cities and A/W metro.

Figure 6.2 Comparison of frequency of driving between inner city A/W and other areas

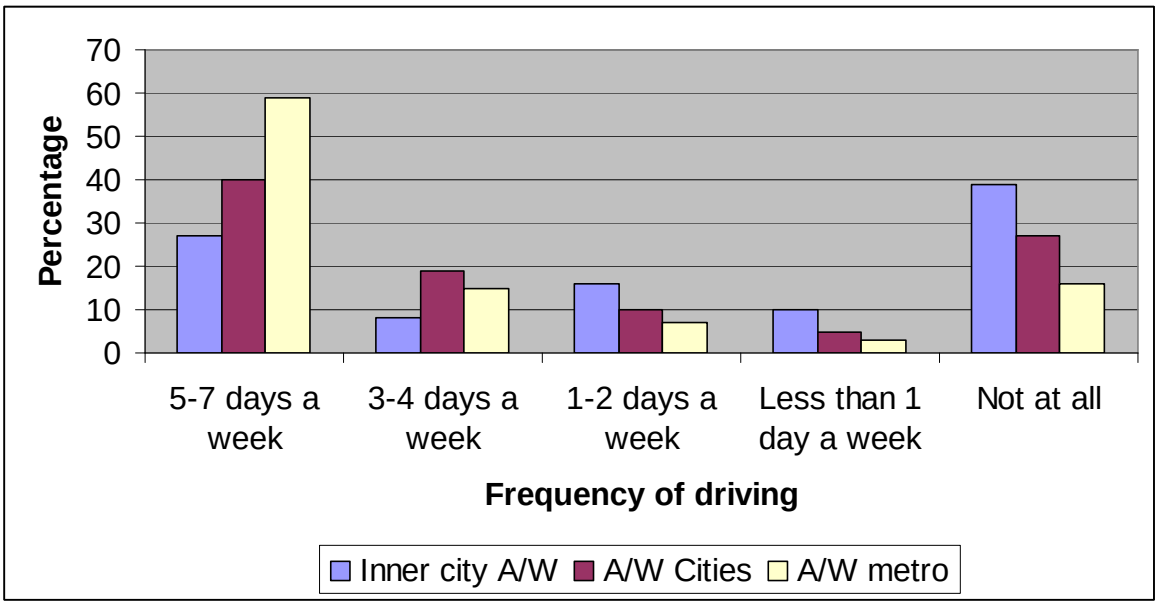
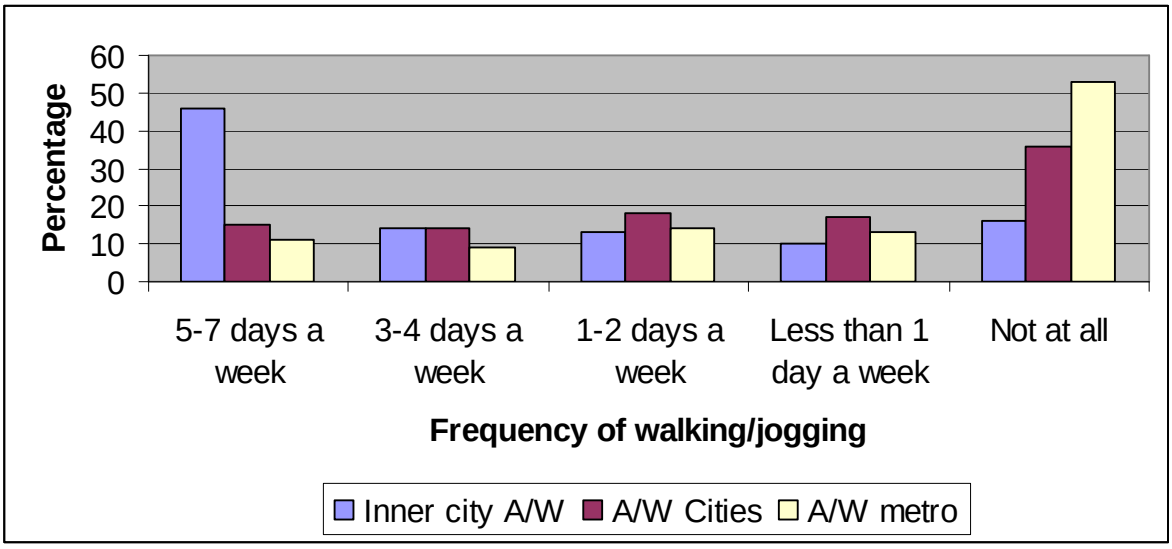


Figure 6.3 Comparison of frequency of walking or jogging between inner city A/W and other areas



In contrast with driving and walking, public transport use was very similar between inner city A/W and A/W cities respondents (25% reported using public transport on three or more days a week) and lower in A/W metro (13%). The lower use by A/W metro respondents probably reflects the differences in availability and frequency of services (eg no services available, limited hours of service, low frequency) in these areas compared with A/W cities and inner city A/W. For inner city residents, trips need to be of a reasonable distance not to walk and to take public transport instead. Given that most residents reported they worked or studied, went supermarket shopping, ate out and exercised or played sport in the central city (refer section 6.4.2), it seems likely the trips were too short to justify public transport use. Inner city residents are also reliant on reverse-direction services during peak periods, and it may be that services are reasonably infrequent during these time period when the focus is on bringing people in from the suburbs in the mornings and out again in the evening.

Table 6.6 Comparison of frequency of public transport use between inner city A/W and other areas

Frequency of public transport use	Current residential location			
	Inner city A/W	A/W cities	A/W metro	All areas
5–7 days a week	11%	17%	8%	12%
3–4 days a week	14%	8%	5%	8%
1–2 days a week	14%	14%	8%	12%
Less than 1 day a week	26%	20%	16%	19%
Not at all	34%	40%	63%	49%
Total	100%	100%	100%	100%

6.4.2 Typical mode use for various activities

The previous section highlighted the frequency of mode use in a typical week. In order to understand the variations in mode use, respondents were also asked what method of travel they or other members of their household used for specific destinations (supermarket, primary school or college, the education or workplace of another adult in the household and their own exercise or sport location), and where they conducted some activities, namely eating out, supermarket shopping, working or study, exercise or playing sport.

Given that inner city households had lower vehicle ownership rates, it is not surprising to find the respondents typically used motor vehicles less often for such trips (refer table 6.7). The one exception was for travel to primary school or college, where inner city students were driven to school apparently more often than those in A/W cities, but less frequently than in the A/W metro areas. While 50% of inner city respondents' trips to the supermarket were by motor vehicle, 37% of them were by walking or cycling – quite different from those in A/W cities and A/W metro, where the vast majority were by motor vehicle. The commute trip to work or education by another adult in the household showed that much higher proportions of inner city residents walked or used public transport (and consequently fewer travelled by car) than in A/W cities or A/W metro.

Table 6.7 Means of travel to typical household activities (in percent)

		In your *current* residence, how do you or others in your household usually travel to…			
Current residential location	**Means of travel**	**Supermarket**	**Primary school or college**	**Another adult in my household's work/ education**	**Your usual place to exercise or play sport**
All	No. of respondents (N)	656	282	450	492
	In a motor vehicle	81%	46%	65%	53%
	Walk/jog/cycle	15%	33%	14%	42%
	Public transport (bus, train, ferry)	4%	21%	20%	5%
Inner city A/W	No. of respondents (N)	113	51	81	95
	In a motor vehicle	50%	41%	35%	33%
	Walk/jog/cycle	37%	35%	41%	58%
	Public transport (bus, train, ferry)	12%	24%	25%	9%
A/W cities	No. of respondents (N)	259	105	171	196
	In a motor vehicle	82%	30%	63%	46%
	Walk/jog/cycle	16%	35%	12%	47%
	Public transport (bus, train, ferry)	2%	35%	26%	7%
A/W metro	No. of respondents (N)	284	126	198	201
	In a motor vehicle	93%	61%	80%	68%
	Walk/jog/cycle	6%	30%	6%	30%
	Public transport (bus, train, ferry)	1%	9%	14%	1%

One cannot assume that, because inner city residents typically walk more frequently to the supermarket than A/W city and A/W metro households, they drive fewer VKT for grocery shopping. Those walking to supermarkets in the inner city are presumably not purchasing large or heavy items since they have to carry the groceries home. Also, they may make more frequent trips because the supermarket is nearby and/or convenient. As a result, they might be making more trips to the supermarket per month in order to purchase the same volume of groceries. Thus, while their 'typical' trip might be by foot, others might be by car to an out-of-neighbourhood supermarket.

6.4.2.1 Reverse travel or 'Do residents live where they work and play?'

Excluding those who responded 'don't usually do this' to a listed activity in the question 'When you do the following activities, where do you usually do them?', inner city residents more consistently stated they usually worked (78%), attended their own education (63%), shopped for food (64%), ate out/had coffee (73%) and exercised or played sport (64%) in the area they lived in than did A/W cities and A/W metro respondents. On a broader basis, using the 2006 Census, Statistics NZ (2010) reported that 81% of

Auckland city residents and 88% of Wellington city residents lived and worked in the same territorial authority city.

Responses varied by activity for those living in A/W cities or A/W metro, reflecting in part the concentration of paid work positions and tertiary educational institutes in the A/W central city areas (49% of A/W cities and 32% of A/W metro respondents attended work and 57% of A/W cities and 41% of A/W metro attended study in the central city), and the existence of café and restaurant precincts (44% of A/W cities and 27% of A/W metro residents ate out in the central city). As was the case for inner city residents, food shopping was apparently concentrated nearer to home: 72% and 80% of A/W cities and A/W metro residents shopped in 'another area' (not the central city).

Respondents could select both 'central city' and 'another area' if that best described where they carried out their activities; however, generally very few (<10%) indicated they usually did their food shopping, eating out, exercise or playing sport in both the central city and another area. Work and study was basically conducted in one identified location.

There was no notable variation between Auckland and Wellington respondents when disaggregated by residential location.

6.4.3 Typical mode use for commute to work or study

Respondents were asked 'In a typical week, how often did you use each of the following travel methods to commute to work (study)?' The choices were largely based on the census, namely: drive a motor vehicle (car, truck, van or motorcycle)[11], passenger in a motor vehicle, walking or jogging, bicycle, public transport (bus, train, ferry) and worked from home. The response choices were '5–7 days per week', '3–4 days a week', '1–2 days a week', 'less than one day a week', and 'not at all'. To analyse the responses for this report, the one mode each respondent used most frequently for commuting to work or study in a typical week was identified, as shown in table 6.8.

Table 6.8 Mode used most frequently for travel to work/study by residential location

	Current residential location			Total sample
Mode used most frequently in a typical week commuting to work or study	**Inner city A/W**	**A/W cities**	**A/W metro**	
Drive a vehicle (incl walk)	30%	50%	66%	52%
Private vehicle passenger	2%	4%	6%	5%
Walk	39%	10%	2%	13%
Bicycle	1%	2%	1%	1%
Public transport (including park and ride, and walk)	24%	31%	16%	24%
Work from home	4%	3%	8%	5%
Total	100%	100%	100%	100%

[11] The 2006 Census questionnaire specifically excluded 'motorbikes' from the count of the number of motor vehicles available for use in a household, although 'motorbikes' were included as an option in choosing the 'main means of travel to work'.

In the inner city, walking (39%) was the most frequent means of travel to work, followed by driving (30%, including walk and drive) and using public transport (24%, including park and ride, and walk and ride). This contrasts sharply with other areas of Auckland and Wellington, where 50% and 66% most frequently drove in A/W cities and A/W metro respectively. Public transport use was most common in A/W cities (31%).[12]

A factor influencing mode choice for the commute in situations where a person chooses to walk even though a vehicle is available could be *proximity to the workplace.* Our survey did not specifically measure proximity to workplace, instead respondents were asked to identify their current work location as 'central city' or 'other area'. Over three-quarters (76%) of respondents living in the inner city also worked in the inner city (which would facilitate walking as a mode of transport), while nearly half (49%) of those in A/W cities and one-third (32%) in A/W metro also worked in inner city A/W, suggesting that fewer lived in the same area as where they worked[13] and thus would have to use alternative means to travel there.

6.4.3.1 Time spent commuting

There was surprisingly little variation in the amount of time usually spent travelling from home to work or study: in the inner city and A/W cities the median time spent was 20 minutes, while those living in the greater A/W metro area reported a median time of 25 minutes.[14] Schwanen et al (2005) made a similar observation in their Netherlands study, and posited the reason for the similarity was due to the fact that those outside the city centre tended to use their vehicles, rather than public transport or walking, for commuting, as well as having less congestion and fewer parking issues on their local road network.

Our study population was too small to fully disaggregate by mode *and* residential location in order to comment on the time spent commuting by mode, but the indications are that proportionally more respondents spent longer times driving or using public transport to work or study from A/W metro than from either the inner city or A/W cities. Also, proportionally more walkers spent longer times commuting (>30 minutes) from A/W cities than in the inner city, where the majority spent <20 minutes walking.

6.4.3.2 Reverse commuting

Nineteen inner city residents (22%) stated they worked in 'another area', outside the central city, indicating reverse commuting does occur. Fourteen of these respondents lived in Auckland and, in a typical week, thirteen most frequently drove a vehicle to work rather than used public transport or walked.

[12] Note that the inclusion of 1) commute trips to study, which have far fewer trips as drivers and more on public transport and 2) a higher proportion of inner city residents than in the general population (and thus an emphasis on students) means the proportions vary from those reported for the journey to work in the 2006 Census.

[13] This finding complements and refines the 2006 Census reporting, discussed in section 4.2.4, which highlighted how residents in the eight Auckland and Wellington cities lived and worked, by separately identifying the behaviour of those living in the inner city of Auckland and Wellington cities and contrasting it with the remainder of A/W cities and A/W metro.

[14] The median is the value that divides the distribution into halves; where one-half of the trip segments are above the median length and one-half are below it if the data was arranged in numerical order. Where the data is known not to have a normal distribution, as is the case with the current dataset (which is skewed towards shorter commuting times rather than longer ones), the median is an appropriate choice for describing the typical person or situation. The median is less susceptible to outliers than is the mean.

6.4.4 Walking and cycling for transport and leisure or recreation

Other studies found the occurrence of recreational walking trips was largely unaffected by the built environment (eg Lund 2001; Cao et al 2005a; Saelens and Handy 2008; Oakes et al 2007; and Forsyth et al 2009).

Hence, in addition to asking about mode use 'in a typical week' (recognising that the surveying occurred during the summer holiday period in New Zealand), including walking and cycling, respondents were asked to report on walking and cycling activity over the past seven days, both in terms of transport walking and cycling and that done for recreation, sport, exercise or leisure. In both cases, they were asked to count 'only those occasions where you did at least 10 minutes at one time' of walking or cycling, as we wanted to gain some idea of the potential contribution of walking and cycling to a person's overall physical activity levels, in the context of the 'built environment' they lived in (ie inner city, A/W cities or A/W metro). Despite the differences in the questions, there was a satisfying consistency in the responses with respect to walking or cycling as a travel method 'to get from place to place' and 'for transport', which never varied by more than 5% and more commonly by 1% to 2%.

While cycling occurred more frequently in the past seven days, both recreationally and as a mode of transport, in the inner city, it was not a particularly large difference. Eighty-three percent of inner city residents reported they had done no cycling for recreation, sport, exercise or leisure compared with 89% of A/W cities and metro respondents, while 16% reported cycling for transport on one or more days, compared with 7% of respondents from A/W cities and metro.

Similarly, there was little reported difference in the amount of walking for recreation, sport, exercise or leisure in the past seven days: 19% of inner city respondents did no walking for leisure, compared with 27% of A/W cities and metro respondents.

There was a much more notable difference in the frequency of walking for *transport*, with 48% of inner city respondents reporting they had walked at least 10 minutes at a time on five to seven days in the past seven days. This contrasted with 16% of respondents from A/W cities and metro who reported the same level of activity. Nearly half (48%) of the respondents from A/W cities and metro reported *no* walking for transport in the past seven days.

Oakes et al (2007) and Forsyth et al (2009) determined that people who lived in higher density areas, *without a car available in their household*, walked for transport purposes at higher levels than those with cars. Our data mirrored their finding: in the higher density inner city A/W, 60% of households with zero vehicles walked for transport at least 10 minutes at a time on five to seven days compared with 31% of inner city households with one or more vehicles per adult. They also walked more than people living in A/W cities or metro households with zero vehicles (where 35% walked for transport on five to seven days in the last seven days).

It appears factors other than vehicle ownership were at play, given that inner city households sharing one vehicle between two or more adults (ie a household vehicle:adult ratio of >0 and <1) also showed a much greater propensity to walk for transport, with nearly 50% walking on five to seven days in the last seven days, compared with 27% in A/W cities and 12% in A/W metro.

6.5 Comparing travel behaviour in current residence with previous residential location

In order to develop an understanding of the interaction between living in an intensified environment, travel behaviour and possible external factors (eg changing jobs, health problems), respondents who had shifted residence in the last three years were asked several questions about their previous residence, including the makeup of their household, vehicle ownership, trip-making and previous mode use relative to their current use. Three hundred and two respondents had shifted into their current residence in 2008 or later. There was a general tendency to stay in the same part of the city one had lived in before, ie most inner city residents (26 of 29 (90%) in Auckland and 10 of 20 (50%) in Wellington) shifted to another residence in the inner city, while 51 of 68 (75%) in Auckland and 29 of 38 (76%) in Wellington shifted within their respective A/W metro area.[15]

One of the aims of this study was to consider the effect of shifting to a different environment (eg from a lower residential density area to a higher residential density area or vice versa) on travel behaviour and household vehicle ownership, while taking into account mitigating factors, such as a change in household composition, job or other personal circumstances. Unfortunately, there were only 44 respondents who had shifted from a lower density area to the inner city of either Auckland or Wellington, and 13 respondents who had shifted from the inner city to a lower density area. As it had proved difficult to recruit inner city respondents generally, we did not attempt to include a quota for either of these two groups. The vast majority (81%) of shifters had stayed in an area with a similar density to their previous residence.

Recognising the limitations of the small number of respondents involved, it is interesting to note that of the 44 who shifted from a lower density area to the inner city, 22 now lived in households with zero motor vehicles, compared with eight in their previous households. Five others had reduced the vehicle:adult ratio in their current household compared with the previous. The net result was both the median and mean vehicle:adult ratios had declined for those shifting from the lower density area to inner city A/W, while those who shifted within the inner city or within another lower density area maintained the same vehicle:adult ratios. There were far too few shifting from inner city to lower density areas (N=13) to comment on.

[15] The metropolitan areas of Auckland and Wellington physically cover a much larger land mass – and both incorporate three smaller cities – than the inner city areas, so that respondents could have shifted between quite different locations in terms of services, transport networks, etc. However, the primary focus of the study here is on the difference in travel behaviour between inner city residents in high density areas and those living in less dense urban areas.

Table 6.9 Household:adult vehicle ratio – previous residential location compared with current residential location

			Median vehicle:adult ratio*		Mean vehicle:adult ratio*	
Shifted in past three years from and to	**No. of respondents (N)**	**Percent**	**Previous**	**Current**	**Previous**	**Current**
Shifted from lower density to inner city	44	15	0.5	0	0.6	0.3
Shifted from inner city to lower density	13	4	0.5	0.6	0.5	0.6
Shifted within inner city	36	12	0.5	0.5	0.4	0.4
Shifted within lower density area (eg A/W cities; A/W metro)	209	69	0.67	0.67	0.7	0.7
Total respondents shifting	302	100				
Did not shift	*364*					

* All values treated as indicative only, given the small sample sizes

Those shifting to or within inner city A/W were more likely to agree/strongly agree (A/SA) with 'I prefer living in inner city to living in a suburb' than those shifting within lower density areas, who were much more likely to disagree/strongly disagree (D/SD) with that statement and A/SA with 'I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services'.

6.5.1 Main reason for shifting to current residence

Respondents who had shifted to their current residence in 2008 or later were asked 'What was the main reason you moved from your previous residence to your current one?' We were particularly interested in whether or not specific neighbourhood or built environment characteristics would be mentioned or if other factors were more prevalent. Table 6.10 shows one-third of respondents who had shifted indicated the main reason for their move was that the current accommodation was better than the previous one, eg it was bigger, sunnier, cheaper, newer or smaller. The next most common reason for moving was to be closer to work, study or school or 'town' (14%) or a change in living arrangements (14%), such as moving in with a partner, divorce or having a baby, which resulted in a change in the number of people living in a household. Buying a house or apartment (13%) or the lease expiring (8%) were also fairly common reasons for shifting. These were not unlike the ones selected by respondents to the Wellington City Council (2009) survey which provided a set checklist of possible reasons, with the most commonly selected reasons being lifestyle, to be close to work, shops and cafes, and low maintenance. Preferring a specific mode of transport or wanting to live in a specific type of neighbourhood (eg inner city or suburban) were not given as reasons in either survey. Bina et al (2006) also reported the primary reasons given for shifting by apartment dwellers was cost of housing, easier commute trip and having a new job or course of study to attend.

Apart from a desire to be closer to work, study or town by some respondents, largely exogenous factors not having to do with neighbourhood attributes were offered as explanations for residential shifts, eg changes in household size, the characteristics of the accommodation itself, and ownership or change in lease. Two respondents identified issues about personal security as the reasons for their move.

Table 6.10 The main reason for move from previous residence to current one (up to three reasons given per respondent)

Main reason (categorised)	No. of responses	Percent
Better or cheaper accommodation (more suited to needs)	101	34%
New job or study	22	7%
To be closer to work, study or town	43	14%
Change of living arrangements (eg moved in with partner or spouse, having baby, custody of children, relationship ended)	43	14%
Bought house or apartment	38	13%
Lease expired	25	8%
Other	26	9%
Total	298	100%

Respondents shifting from lower density areas to the inner city were most likely to state the primary reason for shifting was for a new job, study or training, or that it was due to better or cheaper accommodation (both were 21% of the reasons), followed by a desire to be closer to work, study or town. Those shifting within lower density areas gave better or cheaper accommodation as their first reason followed by bought house or apartment, to be closer to work, study or town and change of living arrangements. Respondents shifting to the inner city were also much more likely to report they walked 'a lot less often than I do now' and drove 'a lot more often than I do now' in their previous (lower density) residence, while those shifting within lower density areas, or even within inner city A/W, were more likely to report the status quo for both walking and driving. Carroll et al (2011) also found families who had shifted into inner city Auckland commented on the ease of walking 'everywhere', compared with their dependence on cars or public transport when living in Auckland city or metro. However, affordability was the key factor in choosing their residential location, and 8 of the 10 families interviewed aspired to have a house with a section in the suburbs.

6.5.2 Travel behaviour in previous residence compared with current one

In order to observe the effect on transport mode use of shifting from a low density neighbourhood to a high density one or vice verse, shifters were asked 'In your *previous residence*, would you have used these travel methods more or less often than you have in the last 4 weeks?' Again, due to the relatively infrequent use of the modes 'vehicle passenger' and 'cycling', these have been excluded from the analysis.

Table 6.11 Frequency of mode use in current residence location compared with previous residence

		Drive		Walk		Public transport	
Shifting from and to	**Frequency of use in now compared with previously**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Shifted from lower density to inner city	Didn't use this method previously	6	14%	3	7%	6	14%
	Use less often now	18	41%	10	23%	20	45%
	Use about the same now as previously	7	16%	7	16%	8	18%
	Use more now than previously	13	30%	24	55%	10	23%
	Total	44	100%	44	100%	44	100%
Shifted from inner city to lower density	Didn't use this method previously	4		1		4	
	Use less often now	1		7		2	
	Use about the same now as previously	5		2		1	
	Use more now than previously	3		3		6	
	Total	13		13		13	
Shifted within inner city	Didn't use this method previously	11	31%	1	8%	4	11%
	Use less often now	9	25%	8	22%	12	33%
	Use about the same now as previously	13	36%	21	58%	13	36%
	Use more now than previously	3	8%	6	17%	7	19%
	Total	36	100%	36	100%	36	100%
Shifted within lower density area	Didn't use this method previously	23	11%	30	14%	45	22%
	Use less often now	68	33%	60	29%	59	28%
	Use about the same now as previously	82	39%	59	28%	58	28%
	Use more now than previously	36	17%	60	29%	47	22%
	Total	209	100%	209	100%	209	100%

Examining the responses within a particular shift category (eg shifted within lower density area), it appears, in a typical week, respondents shifting from lower density areas to the inner city were more likely to report they drove a motor vehicle and used public transport *less* often, and walked *more* often in their current residential location, than they were to report they drove and used public transport *more* often and walked *less* often. By contrast, those shifting from and to a lower density area or within the inner city were more likely to report they drove and used public transport more often in their current residence while their walking trips were largely unchanged overall (eg 29% in lower density areas reported fewer trips and 29% reported more trips, effectively cancelling each other out).

Respondents reporting they drove 1) less often (N=41) or 2) more often (N=130) now than they did in their previous residence were also asked to provide up to three reasons for the change in their behaviour.

As can be seen in table 6.12, the most commonly selected reason for driving *less often* now was the respondent lived closer to the places they wanted to go to now (19% of all reasons selected), followed by changed jobs or started working (14%) and the cost of driving (12%).

Table 6.12 Reasons for driving a motor vehicle less often now than in previous residence (up to three reasons selected by 41 respondents)

Reasons for driving less	No. of responses	Percent
Live closer to places I want to go to now	15	19%
Changed jobs/started working	11	14%
The cost of driving	9	12%
To improve health	4	5%
Stopped working	3	4%
Had children	3	4%
Sold a car	3	4%
To avoid congestion	3	4%
Better public transport where I live now	3	4%
Concerns about the environment	3	4%
Health problems	2	3%
Started education/training course	2	3%
Other	16	21%
Total	77	100%

People who reported they drove a motor vehicle *more often* now than in their previous residence gave basically the same two main reasons: 'live further away from places I want to go to now' (26%), and – rather than closer now (which was the reason for driving *less*) – 'changed jobs/started working' (18%). The third most commonly selected reasons were 'had children' (10%) and 'changes to public transport provision' (10%).

Table 6.13 Reasons for driving a motor vehicle more often now than in previous residence (up to three reasons selected by 92 respondents)

Reasons for driving more now	No. of responses	Percent
Live further away from places I want to go to now	32	26%
Changed jobs/started working	22	18%
Changes to public transport provision	12	10%
Had children	12	10%
Bought a car	9	7%
Stopped working	6	5%
Health problems	5	4%
To avoid congestion	4	3%
Children started school	3	2%
Other	17	14%
Total	122	100%

6.5.3 Typical mode use for various activities in previous residence compared with current one

Respondents were asked the same question about what method of travel they or other members of their household used for specific destinations (supermarket, primary school or college, their own work, their own study, another adult in the household's work or education and their own exercise or playing sport) for their previous residence. The responses to this question were compared with the modes used in their current residence to further assess the effect of the shift on their travel behaviour. There were too few students who shifted to comment on changes in their commute mode use as well as too few households with primary or secondary school students.

Table 6.14 indicates the shift from a lower density area to the inner city was often accompanied by a change in the travel method(s) used to access various activities, notably the supermarket, another adult in the household's work or study, and the respondent's own work, and exercise or playing sports. Generally, there was a consistent trend away from using the motor vehicle – the exception being the respondent's own work where walking displaced public transport use – towards walking trips. Further work is required with a larger sample to validate this trend. Those who shifted within the inner city did not show any consistent changes in their mode use to access various activities, while those shifting within a lower density did not alter their travel methods at all.

Table 6.14 Change in travel methods for various activities between previous and current residence by category of shifter

	Supermarket		Own work		Other adults work/study		Own exercise/sports	
Shifted from and to:	**Previous**	**Current**	**Previous**	**Current**	**Previous**	**Current**	**Previous**	**Current**
Lower density to inner city	N=43	N=43	N=37	N=29	N=44	N=44	N=35	N=33
In a motor vehicle	67%	49%	43%	41%	45%	27%	43%	24%
Walk/jog/cycle	14%	40%	19%	31%	9%	36%	40%	73%
Public transport	19%	12%	38%	28%	32%	14%	17%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%
Stayed in inner city	N=34	N=32	N=33	N=25	N=29	N=26	N=24	N=29
In a motor vehicle	50%	38%	30%	36%	31%	19%	29%	24%
Walk/jog/cycle	41%	53%	45%	48%	48%	46%	67%	62%
Public transport	9%	9%	24%	16%	21%	35%	4%	14%
Total	100%	100%	100%	100%	100%	100%	100%	100%
Stayed in lower density	N=206	N=206	N=160	N=113	N=149	N=154	N=145	N=150
In a motor vehicle	83%	86%	66%	72%	72%	71%	54%	53%
Walk/ jog/ cycle	10%	12%	11%	8%	7%	9%	40%	41%
Public transport	7%	2%	24%	20%	21%	20%	6%	5%
Total	100%	100%	100%	100%	100%	100%	100%	100%

6.5.4 Intention to shift in the next two years

All respondents were asked about their intention to shift, either within New Zealand or overseas, in the next two years, so their neighbourhood preferences, household vehicle ownership and travel preferences could be explored. As table 6.15 shows, apart from 82 respondents who intended to leave New Zealand in the next two years, there were 268 (40%) who indicated they definitely or might shift within New Zealand in the next two years. In all, two-thirds (66%) of those living in inner city A/W intended to shift either within New Zealand or overseas in the next two years, compared with just under 50% of those living in either A/W cities or A/W metro.

Table 6.15 Intended residential location in the next two years

		Current residential location			
Intended residential location if shifting in the next 2 years	**No. of respondents (N)**	**Inner city A/W**	**A/W city**	**A/W metro**	**Total sample**
No. of respondents (N)		119	260	287	666
Live in the central city	51	16%	7%	5%	8%
Live somewhere else in the same city as I live in now	130	15%	19%	22%	20%
Move to another New Zealand location (town/city/rural area)	87	10%	11%	16%	13%
Shift overseas	82	25%	12%	8%	12%
Do not intend to shift	316	34%	52%	49%	47%
Total	666	100%	100%	100%	100%

Comparing the likely residential density of a respondent's current residential location with their intended one produces the summary shown in table 6.16. Note that the small numbers of respondents proposing to shift from inner city or lower density areas to the inner city (n=32 and n=19) or from inner city to lower density areas (n=18) means the commentary on these groups is indicative only.

Table 6.16 Intended residential location compared with current one in terms of residential density

Intended residential location compared with current residential location	**No. of respondents (N)**	**Percent**
Shifting from lower density to inner city	32	5%
Shifting from inner city to lower density	18	3%
Shifting within inner city	19	3%
Shifting within lower density area (eg A/W cities; A/W metro)	112	17%
Shifting to somewhere else in New Zealand	87	13%
Shifting overseas	82	12%
Not shifting in next two years	316	47%
Total	666	100%

Forty-seven percent of those who intended to shift within New Zealand in the next two years stated their household size, both in terms of the number of adults over the age 18 and the number of household vehicles they had, would stay the same as it was now. Current inner city residents were more likely than A/W cities or A/W metro residents to think their household size and/or vehicle ownership rates would either increase or decrease, rather than remain the same size once they shifted. Generally the anticipated vehicle ownership patterns moved in the directions expected; those intending to shift from a lower density area to inner city speculated the number of vehicles would decrease, while those shifting the other direction (higher density to lower) thought household vehicle ownership would increase. Respondents shifting within a lower density area were more likely to indicate the number of household vehicles available would 'stay the same'.

As an age group, 18 to 29 year olds were more likely to intend to shift from a lower density area to the inner city than those aged 40+ (9% of all 18 to 29 year olds compared with 2% of 40+). Approximately 90% of 40+ and 72% of 18 to 29 year olds currently lived in lower density areas. The younger age group (<39 years) was also much more likely than the 40+ age group to say they intended to shift overseas (19% compared with 6%), irrespective of where they lived now. Unsurprisingly, moving up in age group (from youngest to oldest) the proportions who stated they were not planning on shifting at all grew (eg 30% of 18 to 29 year olds; 52% of 40 to 49 year olds and 68% of people aged 60+).

Current inner city residents were less committed to their location than those living in the A/W cities or A/W metro. Of those currently living in the inner city and either working or studying (N=97 or 81% of the inner city residents in the dataset), just under one-half (44%) intended to stay within the inner city, either in their current residence or a new one. Thirty percent intended to move overseas and 25% to a lower density area either in A/W or elsewhere in New Zealand. By contrast, 69% of those working or studying and living in A/W cities intended to stay in such lower density areas in the next two years, with only 16% indicating they might shift overseas. The proportions were very similar for those living in A/W metro.

6.5.4.1 Potential mode use for different activities

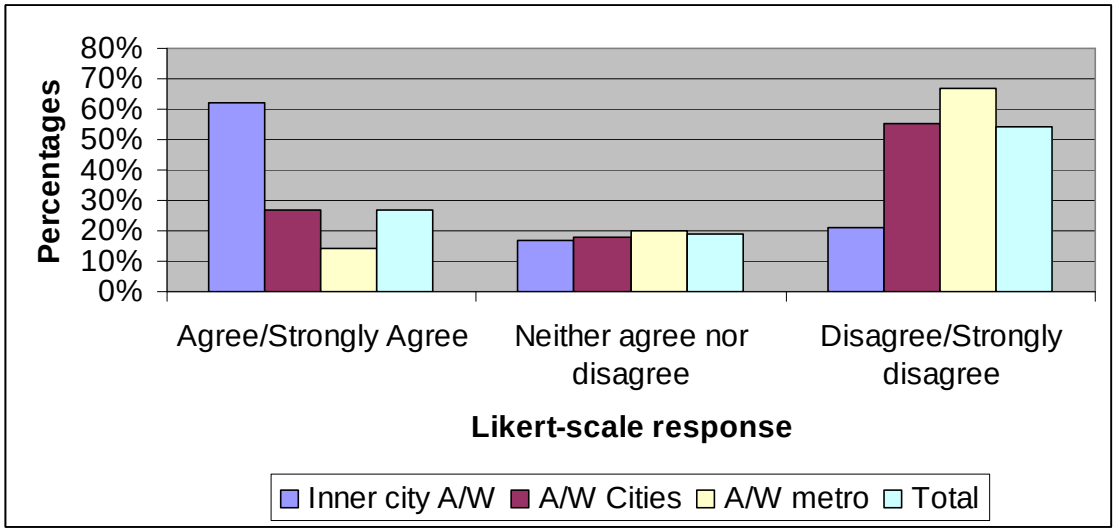
Respondents were asked 'If you shifted residence, what would be your first choice of travel method for going to…' the supermarket, primary school or college, your work, your education, 'another adult's in my household's work/education', your usual place to exercise or play sport. While the proportions were different (and in any case, the sample sizes meant the results were indicative only), respondents indicated that, compared with their mode use at their current residential location, fewer would choose to drive a motor vehicle in their new residential location; instead, more would choose to walk, jog or cycle. This was true (in all but two minor segments) irrespective of whether or not the respondent was intending to shift from a lower density to higher density inner city area, or vice versa, or staying in a similar density area, and for all activities canvassed.

6.6 Attitudes

6.6.1 Preference for inner city living

Overall, just over one-quarter (27%) of the respondents agreed or strongly agreed (A/SA) with the statement 'I prefer living in the inner city to living in a suburb' – over half (54%) disagreed or strongly disagreed (D/SD) as shown in figure 6.4.

Figure 6.4 'I prefer living in the inner city to living in a suburb' by current residential location



Respondents living in the inner city were far more likely to A/SA with the statement than were respondents living elsewhere. There were some notable age-related variations in responses: respondents aged 40+ and living in lower density areas were far more likely to D/SD than were 18 to 29 year olds (77% compared with 45% in A/W metro and similar in A/W cities) or than people in the same age group living in inner city A/W. Irrespective of where they lived, full- and part-time students were more likely to A/SA (44%) than any other group (eg full-time workers 29%; retired 10%; beneficiaries or at home responsibilities 19%). Families with some children under the age of 18 were less likely to A/SA (18%) than households of unrelated adults flatting (40%).

The attitudes of respondents corresponded quite well with their intentions to shift in the next two years; those who indicated they were likely to shift from lower density to inner city were much less likely to disagree with the statement (6%) than those who intended to stay or shift within a lower density area (69% and 66%) or shift from inner city to lower density (44%).

In summary: those who A/SA were more likely to be aged 18 to 29, live in the inner city in a flatting arrangement with other adults while those who D/SD were more likely to be aged 40+; live in lower density areas and have children under the age of 18.

6.6.2 Preference for suburban living

There were two statements in the survey that explored respondents' preferences vis-à-vis suburban, lower density living, namely:

- 'I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services.'
- 'In the next 10 years, I intend to live in a house with a section in the suburbs.'

Considered separately, there were very similar A/SA responses to both questions, ie 47% A/SA with the first statement and 48% A/SA with the second. There was more discrepancy in the proportions who D/SD (26% compared with 14%).

Table 6.17 Comparison of two attitude statements regarding suburban neighbourhood preferences

		In the next 10 years, I intend to live in a house with a section in the suburbs			
		Agree/ strongly agree	Neither agree nor disagree	Disagree/ strongly disagree	Total
I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services	Agree/strongly agree	68%	29%	26%	47%
	Neither agree nor disagree	19%	41%	16%	27%
	Disagree/strongly disagree	13%	30%	59%	26%
	Total	100%	100%	100%	100%

A comparison (refer table 6.17) of those who A/SA with both statements with those who D/SD with both revealed that those who D/SD (ie, did not want to live in a suburban neighbourhood even if they had to drive to services and did not aspire to live in a house in the suburbs) were:

- more likely to be <39 years old (59% compared with 43% of those who A/SA)
- more likely to live in the inner city (24% compared with 11%)
- more likely to live in Auckland than in Wellington (73% compared with 46%).
- less likely to commute by car to work/study (38% compared with 51%) and more likely to commute by public transport (27% compared with 12%).

Overall, driver licence holding rates were similar between the two groups.

Inner city residents were much less likely to A/SA with living in a suburb where they had to drive to services than those living in A/W cities and metro (24% compared with 52% A/SA), and somewhat less likely to aspire to living in a house in the suburbs within the next 10 years (39% compared with 50%).

6.6.3 Residential dissonance: preferring one type of neighbourhood and living in another

Schwanen and Mokhtarian (2005a and 2005b) and Frank et al (2007) found individuals who preferred and lived in a walkable neighbourhood (defined as high residential density and with close proximity to shops and services) walked more and drove less, while those preferring suburban neighbourhoods, drove more and walked less. They found people drove less when located in more walkable environments, regardless of their preference for neighbourhood type. While Schwanen and Mokhtarian (2005b) undertook a more complex modelling exercise to examine the effect on distance travelled overall and by mode, we considered the impact on mode used generated by differences based on a respondent's stated neighbourhood preference (inner city or suburb) and where they actually lived. We used Schwanen and Mocktarian's categories, although the classification of these groups was based on different factors: current residential location and the responses to two attitude statements, namely: 'I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services' and 'I prefer living in the inner city to living in a suburb' as shown in table 6.18.

Table 6.18 Categories of residents based on their stated neighbourhood preferences

	True Urbanite	Dissonant Urbanite	True Suburbanite	Dissonant Suburbanite
No. of respondents (N=363)	47	18	238	60
Current residential location	Inner city	Inner city	Metro	Metro
I prefer living in the inner city to living in a suburb (100% response)	A/SA	D/SD	D/SD	A/SA
I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services (100% response)	D/SD	A/SA	A/SA	D/SD
No matter where I live, I intend to walk, cycle or use public transport to travel to work/study (% A/SA)	62%	--	17%	50%
If I could I would drive to work/study every day (% A/SA)	21%	--	47%	31%

These four groups accounted for over one-half of the respondents in our sample: the remainder either A/SA or D/SD with both attitude statements (leaving one to wonder where they did want to live) or gave the response 'neither agree nor disagree'. The very small number of Dissonant Urbanites (prefer suburban living but currently live in the inner city) makes it very difficult to comment on this group. Overall, respondents' attitudes towards mode use for the commute to work or study mirror their neighbourhood preferences, rather than those of the built environment, in that True Urbanites and Dissonant Suburbanites were much more likely to prefer to walk or use public transport for this trip than True Suburbanites, who were more likely to prefer to drive every day.

As can be seen in table 6.19, Dissonant Suburbanites, who would prefer to live in the inner city but lived in the metropolitan area, drove less frequently and walked and used public transport more often than did the True Suburbanite respondents. As Schwanen and Mokhtarian (2005b) found, residential self-selection (expressed as a preference for living in a particular type of neighbourhood and reflecting a preference for walking, cycling or using public transport to commute) clearly exerted some influence on mode choice, but it is quite likely respondents found the physical environment pre-empted their ability to fully express their mode use preferences.

Table 6.19 Frequency of mode use by residential category

		% using mode 3+ days per week		
	No. of respondents (N)	Driving	Walking	Public transport
True Urbanite	47	21%	74%	26%
Dissonant Urbanite	*18*	*56%*	*56%*	*17%*
Dissonant Suburbanite	60	43%	42%	30%
True Suburbanite	238	77%	22%	13%
Total		63%	34%	18%

We also investigated how their current neighbourhood preferences aligned with their stated future preferences, insofar as they agreed or disagreed with the statement 'In the next 10 years, I intend to live in a house with a section in the suburbs'. As table 6.20 shows, the majority (68%) of True Suburbanites and Dissonant Urbanites (83%) A/SA with this aspiration, compared with a minority of True Urbanites and Dissonant Suburbanites.

Table 6.20 Comparing current residential location and preferred neighbourhood with future neighbourhood aspiration

	In the next 10 years, I intend to live in a house with a section in the suburbs			
	Agree/strongly agree	Neither agree nor disagree	Disagree/strongly disagree	Total
True Urbanite	23%	43%	34%	100%
Dissonant Urbanite	83%	17%		100%
Dissonant Suburbanite	13%	50%	37%	100%
True Suburbanite	68%	24%	8%	100%
	54%	31%	15%	100%

When asked if they were intending to shift residence in the next two years, and where they would shift to, the majority of the Dissonant Urbanites and Dissonant Suburbanites, who were intending to shift within New Zealand (ie not to an overseas location), indicated they would be moving to their preferred type of neighbourhood, while the True Urbanites and True Suburbanites indicated their intention to shift within their preferred neighbourhood (refer table 6.21).

Table 6.21 Current neighbourhood preferences and residential location compared with intended residential location within next two years

	Intended residential location in next two years compared with current residential location (number of respondents)					
	Shifting from lower density to inner city	Shifting from inner city to lower density	Shifting within inner city	Shifting within lower density area (eg A/W cities; A/W metro)	Not shifting in next two years	Total no. of respondents
True Urbanite	0	2	8	0	19	29
Dissonant Urbanite	0	8	0	0	6	14
Dissonant Suburbanite	14	0	0	5	22	41
True Suburbanite	2	0	0	50	141	193
Total no. of respondents	16	10	8	55	188	277

Not only does neighbourhood preference seem to affect travel behaviour, it appears that neighbourhood preferences are not easily changed, once in place.

6.6.4 Travel minimising

To explore attitudes toward reducing trips or travel minimising, respondents were asked about their agreement with the statement 'I often use the telephone or the internet to avoid having to travel somewhere'.

People living in the inner city A/W were more likely to A/SA than those living in A/W cities and metro (73% compared with 60%). Adults living alone were less likely to A/SA (and more likely to D/SD than other household types), especially couples living alone.

Table 6.22 Attitude towards travel minimising

I often use the telephone or the internet to avoid having to travel somewhere	No. of respondents (N)	Percent
Agree/strongly agree	417	63%
Neither agree nor disagree	147	22%
Disagree/strongly disagree	102	15%
Total	666	100%

6.6.5 Environmentally friendly or 'green identity'

Other researchers have found respondents' attitudes towards the environment were associated with their preferred type of residential neighbourhood and mode use (Handy et al 2005a; Frank et al 2007; Chatman 2005; Bagley and Mokhtarian 2002). This led us to investigate whether or not we could discern such behaviour in our sample and how well the neighbourhood preferences aligned with respondents' attitudes towards the environment and transport. There were five statements in the survey that directly explored respondents' attitudes towards the environment – or what Anable (2005) termed their 'green identity', namely:

- Being environmentally responsible is important to me as a person.
- It's important to me to use environmentally friendly travel methods (walking, cycling and public transport).
- No matter where I live, I intend to walk, cycle or use public transport to travel to work (to study/training).
- I'd rather live in a neighbourhood where I can walk to some shops, schools and services.
- If I could, I would drive to work (my study/training course) every day.

With regard to the first two statements, there was a high proportion of respondents (32% and 42% respectively) who could be described as fence sitters, since they selected 'neither agree nor disagree'. Most of the remaining respondents chose to A/SA with the statements, leaving relatively small minorities who D/SD, as shown in table 6.23. As about three-quarters of all respondents A/SA with the statement 'I'd rather live in a neighbourhood where I can walk to some shops, schools and services', with less than 5% disagreeing, we excluded this statement from further analysis.

Table 6.23 'Green identity' attitude statements compared with current residential location

	Being environmentally responsible is important to me as a person		It's important to me to use environmentally-friendly travel methods (walking, cycling and public transport)		No matter where I live, I intend to walk, cycle or use public transport to travel to work (to study/training)		If I could, I would drive to work (my study/training course) every day	
	Inner city A/W	A/W cities & metro	Inner city A/W	A/W cities & metro	Inner city A/W	A/W cities & metro	Inner city A/W	A/W cities & metro
No. of respondents (N)	119	547	119	547	106	391	106	391
A/SA	52%	61%	51%	41%	50%	27%	32%	44%
Neither agree nor disagree	38%	32%	34%	44%	18%	17%	16%	26%
D/SD	10%	8%	14%	14%	32%	55%	52%	30%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Examining the pattern of responses to the environmental statements, we identified two distinct population segments: Pro-Green Travellers and Committed Drivers. Their overriding characteristics can be summarised as:

1 Pro-Green Travellers (N=53) – those who D/SD with 'If I could, I would drive to work (my study/training course) every day' and A/SA with all three of the statements:

   a Being environmentally responsible is important to me as a person

   b It's important to me to use environmentally friendly travel methods (walking, cycling and public transport)

   c No matter where I live, I intend to walk, cycle or use public transport to travel to work (to study/training)

2 Committed Drivers (N=105) – those who:

   a A/SA with 'If I could, I would drive to work (my study/training course) every day'

   b D/SD with 'No matter where I live, I intend to walk, cycle or use public transport to travel to work (to study/training)'[16]

   c were neutral (neither disagree nor agree) or D/SD with 'It's important to me to use environmentally friendly travel methods (walking, cycling and public transport)'.

Together, these people formed 31% of the workers and students in the study population. Note that the total possible number of respondents was limited to the subset of 512 workers and students because the

[16] Their response to the statement 'Being environmentally responsible is important to me' was excluded because the very low numbers D/SD with the statement (8% in the whole sample) meant there would be too few respondents in the segment to comment on.

commuting statements were only presented to those who currently travelled to work or study. Unfortunately, we did not have sufficient attitude questions to be able to discern other potential groups along the lines of Anable (2005) or Bagley and Mokhtarian (2002). The relatively small number of respondents categorised as Pro-Green Travellers (N=53) means the results are indicative only.

As a group, Pro-Green Travellers reported travel behaviours that one might expect from an environmentally minded population segment; they drove vehicles far less often to the supermarket, work or study and just less generally than Committed Drivers. Irrespective of where they lived (inner city, city or metro), Pro-Green Travellers more commonly walked to work, for food shopping and other trip purposes, in combination with much higher overall public transport use. Their households owned fewer vehicles per adult, and they were much less likely to have one or more vehicles per adult than a committed driver household.

Sixty-four percent of the Pro-Green Travellers resided *outside* the inner city. They had a greater propensity to live in the inner city than the Committed Drivers (36% of Pro-Green Travellers compared with 13% of Committed Drivers) and were also more in favour of inner city living (42% A/SA with the statement 'I prefer living in the inner city to living in a suburb' compared with 19% of Committed Drivers). Similarly, Pro-Green Travellers were less likely to A/SA with 'I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services'.

Table 6.24 Characteristics of Pro-Green Travellers and Committed Drivers compared with all workers and students

Segment		Pro-Green Travellers	Committed Drivers	All workers/students
No. of respondents (N)		53	105	512
Age = % <50 years old		94%	73%	77%
% Female		64%	49%	52%
Live in inner city A/W		36%	13%	21%
Live in 'family' (not couple or adult(s) only)		34%	61%	45%
House type = single dwelling		47%	77%	64%
No driver licence		19%	3%	7%
Median number of household vehicles per adult (ratio)		0.5	1.0	0.7
% vehicle:adult ratio ≥1.0		21%	56%	43%
Supermarket – usual mode = motor vehicle		55%	96%	80%
Commute mode most frequently used	Driving	8%	88%	52%
	Walking	32%	5%	13%
	Public transport	47%	4%	24%
Mode use in a typical week (for any purpose)	Driving			
	5–7 days/wk	11%	79%	47%
	3+ days/wk	19%	90%	61%
	Walking			
	5–7 days/wk	43%	6%	19%
	3+ days/wk	59%	11%	28%
	Public transport			
	5–7 days/wk	28%	4%	15%
	3+ days/wk	57%	6%	24%

Segment	Pro-Green Travellers	Committed Drivers	All workers/students
A/SA: I prefer living in the inner city to living in a suburb	42%	19%	27%
A/SA: I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services	30%	66%	47%

In terms of demographic characteristics, a Pro-Green Traveller was more likely to be <50 years old (95%), female, live in alone, with other unrelated adults or as a couple (rather than a family with children) in a multiple-unit dwelling (as opposed to a single family dwelling) than a Committed Driver. Committed Drivers were largely within the same <50 age bracket (72%), but included older people as well, were about equally male and female, and were living as a family in a single family dwelling. Pro-Green Travellers were less likely to hold any type of driver licence than Committed Drivers (19% compared with 3% had no licence).

We investigated the alignment between neighbourhood preference (eg True Suburbanite, Dissonant Urbanite) and environmental attitude segments. There were only 91 respondents who had responses for both variables. Pro-Green Travellers did not belong to any specific neighbourhood preference segment, whereas 78% (50 of 64) of Committed Drivers were classified as True Suburbanites (living in metro area and preferring to live in metro area).

Table 6.25 Comparing neighbourhood preferences and environmentally oriented attitudes

	Environmental attitudes and transport use		
	Pro-Green Traveller	Committed Driver	Total
	No. of respondents (N)		
True Urbanite	9	3	12
Dissonant Urbanite	6	5	12
Dissonant Suburbanite	3	6	8
True Suburbanite	9	50	59
Total (N)	27	64	91

Based on a revealed preference analysis of Scottish household travel survey data, Ryley (2005) suggested the *life stage* of an individual determined their vehicle ownership and use. Our analysis suggested *attitudes* were also a determinant factor in travel behaviour and household vehicle ownership preferences. Pro-Green Travellers fitted the demographic description, travel behaviour and vehicle ownership preferences devised by Ryley. While proportionately more of them did live in the inner city, the majority (64%) lived elsewhere in the city and metropolitan region.

6.7 Car-sharing in Auckland

Self-service car-share companies have cars available for hire by the hour, day or week. Experience in the USA and Europe shows some households may sell their only household vehicle or a second one, or delay

the purchase of a vehicle, if they have car-sharing options nearby (eg Buffalo CarShare 2010; LDA Consulting and CIC Research Inc 2008; Cervero et al 2007; Cervero et al 2002).

Established in Auckland in late 2007, 'Cityhop' has more than 20 cars parked in various places around the Auckland central business district which may be hired for NZ$15 or less per hour. Booking is done electronically and cars are available 24 hours a day.[17] Further information about Cityhop is available on their website www.cityhop.co.nz

At the suggestion of one of our peer reviewers, a brief description of Cityhop's car-sharing concept and how it works was added to the survey, along with four questions to assess respondents' awareness, use and the impacts of Cityhop in Auckland. Of the 345 Auckland-based respondents, 30% (N=104) were aware car sharing was available in Auckland, while only two (2%) had been a member of the Cityhop scheme. Both members lived in the inner city. The two members used the cars about once or twice a month, and reported that 'since being a member of Cityhop, my household has decided not to acquire a car'.

Cityhop does not have any publicly available data on membership or usage of its car-share fleet.

[17] Cityhop now operates two cars in central Wellington.

7 Discussion and conclusions

7.1 Overview

In this chapter we draw together the outputs of the international literature review, quantitative analysis of secondary data, accessibility and land-use indices, and the primary data gathered through the survey of inner city and non-inner city residents in Auckland and Wellington in order to compare and contrast the characteristics and attitudes of inner city residents and suburban residents, the physical and/or built environment characteristics of the neighbourhoods they live in, and the effects of both of these on their travel behaviour and household vehicle ownership.

7.2 Key findings

7.2.1 Inner city residents do more walking for transport

A core finding from our fieldwork and analysis of existing datasets is that inner city residents are more likely to walk and less likely to drive, for any trip purpose, than residents living elsewhere in A/W cities and metro, as illustrated in table 7.1. Based on our examination of the accessibility and land-use indices, we surmise this is largely because more potential destinations are within walking distance. We found walking and/or public transport use was substituted for driving trips for work, study and supermarket shopping in inner city A/W, compared with lower density A/W cities and metro. We suspect this would have an impact on overall VKT, but did not measure this in our study.

Table 7.1 Summary of mode use for different purposes by residential location

Data	Inner city A/W	A/W cities	A/W metro
Main means of travel to work (2006 Census)	45% (Akl) –walk 62% (Wlg) – walk	60% (Akl) – drive 42% (Wlg) – drive	66% (Akl) – drive 50% (Wlg) – drive
Most frequently used mode for commute to work (survey)	39% walk	50% drive	66% drive
Drive 3+ days/week (for any purpose)	35%	59%	74%
Public transport – 3+ days/week (for any purpose)	25%	25%	13%
Walking for transport on 5–7 days in the last 7 days	46%	20%	12%
Usual mode to supermarket	37% walk	82% drive	93% drive
Other adult in household's usual mode to work is most commonly…	walk	drive	drive
Median time spent travelling to work	20 minutes	20 minutes	25 minutes

Despite the difference in mode use for commuting to work, the median time spent travelling is quite similar: 20 minutes for both inner city A/W (where the majority of people walk) and A/W cities (where 50% drive) and 25 minutes for A/W metro (where two-thirds drive). This suggests there is a budget or ideal

amount of time allocated for commuting, which is a topic of another research project (O'Fallon and Wallis 2012).

Similar to the literature review findings, there was no notable difference in the amount of walking or cycling for recreation, sport, exercise or leisure in the past seven days between the inner city A/W and other areas in our sample.

7.2.2 Inner city residents own fewer household vehicles

No matter how measured, whether by number of vehicles per household, the ratio of vehicle:adults, or by age group, inner city residents had demonstrably fewer vehicles per household in our sample and the 2006 Census. In our study population, the median increased from 0.5 vehicles per adult in the inner city to 0.67 in the A/W cities and 1.0 in the A/W metro.

Shifting from a lower density area to a higher density one had an effect on household vehicle ownership. Twenty-two of the 44 inner city respondents who had done such a shift now lived in households with zero motor vehicles, whereas only eight of them had zero vehicles in their previous households. In total, 19 inner city respondents (43%) lived in households with a lower vehicle:adult ratio now compared with their previous household. By contrast, respondents who shifted within their current residential area, either inner city or lower density, reported no change in the vehicle:adult ratio.

Fewer vehicles led to greater walking, particularly in areas with good walkability and destination accessibility, as discussed in chapter 5. Sixty percent of respondents in inner city A/W households with zero vehicles walked for transport at least 10 minutes at a time on five to seven days compared with 31% of inner city households with one or more vehicles per adult. As might be expected, inner city residents with zero vehicles also walked more frequently than people living in A/W cities or metro households with zero vehicles (where 35% walked for transport on five to seven days in the last seven days). Inner city households sharing one vehicle between two or more adults (ie a household vehicle:adult ratio of >0 and <1) also showed a much greater propensity to walk for transport, with nearly 50% walking on five to seven days in the last seven days, compared with 27% in A/W cities and 12% in A/W metro.

7.2.3 Effect of built environment and density

It might be tempting to think the distinctive travel and vehicle ownership patterns of those living in inner city A/W is due to the higher population/residential density of the area. However, our analysis of the 2006 Census data in section 4.2.5 indicated, *on their own*, neither the population nor employment density of major New Zealand cities appeared directly correlated with the choice of mode for the *journey to work*. The journey to work is a commonly recurring trip and, with the return journey home, comprises about 25% of all journeys made in New Zealand metropolitan areas (O'Fallon and Sullivan 2009). Hence, we consider if density does not correlate with the journey to work, it is unlikely that mode use for other trip purposes (eg shopping or eating out) would be specifically affected by population or employment density.

It is more likely that density works in conjunction with the mix of activities or destinations in an area and destination accessibility to affect travel patterns and vehicle ownership. As posited by Ewing and Cervero (2010), factors such as street connectivity (eg average length of blocks and/or intersection density and/or the presence/absence of footpaths), pedestrian, cycle and public transport facilities and services, and proximity to work, study, shops and services have greater significance. The indices we reviewed in chapter 5 (Walkability Index, NDAI and Walk Score) all confirmed the inner city areas are highly accessible and walkable, particularly when compared with surrounding suburbs or ones located further away.

7.2.4 Effect of preferences and attitudes

We included nine statements which measured respondents' attitudes to different types of mode use and the environment as well as their neighbourhood preferences. We found their attitudes mirrored their revealed mode use and choice of residential neighbourhoods in that:

- True Urbanites and Dissonant Suburbanites (who would prefer to live in the inner city but live in the metropolitan area) were much more likely than True Suburbanites to state they preferred to walk or use public transport for commuting to work.
- Dissonant Suburbanite respondents actually drove less frequently, and walked and used public transport more often, than did True Suburbanite respondents.
- All groups' preferences were reflected in their choice of neighbourhood when asked where they might move to in the next two years, as well as in their agreement or disagreement with the statement 'In the next 10 years, I intend to live in a house with a section in the suburbs' (eg a True Suburbanite would express a desire to move within the metropolitan area in the next two years and agreed that their intention was to live in a house in the suburb in the next 10 years).
- Pro-Green Travellers reported travel behaviours that one might expect from an environmentally minded population segment; they drove vehicles far less often to the supermarket, work or study and just less generally than Committed Drivers, irrespective of where they lived.
- Pro-Green Traveller households owned fewer vehicles per adult than Committed Driver households, again irrespective of where they lived.
- Most Committed Drivers could be classified as True Suburbanites.

Thus, while inner city residents in our dataset definitely drove less and walked or used public transport more often than A/W cities or metro residents, population segments who shared the same neighbourhood preference for inner city living and/or environmental attitudes (ie Pro-Green Travellers, True Urbanites and Dissonant Suburbanites) – *irrespective of where they lived* – exhibited travel behaviours and vehicle ownership patterns very similar to those actually living in the inner city.

Hence, we contend that people whose attitudes towards the environment and different modes predispose them to driving less and walking or using public transport more often are more likely to choose to live in areas, such as the high density inner city, where they can exhibit their preferred travel behaviour. In this regard, it could be said their attitudes are the primary determinant of their mode use, rather than the built environment, although the built environment *facilitates* residents to actively demonstrate their favoured travel and vehicle ownership behaviours.

7.3 Policy implications

We found density on its own was insufficient to explain the travel behaviour and vehicle ownership patterns of inner city residents. However, we observed that inner city A/W residents in mixed-use settings with many destinations nearby tended to walk far more and drive less than when or if they lived in (lower-density) suburbs with fewer destinations and lower destination accessibility. This has potential benefits for society, such as improved public health (and reduced health care costs) from a more active lifestyle; opportunities for creating more vibrant urban districts as an economic stimulus; building social capital

and natural surveillance through having 'eyes on the street'; mobility benefits from less road expansion; and land conservation due to urban sprawl abatement.

Our fieldwork suggested attitudes towards the environment and different modes (eg walking and driving) and neighbourhood preferences also played an important role in determining travel behaviour and vehicle ownership patterns. We found largely exogenous factors, ie not having to do with neighbourhood attributes, explained residential shifts (refer section 6.5.1). Proportionately more respondents were Dissonant Suburbanites than Dissonant Urbanites, implying a latent demand for residential locations with suitable housing options and greater destination accessibility (that would in turn facilitate walking, cycling and public transport use over driving).

As a caveat, it should be recalled that the overwhelming majority of the respondents in our sample, whose residential preferences could be classified, were True Suburbanites who did not want to live in the inner city, preferred living in a suburb, and were quite content to drive to their destinations.

Taken together, all of these factors suggest the focus for inner city (and the immediately surrounding suburbs) planning and policy should be less on creating density and more toward targeting inner city housing and location opportunities to the kinds of market niches drawn to these settings. The current population mix living in these areas in Auckland and Wellington, 'generation-Xers' (students and young professionals) and 'empty-nesters' (middle aged and older people, without young children) suggest possible niche markets, for whom neighbourhood attributes apparently do not weigh heavily in relocation decisions to the central city. Planning and policy development could take the form of changing building and zoning codes in order to build the type of accommodation that appeals to these niches or to attract and maintain a high level of destination accessibility (eg more retail, educational, recreational, entertainment, workplace and other destinations) in inner city locations. Car-sharing could be promoted and made more available to provide access to a car on an as-need basis to central-city households to serve those without cars and those who may wish to reduce car ownership. This might mean facilitating the re-location of 'destinations' from suburbs to be within central city residential districts that are accessible by walking, cycling and public transport. Environmentally friendly mobility (particularly driving less and walking more) would be a fortunate by-product for those making the move and for the city as a whole.

7.4 Future research directions

The next logical step would be to develop some models based on the dataset we have created which could explore the relative strength of the effect of different variables on travel behaviour. Ideally this would involve increasing the size of the study population, so further population segments based on attitudes, neighbourhood preferences, and observed residential shifting behaviour and mode use, could be delineated and characterised. The data collected could also be expanded to include questions around affordability, school quality and perception of personal safety and crime factors affecting neighbourhood choice and mode use.

It would also be useful, from a public policy perspective, to consider disproportionate stratified sampling of inner city households in the NZHTS in order to generate enough data to allow more rigorous modelling and analysis to be undertaken. The creation of a longitudinal panel of households to survey over time would enable researchers, policy- and decision-makers to make strong and valid inferences about transportation and land-use relationships.

Such a longitudinal panel would also assist in addressing the issue of residential self-selection and its possible biasing effects on statistical results, in part because the vast majority of previous studies have

been based on non-experimental cross-sectional data. Currently, the best that can be done in such situations is to statistically control for lifestyle preferences and predispositions based on attitudinal variables. However, this is second-best. While panel data is still prone to some issues (see for example Brownstone 2008; Boarnet 2003), using modern dynamic panel data methods to collect the required panel data is probably the most suitable option for finally accounting for self-selection bias.

Another potential area of research could consider whether or not there is a sufficient supply of neighbourhood choices suited to the lifestyle, mobility and location preferences of households (especially newly forming ones) to allow some near-optimal level of residential sorting to take place. One question could be: do existing regulatory and institutional restrictions suppress the amount of residential self-selection that might otherwise occur? Of course, if the ultimate aim is to create healthier, more viable, low-carbon cities of the future, it may also be necessary to over-supply neighbourhoods that have high destination accessibility and mobility options and to 're-educate' the bulk of the population about their mobility and lifestyle preferences, rather than to cater to them by providing the types of neighbourhoods they currently prefer.

8 References

ARTA (2006) *Auckland urban density study draft report*. Prepared by Brian Waddell, Urbanista Ltd with the assistance of Auckland Regional Council.

Anable, J (2005) 'Complacent car addicts' or 'aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy 12*: 65–78.

Auckland City (2003) *Behaviour and attitudes and perceptions of residents, workers and visitors in the central city*. Report part A. Prepared by Central Area Planning City Planning, February 2003.

Badland, H (2007) Transport-related physical activity, health outcomes, and urban design: descriptive evidence. A thesis submitted to Auckland University of Technology.

Badland, H and G Schofield (2005a) The built environment and transport-related physical activity: what we do and do not know. *Journal of Physical Activity and Health*, no.2: 433–442.

Badland, H and G Schofield (2005b) Transport, urban design, and physical activity: an evidence-based update. *Transportation Research Part D-Transport and Environment 10*, no.3: 177–196.

Bagley, MN and PL Mokhtarian (2002) The impact of residential neighborhood type on travel behavior: a structural equations modelling approach. *The Annals of Regional Science 36*, no.2: 279–297.

Bauman, AE and FC Bull (2007) *Environmental correlates of physical activity and walking in adults and children: a review of reviews.* Review undertaken for National Institute of Health and Clinical Excellence (NICE PH8).

Bhat, CR and JY Guo (2006) A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels. Center for Transportation Research, University of Texas at Austin. *Technical report SWUTC/06/167860-1*.

Bina, M, V Warburg and KM Kockelman (2006) Location choice vis-à-vis transportation: the case of apartment dwellers. *Transportation Research Record 1977*: 93–102.

Boarnet, M (2003) The built environment and physical activity: empirical methods and data resources. Paper prepared for the Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use. Accessed August 2011 from *www.uctc.net/papers/706.pdf*

Braun Kohlová, M (2009) Everyday travel mode choice and its determinants: trip attributes versus lifestyle. *European Summer School, Venice, 5–11 July 2009*.

Brownstone (2008) Key relationships between the built environment and VMT. *Special report 298: driving and the built environment: the effects of compact development on motorized travel, energy use, and CO_2 emissions*. Paper prepared for the Committee on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption.

Buchanan, N, R Barnett, S Kingham and D Johnston (2006) The effect of urban growth on commuting patterns in Christchurch, New Zealand. *Journal of Transport Geography 14*, no.5: 342–354.

Buffalo CarShare (2010) First year impacts summary – Buffalo carShare. Accessed December 2010 from *http://buffalocarshare.blogspot.com/2010/06/first-year-impacts-summary-buffalo.html*

Cao, XY (2006) The causal relationship between the built environment and personal travel choice: evidence from Northern California. PhD Dissertation. University of California Davis.

Cao, XY (2007) Is alternative development undersupplied? An examination of residential preferences and choices of Northern California movers. *TRB 08-0216*.

Cao, XY, S Handy and PL Mokhtarian (2005a) The influences of the built environment and residential self-selection on pedestrian behavior. *TRB 2005 Annual Meeting* CD-ROM.

Cao, XY, PL Mokhtarian PL and SL Handy SL (2005b) The impacts of the built environment and residential self-selection on non-work travel: a seemingly unrelated regression approach. *Paper 06-1595 presented at the 85th Transportation Research Board Annual Meeting, Washington, DC*, January 2006.

Cao, XY, PL Mokhtarian and S Handy (2008) Examining the impacts of residential self-selection on travel behavior: methodologies and empirical findings. University of California. *Davis working paper 2008_UCD-ITS-RR-08-25*.

Cao, XY, PL Mokhtarian and S Handy (2009) Examining the impacts of residential self-selection on travel behaviour: a focus on empirical findings. *Transport Reviews 29*, no.3: 359–395.

Carroll, P, K Witten and R Kearns (2011) Housing intensification in Auckland New Zealand: implications for children and families, *Housing Studies 26*, no.3: 353–367.

Cervero, R (1996) Mixed land-uses and commuting: evidence from the American Housing Survey. *Transport Research Part A: Policy and Practice 30*: 361–377.

Cervero, R (2002) Reverse commuting and job access in the United States. *Paper prepared for International Seminar on Day-to-Day Mobility and Social Exclusion Institute Pour La Ville En Mouvement University of Marne-la-Vallée*. December 2002.

Cervero, R (2007) Transit-oriented development's ridership bonus: a product of self-selection and public policies. *Environment and Planning A 39*: 2068–2085.

Cervero, R and GB Arrington (2008) Vehicle trip reduction impacts of transit-oriented housing. *Journal of Public Transportation 11, no.3*: 1–18.

Cervero, R and J Murakami (2010) Effects of built environments on vehicle miles traveled: evidence from 370 U.S. metropolitan areas. *Environment and Planning A 42*: 400–418.

Cervero, R, A Golub and B Nee (2007) City carshare: longer-term travel-demand and car ownership impacts. *Transportation Research Record 1992*: pp70–80

Chapman J and L Frank (2004) Integrating travel behavior and urban form data to address transportation and air quality problems in Atlanta. Deliverable # V.30 under GDOT Research Project No. 9819, Task Order 97-13 Final report. Contract with the Georgia Department of Transportation and State of Georgia. Accessed November 2010 from *www.act-trans.ubc.ca/smartraq/*

Chatman, DG (2003) How density and mixed uses at the workplace affect personal commercial travel and commute mode choice. *Transportation Research Record 1831*: 193–201.

Chatman, DG (2005) How the built environment influences non-work travel: theoretical and empirical essays. Dissertation. Department of Urban Planning, School of Public Affairs.

Chatman, DG (2009) Residential self-selection, the built environment, and nonwork travel: evidence using new data and methods. *Environment and Planning A 41*, no.5: 1072–1089.

DTZ Research (2003) Executive summary of the Auckland inner city living survey. Prepared for Auckland City Council.

Ewing, R and R Cervero (2010) Travel and the built environment: a meta-analysis. *Journal of the American Planning Association 76*, no.3: 265–294. Accessed August 2010 at *www.climateplanca.org/Travel_Built_Environ.pdf*.

Falconer, R, P Newman and B Giles-Corti (2008) Living on the edge – transport sustainability in Perth's liveable neighbourhoods. *Paper presented at Planning and Transport Research Centre (PATREC) Research Forum, Perth, WA*, 2 October 2008.

Forsyth, A, JM Oakes, B Lee and KH Schmitz (2009) The built environment, walking, and physical activity: is the environment more important to some people than others? *Transportation Research Part D 14*: 42–49.

Frank, LD, S Kavage and T Litman (2006) *Promoting public health through Smart Growth building healthier communities through transportation and land use policies and practices*. Prepared for Smart Growth BC.

Frank, LD, BE Saelens, KE Powell and JE Chapman (2007) Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? *Social Science & Medicine 65*: 1898–1914.

Frank, LD, TL Schmid, JF Sallis, J Chapman and BE Saelens (2005) Linking objectively measured physical activity with objectively measured urban form findings from SMARTRAQ. *American Journal of Preventive Medicine 28*, no.2S2: 117–125.

Goldberg, D, J Chapman, L Frank, S Kavage and B McCann (2007) New data for a new era – a summary of the SMARTRAQ findings – linking land use, transportation, air quality and health in the Atlanta Region. Accessed November 2010 from *www.livablecommunitiescoalition.org/*

Goodyear, R (2008) Workforces on the move: an examination of commuting patterns to the cities of Auckland, Wellington and Christchurch. *Paper presented at NZAE Conference, Wellington City, New Zealand*, July 2008.

Gordon, I (1997) Densities, urban form and travel behaviour. *Town and Country Planning 66, no.9*: 239–241.

Greenaway, S, T McCreanor and K Witten (2008) Reducing CO2 emissions from domestic travel: exploring the social and health impacts. *EcoHealth 5*: 504–512.

Halcrow Group, P Headicar, D Banister and T Pharoah (2008) *Land-use and transport: settlement patterns and the demand for travel*. Stage 2: Final report. Prepared for Commission for Integrated Transport (CfIT).

Handy, S, XY Cao and PL Mokhtarian PL (2005) Correlation or causality between the built environment and travel behaviour? Evidence from Northern California. *Transportation Research Part D 10*: 427–444.

Handy S, XY Cao and PL Mokhtarian (2006) Self-selection in the relationship between the built environment and walking – empirical evidence from northern California. *Journal of the American Planning Association 72*, no.1: 55–74.

Handy, SL and KJ Clifton (2001) Local shopping as a strategy for reducing automobile travel. *Transportation 28*: 317–346.

Hickman, R and D Banister (2007) *Transport and energy consumption: does co-location of housing and workplaces occur over time*? Transport Studies Unit (Ref. 1027), Oxford: Oxford University Centre for the Environment.

Hinckson, E, N Snowling, P Batts, H Badland and G Schofield, G (2007) *Auckland Regional Transport Authority – school travel plan evaluation 2007.* Auckland, New Zealand: AUT University.

Holden, E (2007) *Achieving sustainable mobility: everyday and leisure time travel in the EU*. Great Britain: Antony Rowe Ltd.

Kim, JH, F Pagliara and J Preston (2005) The intention to move and residential location choice behaviour. *Urban Studies 42*, no.9:1621–1636.

Krizek, K (2003) Residential relocation and changes in urban travel: does neighborhood-scale urban form matter? *Journal of the American Planning Association 69*, no.3: 265–281. Accessed October 2010 from *http://carbon.ucdenver.edu/~kkrizek/journal.html*

Krizek, K (2005) Household lifestyles and their relationship to land-use and transportation planning. CURA Reporter Fall 2005, pp 3–11. Accessed February 2009 from: *www.cura.umn.edu/reporter/05-Fall/Krizek.pdf*

Krizek, K (2006) Lifestyles, residential location decisions, and pedestrian/transit activity. Transportation Research Record, *Journal of the Transportation Research Board 1981*: 171–178. Accessed February 2009 from *http://carbon.ucdenver.edu/~kkrizek/journal.html*

Krizek, K, A Forsyth and L Baum (2009) Walking and cycling international literature review. Melbourne: Victoria Department of Transport. Accessed May 2010 from: *www.transport.vic.gov.au/doi/internet/ict.nsf/headingpagesdisplay/sustainable+transport+publications*

LDA Consulting and CIC Research (2008) National Capital Region Transportation Planning Board commuter connections program – carshare survey. Prepared for Metropolitan Washington Council of Governments. Accessed December 2010 from *www.mwcog.org*

Lee, C and AV Moudon (2006) Correlates of walking for transportation or recreation purposes. *Journal of Physical Activity and Health 3*, no.1: S77–S98.

Lewis, M (2007) Reducing the need to travel, what role for land use planning? *IPENZ Transportation Group Conference Tauranga,* 10 October 2007. Published: IPENZ.org.nz/ipenztg/archives.htm

Li, F, KJ Fisher, RC Brownson and M Bosworth (2005) Multilevel modelling of built environment characteristics related to neighborhood walking activity in older adults. *Journal of Epidemiology and Community Health 59,* no.7: 558–564.

Lilley, SJ (2006) Digging the dirt on density – a study of medium density housing in Christchurch's living three zone. Master of Arts thesis, University of Canterbury, Christchurch, New Zealand

Litman, T (2004) Understanding smart growth savings – what we know about public infrastructure and service cost savings, and how they are misrepresented by critics. Accessed March 2008 from *www.vtpi.org*

Litman, T (2008) Land use density and clustering. TDM Encyclopedia, Victoria Transport Policy Institute. Accessed September 2008 from *www.vtpi.org*

Litman, T (2010) Land use impacts on transport – how land use factors affect travel behavior. Accessed May 2010 from *www.vtpi.org*

Litman, T (2011) Mobility as a positional good – implications for transport policy and planning. Accessed August 2011 from *www.vtpi.org*

Lund, H (2001) Local accessibility, pedestrian travel and neighbouring: testing the claims of new urbanism. *Paper presented at American Planning Association 2001 National Planning conference, New Orleans,* March 2001.

Maat, K and H Timmermans (2006) Autobezit van huishoudens in samenhang met de woon- en de werklocatie. Paper presented at the Colloquium Vervoersplanologisch Speurwerk, Amsterdam, 23–24 November 2006. Accessed February 2011 from *www.cvs-congres.nl*

Maat, K and H Timmermans (2009) A causal model relating urban form with daily travel distance through activity/travel decisions. *Transportation Planning and Technology 32*, no.2: 115–134

Manaugh, K and A El-Geneidy (2011) Validating walkability indices: how do different households respond to the walkability of their neighbourhood? *Paper presented to the Transportation Research Board 90th Annual Meeting, Washington DC*, 23–27 January 2011. Accessed from *http://amonline.trb.org/12k22o/1*

Mavoa, S, K Witten, J Pearce and P Day (2009) Measuring neighbourhood walkability in New Zealand cities. Accessed May 2010 from *www.shore.ac.nz/research_team/suzannne_mavoa.htm*

Melia, S (2007) Potential for carfree development in the UK. Master of Arts thesis, University of the West of England, Bristol, UK.

Michael, YL, TE Beard, D Choi, SA Farquhar and NE Carlson (2006) Measuring the influence of neighborhood environment on walking among older adults. *Journal of Aging and Physical Activity 14*: 302–12.

Mokhtarian, P and I Salomon (2001) How derived is the demand for travel? Some conceptual and measurement considerations. Institute of Transportation Studies (University of California, Davis) Paper UCD-ITS-REP-01-15. Also: *Transportation Research Part A 35*, no.8: 695–719.

Morrison, PS and S McMurray (1999) The inner-city apartment versus the suburb: housing sub-markets in a New Zealand city. *Urban Studies 36*, no.2: 371–391.

Naess, P (2009) Residential self-selection and appropriate control variables in land use: travel studies. *Transport Reviews 29*, no.3: 293–324.

Norman, D and K Sanderson (2010) Relationships between passenger transport use and urban form in New Zealand. Working paper ref #4756. Wellington: BERL Economics. Accessed November 2010 from *http://successfulcities.co.nz/publications.html*

O'Fallon, C and C Sullivan (2004) Personalised marketing – improving evaluation. *Transport Engineering in Australia 9*: 85–102.

O'Fallon, C and C Sullivan (2009) Trends in trip chaining and tours: analysing changes in New Zealanders' travel patterns using the ongoing New Zealand household travel survey. *NZ Transport Agency research report 373*.

O'Fallon, C and I Wallis (2012) A wider look at how travellers value the quality and quantity of travel time. *NZ Transport Agency report 469*.

Oakes, JM, A Forsyth and KH Schmitz (2007) The effects of neighborhood density and street connectivity on walking behavior: the twin cities walking study. *Epidemiologic Perspectives & Innovations 4*: 16–25.

Pagliara, F, J Preston and J-H Kim (2002) Residential location choice behaviour in Oxfordshire. In *Proceedings from the European Transport Conference,* Cambridge, September 2002.

Pikora, T, B Giles-Corti, M Knuiman, K van Niel, M Bulsara, F Bull and T Shilton (2006) The impact of urban design on walking and cycling: the RESIDE project. *Paper presented at Planning and Transport Research Centre Forum*, September 2006. Accessed February 2009 from *www.patrec.org/conferences*

Pinjari, AR, CR Bhat and DA Hensher (2009) Residential self-selection effects in an activity-time-use behaviour model. *Transportation Research Part B: Methodological 43*, no.7: 729–748.

Pinjari, AR, M Pendyala, CR Bhat and PA Waddell (2007) Modelling residential sorting effects to understand the impact of the built environment on commute mode choice. *Transportation 34*, no.5: 557–573.

Project for Public Spaces Inc (1998) Transit-friendly streets: design and traffic management strategies to support livable communities. Transit Cooperative Research Programme (TCRP). *TCRP report 33*. Washington DC: National Academy Press.

Public Health Advisory Committee (PHAC) (2010) Healthy places, healthy lives: urban environments and wellbeing. Wellington: Ministry of Health.

Ramfos, N and L Diggins L (2009) National Capital Region Transportation Planning Board (TPB) Commuter connections carshare survey 2008. Report prepared for Metropolitan Washington Council of Governments. Accessed December 2010 from *www.mwcog.org*

Rauterkus, SY, GI Thrall and E Hangen (2010) Location efficiency and mortgage default. *Journal of Sustainable Real Estate 2*, no.1: 117–141.

Rhodes, RE, KS Courneya, CM Blanchard and RC Plotnikof (2007) Prediction of leisure-time walking: an integration of social cognitive, perceived environmental, and personality factors. *International Journal of Behavioral Nutrition and Physical Activity 2007*, no.4: 51,

Roberto, E (2008) Commuting to opportunity: the working poor and commuting in the United States. Transportation Reform Series for the Metropolitan Policy Program at Brookings. *www.drcog.org/documents/Commuting%20to%20Opportunity.pdf*

Ryley, T (2005) Use of non-motorised modes and life stage in Edinburgh. *Journal of Transport Geography 14*, no.5: 367–375.

Saelens, BE and SL Handy (2008) Built environment correlates of walking: a review. *Medicine &. Science in Sports & Exercise 40*, (7 Supplement): S550–66.

Saelens, BE and C Papadopoulos (2008) The importance of the built environment in older adults' physical activity: a review of the literature. *Washington State Journal of Public Health Practice 1*, no.1: 13–21.

Schwanen, T and PL Mokhtarian (2005a) What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods? *Journal of Transport Geography 13*: 83–99.

Schwanen, T and PL Mokhtarian (2005b) What if you live in the wrong neighborhood? The impact of residential neighborhood type dissonance on distance traveled. *Transportation Research Part D 10*: 127–151.

Schwanen, T and PL Mokhtarian (2007) Attitudes toward travel and land use and choice of residential neighborhood type:e Evidence from the San Francisco Bay area. *Housing Policy Debate 18*, no.1: 171–207.

Schwanen, T, M Dijst and F Dieleman (2005) The relationship between land use and travel patterns: variations by household type. In: *Spatial planning, urban form and sustainable transport*. K Williams (Ed). Aldershot, Hampshire: Ashgate.

Snellen, D (1999) The relationship between urban form and activity patterns – multi-variate analysis of frequently made trips. In *Proceedings of the European Transport Conference,* Cambridge, September 1999.

Snellen, D (2001) Urban form and activity-travel patterns an activity-based approach to travel in a spatial context. PhD thesis, Eindhoven University of Technology, Urban Planning Group.

Stanbridge, K, G Lyons and S Farthing (2004) Travel behaviour change and residential relocation. Paper presented at the 3rd International Conference of Traffic and Transport Psychology, Nottingham, 5–9 September 2004. Accessed June 2010 from *www.uwe.ac.uk*

Statistics New Zealand (2006) Downtown dwellers 2005: New Zealand's CBD residents. Wellington: Statistics New Zealand. Accessed June 2010 from *www.stats.govt.nz/browse_for_stats/people_and_communities/housing/downtown-dwellers-2005.aspx*

Statistics New Zealand (2009a) Commuting in Auckland. Accessed May 2010 from *www.stats.govt.nz/*

Statistics New Zealand (2009b) Commuting patterns in Wellington. Accessed May 2010 from *www.stats.govt.nz/*

Statistics New Zealand (2009c) Commuting patterns in Christchurch. Accessed May 2010 from *www.stats.govt.nz/*

Statistics New Zealand (2010) Household use of information and communication technology 2009. Excel workbook. Accessed April 2011 from

www.stats.govt.nz/browse_for_stats/people_and_communities/Households/HouseholdUseofICT_HOTP2009.aspx

Statistics New Zealand (2010) Apartment dwellers: 2006 Census. Wellington: Statistics New Zealand. Accessed June 2010 from *www.stats.govt.nz/publications/standardofliving/apartment-dwellers.aspx*

Statistics New Zealand (undated) Housing indicator 1: Occupancy rate tables (2006 Census). Accessed October 2010 from *www.stats.govt.nz/browse_for_stats/people_and_communities/Households/housing-indicators.aspx*

Sullivan, C and C O'Fallon (2010) Walking and cycling: improving combined use of physical activity/health and transport data. *NZ Transport Agency research report no.435*. 74pp.

Suminski, RR, LM Katzenmoyer, RL Petosa, WSC Poston and E Stevens (2005) Features of the neighbourhood environment and walking by US adults. *American Journal of Preventive Medicine 28*: 149–155.

Syme, C, V McGregor and D Mead (2005) *Social implications of housing intensification in the Auckland region: analysis and review of media reports, surveys and literature reviews*. Auckland New Zealand.

Tal, G, Handy S and M Boarnet (2010) Network Connectivity (2 draft mini-papers) Accessed November 2010 from *www.des.ucdavis.edu/faculty/handy/TTP220/NETWORK_CONNECTIVITY_5_10.pdf*

Turcotte, M (2008) Dependence on cars in urban neighbourhoods. Canadian Social Trends, 85: 20–31. Accessed March 2009 from *www.statcan.ca*

Van de Coevering, P and T Schwanen (2006) Re-evaluating the impact of urban form on travel patterns in Europe and North-America. *Transport Policy 13*: 229–239.

Van Reenen, K (2007) Residential intensification in Dunedin: impacts and acceptability. A thesis submitted in partial fulfilment for the degree of Master of Planning. University of Otago, Dunedin, New Zealand. Accessed January 2009 from *www.chranz.co.nz/publications.html*

van Wee, B (2009) Self-selection: a key to a better understanding of location choices, travel behaviour and transport externalities? *Transport Reviews 29*, no.3: 279–292.

Wellington City Council City Planning (WCC) (2009) Central city apartment dwellers – a summary of results. Wellington: Wellington City Council. Accessed January 2010 from *www.wellington.govt.nz/services/urban/managinggrowth.html*

Williams, K (2004) Can urban intensification contribute to sustainable cities? An international perspective. Accessed December 2008 from *http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN026009.pdf*

Zegras, C (2007) The built environment and motor vehicle ownership and use: evidence from Santiago de Chile. Paper presented at Transportation Research Board 2007 Annual Meeting. Accessed January 2009 from *http://web.mit.edu/czegras/www/Papers.htm*.

Appendix A: Key attributes of empirical studies and meta-analyses

Author and date	Primary factors examined	Data type	Study site	Data	Methods	Controls	Self-selection controlled for
Badland (2007)	BE, walk/cycle	XS/D	Auckland NZ	2000	LGR	SE/VO	No
Bagley and Mokhtarian (2002)	BE, mode use, attitude	XS/D	North California	515	SEM	SE/AT/	Yes
Bhat and Guo (2006)	BE, RSS, VO	XS/D	San Francisco	Aggregate of various datasets	MNL	SE/VO	Yes
Bina et al (2006)	Location vs travel choices	XS/D	Austin Texas apt dwellers	240	LNR/BL/ OPM	OT	No
Braun Kohlová (2009)	BE, mode use	XS/D	7 Czech cities	1438	PCA/MNL	No	No
Buchanan et al (2006)	Journey to work, population density, mode, ethnicity	L (1991–2001)/A	Census data for 115 area units in Christchurch, NZ	Whole population	LNR	SE	No
Cao (2007)	Perceived NHD characteristics, preferences, SE	XS/D	8 NHDs in northern California	594	OPM/BL	SE	Yes
Cao (2006)	VMT, walk distance, vehicle ownership	XS; QL/D	8 NHDs in northern California	1682	LNR/SUR/OPM /SEM	AT/SE	Yes
Cao et al (2005a)	RSS, walk trips, BE	XS/D	Austin Texas	1368	NBR	No	Yes
Cao et al (2005b)	NHD characteristics, non-work travel, RSS	XS/D	Austin Texas	1368	SUR	AT	Yes
Cervero and Murakami (2010)	VMT, car trips, various types of density	XS/D	USA	Aggregate of various datasets	SEM	SE (household income)	No
Cervero (1996)	BE, mixed use NHD, mode choice	XS/D	American housing survey 1985	42,200 housing units	BL	SE/BV	No
Cervero and Arrington (2008)	Vehicle trip generation, BE	XS/A	17 transit-oriented developments in 5 areas, USA	2 day traffic counts	LNR	No	No

Appendix A: Key attributes of empirical studies and meta-analyses

Author and date	Primary factors examined	Data type	Study site	Data	Methods	Controls	Self-selection controlled for
Cervero (2007)	Transit-oriented development, commute VMT	XS/A	26 TODs in 5 California regions	≈1000	LGR	SE/ LS/WP/AT	Yes
Chapman and Frank (2004)	Intersection density, VMT	XS/D	Atlanta, Georgia	8000	LNR	SE	No
Chatman (2005)	Non-work trips, residential location, BE	XS; QL/D	San Diego & San Francisco	999	NBR/TOR	SE/WP	Yes
Chatman (2003)	Intersection density, VMT for commercial trips	XS/D	Nationwide Personal Transport. Survey	14478	TOR	SE/WP	No
Chatman (2009)	Retail job density, walk/bike trips	XS/D	San Francisco & San Diego California	D	NBR	SE/LS/OT/AT	Yes
DTZ Research (2003)		XS/D	Auckland NZ	185	descriptive	No	No
Ewing and Cervero (2010)	BE, VMT, walking, public transport use	various	USA	Meta-analysis	LNR/LGR/NBR/ TOR/POR	Limited	Generally, no
Falconer et al (2008)	Perception of NHD, walk distances, walkability	QL/D	Perth Australia	>1000	Not given	NV	No
Forsyth et al (2009)	BE, walk trips, physical activity, density	XS/D	36 NHDs in Twin Cities, Minnesota	716	LGR	SE	No
Frank et al (2007)	NHD preference, BE, walk, VMT, obesity	XS/D	Atlanta, Georgia	2056 and 1466	LGR/LNR	SE	Yes
Frank et al (2005)	Physical activity levels, BE	XS/D	Atlanta, Georgia	357	LNR/LGR	SE	No
Goldberg et al (2007)	NHD walkability, mode use, obesity (SMARTRAQ study)	XS/D	Household travel survey plus others, Atlanta Georgia	Aggregate datasets, 8000 households	LNR/MNL	SE/NV	Yes
Handy and Clifton (2001)	Distance to nearest store, walk trips	XS/D	6 NHDs in Austin, Texas	1368	LNR	SE	No
Handy et al (2006)	Distance to nearest store/# of businesses, walk trips	XS/D	8 NHDs in northern California	1672	NBR	SE/AT	Yes
Handy et al (2005)	BE, movers/nonmovers, VMT, NHD characteristics & preferences	XS; QL/D	8 NHDs in northern California	1682	LNR/ANOVA/O PM/	SE/AT	Yes

Author and date	Primary factors examined	Data type	Study site	Data	Methods	Controls	Self-selection controlled for
Hickman and Banister (2007)		L (1998 & 2001)/D	Surrey, UK	428	LNR/aggregate & correlation analysis	No	No
Holden (2007)	BE, energy consumption, VMT	XS/D	Oslo Norway	≈1000	LNR	AT	No
Kim et al (2005)	Residential location choice	XS/D	Oxfordshire, UK	96	Nested MNL	No	No
Krizek (2003)	VMT, BE, NHD accessibility	L (1989–1997)/D	Central Puget Sound, Washington	6144 households	LNR	Not specified	Yes
Krizek (2005)	Population and retail density, minutes travel, total trips	XS/D	Twin Cities Minnesota	9000	FA/cluster analysis	None	No
Lee and Moudon (2006)	Walk/cycle, attitude, NHD	XS/D	Seattle, Washington	438	LGR/MNL	SE/LS	Yes
Li et al (2005)	Walk trips, BE	XS/D	Portland Oregon	577	HLM	No	No
Lilley (2006)	Mode use, BE, density	XS/D	Christchurch NZ	42	Descriptive	No	No
Lund (2001)	Walk trip, BE	XS/D	8 NHD in Portland Oregon	499	ANCOVA/HLM	SE/AT	Yes
Maat and Timmermans (2006)	Residential and work place density, vehicle ownership	XS, GIS and other data /D	Central Netherlands	1222	MNL	No	No
Maat and Timmermans (2009)	Residential and work place density, amount of travel, vehicle ownership	XS, GIS and other data /D	Central Netherlands	1211	SEM	No	No
Melia (2007)	Vehicle ownership, attitudes, BE	XS/D	Greater London	822; 199 & 57	Descriptive	No	No
Mokhtarian and Salomon (2001)	Travel liking, amount of travel, attitudes	XS / D	8 NHDs in northern California	≈1900	BA	No	No
Naess (2009)	Distance travelled by mode; attitude; residential preferences, vehicle ownership	XS; QL/D	29 residential areas in Copenhagen	1932 and 273	SEM/LGR	AT/OT/VO	Yes
Norman and Sanderson (2010)	Public transport use, residential and work place density	L(1996-2006)/A	Census data for 18 largest NZ urban centres	1.19M workers	LNR	No	No

Author and date	Primary factors examined	Data type	Study site	Data	Methods	Controls	Self-selection controlled for
Pikora et al (2006)	NHD preference, walk/cycle trips	L (base line report)/D	Across all of Perth	1803	LGR	SE	No
Pinjari et al (2009)	Residential location, activity time use	XS/D	Household travel survey, San Francisco	15000	MNL/MDC	No	Yes
Pinjari et al (2007)	BE, commute time	XS/D	Household travel survey, census, and other data, San Francisco	Aggregate datasets, San Francisco	SLR	AT/SE	Yes
Rauterkus et al (2010)	Mortgage data, Walk score assessment, vehicle ownership	XS/A	Chicago, Jacksonville, Chicago	Aggregate datasets, 40000	PRR	SE	No
Rhodes et al (2007)	Leisure time walking, personality, perceived environment, distance to retail	XS/D	Canada	358	SEM/LNR	No	No
Ryley (2005)	Mode use, NHD characteristics	XS/D	Scottish HH travel survey, Edinburgh	4016	Cluster analysis	No	No
Schwanen and Mokhtarian (2005a)	Residential NHD, commute mode choice, attitude	XS/D	8 NHDs in northern California	1358	MNL	AT/SE/OT	n/a
Schwanen and Mokhtarian (2007)	NHD characteristics, attitudes, mode use	XS/D	8 NHD in northern California	1358	BL/MNL	SE/AT/VO	Yes
Schwanen et al (2005)	BE, trip frequency, travel time	XS/D	Netherland National HH travel survey	Not given	Descriptive/ not specified	No	No
Snellen (1999)	Vehicle trips, BE	XS/D	9 Dutch cities	344 HH	MNL	SE	No
Snellen (2001)	Vehicle trips, BE	XS/D	9 Dutch cities	355 HH	LNR/HLM/PRR	SE	No
Stanbridge et al (2004)	Commute mode choice, residential location	QL/D	UK	11	Qualitative interviews	None	No

Author and date	Primary factors examined	Data type	Study site	Data	Methods	Controls	Self-selection controlled for
Suminski et al (2005)	Walk trips, BE	XS/D	Mid-West USA	474	LGR	SE	No
van de Coevering and Schwanen (2006)	Residential & work place density, VMT	XS/A	Aggregate datasets for Europe and North America	large	LNR	Not specified	No
Zegras (2007)	Various (density, distance) Automobile use	XS/D	Household travel survey, Santiago, Chile	1000	LNR/LGR	SE	No

Key to table

Primary factors:

BE = built environment

NHD = neighbourhood

RSS = residential self-selection

VMT = vehicle miles travelled

VO = vehicle ownership

Data type:

XS = cross sectional

QL = quasi-longitudinal

L = longitudinal

D = disaggregated

A = aggregated

Methods:

ANCOVA = analysis of covariance

ANOVA = analysis of variance

BA = bivariate analysis

BL = binary/binomial logit

FA = factor analysis

HLM = hierarchical linear modelling

LGR = logistic regression

LNR = linear regression

MDC = multiple discrete continuous extreme value model

MNL = multinomial logit model

NBR = negative binomial regression

OPM = ordered probit model

PRR = probit regression

SEM = structural equation modelling

SLR = simultaneous linear equations

SUR = seemingly unrelated regression

TOR = Tobit regression

Controls:

AT = attitudinal variables

NV = NHD (characteristics) variables

OT = other variables

SE = socio-economic variables

VO = vehicle ownership variables

WP = workplace variables

Appendix B: Literature review summary

B.1 Abbreviations

-ve	negative
+ve	positive
apt	apartment
avg	average
BE	built environment
CATI	computer assisted telephone interview
CBD	central business district
CCD	census collection district
CMA	census metropolitan area
D	density
ED	employment density
GIS	geographic information system
HH	household(s)
inc	including
JTW	journey to work
LN	liveable neighbourhood
LOS	level of service
mins	minutes
MNL	multinomial logit model
NHD	neighbourhood
NSI	neighbourhood shopping index
nwk	non-work
OD	origin-destination
OR	odds ratio
PA	physical activity
PT	public transport
Q	question
Qre	questionnaire
RC	reverse commute/commuting
RD	residential density
RSS	residential self-selection
SP	stated preference
SS	self-selection
TB	travel behaviour
TOD	transit-oriented development
TPA	transport-related physical activity
veh	vehicle
VKT	vehicle kilometres travelled
VMD	vehicle miles travelled per day
VMT	vehicle miles travelled
vown	vehicle ownership
vs	versus
W/C	walking/cycling

B.2 Reverse commuting

Author, title and date	Research question	Study population, setting, country, sample size	Outcome variables (inc measures)	Primary findings	Other comments/findings	Applicability to NZ
Cervero, R (2002) Reverse commuting and job access in the United States.	Examines the market-demand characteristics of reverse commuting, drawing upon experiences in urbanised California, and reviews experiences with specialised transportation programmes that aim to bridge spatial mismatches.	The spatial gap between where many low-income Americans live (inner-city) and where more and more jobs are being created (the suburbs), many contend, explains high inner-city unemployment. Today, more than half of USA HH receiving financial assistance live in central cities.		Around 10% of commutes in Los Angeles, San Francisco-Oakland, San Diego and Sacramento occur in the reverse direction (eg central city to suburbs in the mornings). Among low income workers, the share is closer to 20%; 1 in 5 reverse commuters = low-income; 1 in 5 are from HH with <=1 car; use transit.	Except in the Bay Area, 19 out of 20 reverse commute trips are estimated to be by private car. In California, more RC is by carpools than mass transit. RC expected to grow in the USA as more jobs migrate to the suburbs, inner-city NHDs get gentrified, and workfare initiatives continue to require the inner-city poor to eventually find jobs.	
Roberto, E (2008) Commuting to opportunity: the working poor and commuting in the United States.	Commuting from one suburb to another and reverse commuting from cities. To suburbs are more common.			Reverse commutes – from centre cities to suburbs – now make up nearly 10% of all metropolitan work trips. US Census Bureau: reverse commutes are so pronounced that cities such as Detroit lose population during the day. Both traditional commuting from suburbs to the central city, and within-city commuting declined slightly from 1990 to 2000 (from 20% to 19% or traditional commutes, and 28% to 26% for within-city commutes).		
Auckland City (2003) Behaviour and attitudes and perceptions of residents, workers and visitors in the central city. Report part A. Prepared by Central Area Planning City Planning.	6th biennial survey – focus on perceptions of personal safety; reasons for being in city centre and people's tripmaking habits.	Same survey supplied to businesses (Qre for employees); residents (posted); and conducted on street. Low response rates for business and residential. Total of 629 Qres returned.		35% of inner city respondents work outside of the central city area (where they lived). 50% commuted to other parts of Auckland city and 30% worked on the North Shore.	Focus of reporting is on non-resident behaviour, including travel behaviour. Basic demographics do not include car ownership.	

B.3 Residential self-selection

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Bagley, MN and PL Mokhtarian (2002) The impact of residential neighborhood type on travel behavior: a structural equations modeling approach.	On-site surveys of NHDs plus mail-out surveys and travel diaries. 3 surveys in total. 39 attitude statements, grouped to 10 factors such as pro-driving; pro-growth; lifestyle info gathered on 100 activities/interests (and whether they read about them, did them in last weekend or last year) – grouped to 11 factors such as hobbyist, couch-potato.	N=515 employed people (from total of 963 HH) – N California NHD.	'This is perhaps the strongest evidence to date supporting the speculation that the association commonly observed between land use configuration and travel patterns is not one of direct causality, but due primarily to correlations of each of those variables with others. In particular, the results suggest that when attitudinal, lifestyle, and socio-demographic variables are accounted for, NHD type has little influence on TB' (279, abstract).	Longer commute distances; >VMD; >PT miles; fewer W/C miles assoc with suburban locations.; 'the only significant effect of residential location on travel demand is the positive effect of a suburban location on transit miles' (due to BART & good bus services).	Age, HH size, # of children, # of vehicles, # of years in NHD are negatively associated with 'traditional' NHD; culture-lover, outdoor enthusiast, pro-alternative; pro-growth; pro-pricing; time-satisfied; work driven, or pro-high density = +ve assoc with traditional NHD; adventurer, homebody, nest-builder, relaxer, pro-drive alone or pro-driving = positive association with suburban NHD.	Econometric conditions of identifiability and the availability of data limited the number and kinds of relationship that could be tested; alternative operationalising of conceptual variables was possible; focus on single individuals rather than HH.	
Bina, M et al (2006) Location choice vis-à-vis transportation: the case of apartment dwellers.	Examines the choices of apartment dwellers and explores their reasons for moving, priorities when choosing a residential location, and the tradeoffs involved. Investigates the variations in rent and apartment size, stated preferences of housing, location, transportation and access. Uses summary statistics of the data, linear regressions, binary logit and ordered probit models.	Self-completion survey distributed door-to-door as well as internet distribution. Sampling frame = all apartments in Austin Texas, rigorous selection process. 240 fully completed survey of 450 people who answered the door.	Models factors affecting rent (density, PT availability, commute distance/time, commercial centre proximity, # of bedrooms and bathrooms, overall size). 6 SP scenarios offered with choice of apt-based feature vs a transport-related option or other apt-related feature – responses then modelled based on demographics.	Reason for moving to apt: easier commute; new job/transfer; less expensive housing; to begin study. Priorities in choice: price; commute time.	Urban area apartment dwellers are more likely to choose shorter commute times, better PT facilities and proximity to shopping centres. HH located further from the CBD are more likely to opt for better PT (bus and rail) options. Also identifies characteristics of those subgroups where the access to some feature is important, particularly distinctions for families, couples and singles.		
Cao, XY (2006) The causal relationship between the built environment and personal travel choice: evidence from Northern California. PhD dissertation. University of California Davis.	Empirical study. Literature review compiled in 'reviews' worksheet - explored the causal link (between BE & personal travel choice) by employing a quasi-longitudinal research design and controlling for RSS (namely, residential preferences and travel attitudes); previous studies have employed multivariate analysis and accounted for the sorting effect of socio-demographic characteristics.	Uses data collected from 1682 respondents living in four traditional and four suburban NHDs in Northern California in 2003.	Investigated the influence of the BE on various measurements of personal travel choices including uses of different modes (driving, transit, walking and biking), trip frequencies for different purposes (overall travel, non-work travel, shopping travel and strolling), auto ownership, and vehicle type choice.	The results showed residential preferences and travel attitudes have pervasive influences on all measurements of travel choices. The results also provide some encouragement that land-use policies designed to put residents closer to destinations and provide them with alternative transportation options will actually lead to less driving and more walking.	(p54) Disentangling the influences of the BE and RSS and determining their relative importance has become one of the most important emerging issues in understanding the relationship between BE and travel behaviour.		

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Hickman, R and D Banister (2007) Transport and energy consumption: does co-location of housing and workplaces occur over time?	Descriptive, correlation and regression analysis, matched pair analysis (longitudinal).		Energy consumption, journey distance, mode share, occupancy (all journey to work. Various urban and socio-economic variables, including density, settlement size, jobs-housing balance, location, accessibility, streetscape layout, household income, car ownership, etc.	The temporal effect and type of resident appear to be important factors in the land use, socio-economic and travel behaviour relationship (in Surrey, UK). Residents who stay at the same HH [based on a survey at two points in time over a 3-year period] are the least energy consuming, with an increase (4%) in transport energy consumption over time, reflecting reduced journey distance (-4%) but increased car mode share (4%); outmovers are the most mobile in terms of distance travelled, have the highest car mode share and account for more (8%) in transport energy consumption than the stayers; inmovers are more mobile than the stayers, but less mobile than the outmovers, and have the largest increase (8%) in transport energy consumption over time. The 'co-location' effect hence does occur in Surrey within the stayers data, but only marginally in terms of journey distance. At the same time car mode share increases, meaning that composite energy consumption increases.	Urban structure may account for around 10% of the variation in travel energy consumption, socio-economic characteristics (including attitudinal characteristics) around 20%–30% of the variation in travel energy consumption, based on journey to work analysis. Within Surrey, energy consumption in the journey to work reduces almost linearly as accessibility to town centres increases.	Limited to JTW as basis for analysis (using NZHTS).	
Krizek, K (2005) Household lifestyles and their relationship to land-use and transportation planning.	To consider, using factor analysis and factor loading then cluster analysis, various decisions an individual faces about his or her travel characteristics, how to spend minutes in the day, and the characteristics of where they choose to live. 'Web of decision making' is known as a 'lifestyle' - but how do increased levels of NHD accessibility relate to how individuals complete daily errands? What is the potential of land-use planning, by itself, to reduce miles of vehicle travel?	Analysed travel behaviour inventory (TBI) home interview survey data for 9000 individuals and HH within the seven-county Twin Cities metropolitan area comprising 24-hour travel diaries and two subsequent HH tel. interviews during the summer of 2001. Incorporated other data to measure the nature of the individual's NHD: the amount of retail within walking	Factors: amount of travel; NHD characteristics (accessibility - number of retail shops and school quality); at-home and maintenance activities; W/transit use; discretionary time. Variables: total minutes spent in travel, avg # of stops each time one leaves home, total veh trips, total mins spent at home, measure of regional accessibility, #of retail stores within 1/2 mile, HH density, avg test scores at 5th grade level, total mins in work-type activities, total W trips, total PT bus trips,	Seven different lifestyle clusters based on the five factors identified. Lifestyle 5 is disproportionately represented among individuals 40 to 59 years old; majority of HH with four or more individuals are located in suburban environments (characteristic of Lifestyles 4, 5, and 6), and there is little difference between walkers/transit users (Lifestyles 1, 2, and 3) with respect to HH size.	Density doesn't feature strongly in any lifestyle/behaviour – three distinct lifestyles that employ walking or transit services (Lifestyles 1, 2, and 3). These three populations behave differently, and the manner in which they differ depends on their other associated characteristics of time use and NHD characteristics. The not so good news is that the combined population represented by these three lifestyles accounts for less than 8% of the study	Another study in the Twin Cities found most people preferred to use the car for almost all trip purposes. Only about 8% of the population surveyed enjoyed a lifestyle which involved substantial walking or public transport use. The other 92% who relied almost entirely on cars lived in both inner and outer parts of the conurbation, and were considered to be unresponsive to	Essentially same paper: Krizek, K (2006). Lifestyles, residential location decisions, and pedestrian/ transit activity.

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
		distance of their home, the population density of the NHD, the quality of local schools, and the degree of regional accessibility.	total mins in discretionary activities.		sample – suggesting the overwhelming majority of the population does not subscribe to a lifestyle conducive to walking or using transit.	attempts by planners to wean them away from the car.	
Naess, P (2009) Residential self-selection and appropriate control variables in land use: travel studies.	Qs about TB, activity participation, socio-economic characteristics of the respondents, attitudes to transport and environmental issues, residential preferences and possible obligations, social relations or routines likely to influence travel behaviour. Residents who had lived<5 years at their present residential address were also asked about the previous residential location and any changes in TB and car ownership due to the move to the present dwelling. The main survey included Qs about the distances travelled by each mode on each day during a week.	Copenhagen Metropolitan Area study data collection included a large travel survey among inhabitants of 29 residential areas (N = 1932), a more detailed travel diarywith some participants of the first survey (N = 273), and qualitative interviews with 17 HH.	Lots of discussion with some bits and pieces of data thrown in, hard to figure out what is actually 'proven' in the article, eg used structural equation modelling where residential location, residential preferences, attitudes to car travel and car ownership are probably mutually influencing each other – didn't find anything stable.	Respondents who had moved in last 5 years asked: were asked whether they, according to their own judgement, had experienced a change in their amount of transportation due to the move – a clear tendency to increasing amounts of transport when moving outward and decreasing when moving closer to the city centre. The respondents' transport attitudes tend to become less car-oriented, the higher the local area density. Car ownership also tends to increase with children in HH and rising income levels, whereas the likelihood of having a car is lower among young respondents.			
Pinjari, AR et al (2008) Residential self-selection effects in an activity time-use behavior model.	Joint model system of residential location and activity time-use choices that considers activity-travel environment and socio-demographic variables, as determinants of individual weekday activity time-use choices; a joint mixed MNL–multiple discrete-continuous extreme value (MNL–MDCEV) structure that a) accommodates both observed and unobserved individual-related attributes and b) controls for the self-selection of individuals into NHD.	Primary source of data used for this analysis is the 2000 San Francisco Bay Area Travel Survey (BATS); individuals from over 15,000 HH in the Bay Area for a two-day period - only 16+ selected; weekday; one of 2 travel days; Alameda County; plus GIS data (business locations, bike facilities, census data, land-use data.	Accommodate RSS effects due to observed and unobserved individual characteristics in examining the impact of activity-travel environment variables on individual time-use in maintenance activity (grocery shopping, HH chores, personal care, etc) and several types of discretionary activity purposes.	The model results indicate the significant presence of RSS effects due to both observed and unobserved individual-related factors, eg individuals from HH with more bicycles are associated with a higher preference for out-of-home physically active pure recreational travel pursuits (such as bicycling around in the NHD). These same individuals locate into NHD with good bicycling facilities. This leads to a non-causal association between individuals' time investment in out-of-home physically active pure recreational travel and bicycling facilities in their NHD. Thus, ignoring the effect of bicycle ownership in the time-use model, would lead to an inflated estimate of the effect of bicycling facility density on the	Similarly, there are significant unobserved individual factors that lead to a high preference for physically active recreational activities and also make individuals locate in areas with good bicycling facilities. When such unobserved factors were controlled by the proposed joint residential location and time-use model, the impact of bicycling facility density on out-of-home physically active recreational activities ceased to be statistically significant. These results highlight the need to control for RSS effects when estimating the effects of the activity-travel environment on activity time-use choices; high income HH locate in NHDs with low employment density and low	Revealed-preference - RSS based on socio-demographics, not on attitudes/perceptions, and associated travel behaviour – no ability to determine causality. *Q for research:* HH owning fewer vehicles are likely to engage in more active transport/PT use, no matter where they live? Or only if they live in high density settings?	

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
				time invested in physically active pure recreational travel.	street block density and have a preference for out-of-home recreational activities/travel.		
Rhodes, RE et al (2007) Prediction of leisure-time walking: an integration of social cognitive, perceived environmental, and personality factors.	The purpose of this study was to incorporate personality, the perceived environment and planning into a theory of planned behaviour framework to predict leisure-time walking. Results: analyses using structural equation modelling.	Survey/questionnaire. Canada, 358 adults – self-reported walking behaviour two months later.		Analyses using structural equation modelling provided evidence that leisure-time walking is largely predicted by intention (standardised effect = 42) with an additional independent contribution from proximity to NHD retail shops (standardised effect = .18). Intention, in turn, was predicted by attitudes toward walking and perceived behavioural control. Effects of perceived NHD aesthetics and walking infrastructure on walking were mediated through attitudes and intention. Moderated regression analysis showed that the intention-walking relationship was moderated by conscientiousness and proximity to NHD recreation facilities but not planning.			
Schwanen, T and PL Mokhtarian (2005a) What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods?	14-page questionnaire that collected information on a variety of travel and related issues, factor analysis done & MNL model developed -MNL model assumes that travellers have unobservable, latent preferences or utilities for different transport modes and they choose the mode providing the highest utility – to what extent commute mode choice differs not only by residential NHD but also by the presence and level of mismatch between a commuter's current and preferred type of NHD.	About 2000 surveys were returned, yielding a 25% response rate. The subset of 1358 respondents identified as workers commuting at least once a month is used for the current analysis.	Their objective mobility – distance and frequency of travel by mode and trip purpose, as well as the average travel time for the commute trip – commute mode was induced (not directly asked); sections on travel attitudes, personality and lifestyle characteristics, actual travel patterns, liking for travel, perceived amount of travel, desire to reduce or increase travel, efforts to reduce or ease travel and demographics.	About 1/4 of the respondents are mismatched in their NHD; urban residents with suburban land use preferences will exhibit some travel patterns that are more beneficial to the environment than those of true suburbanites (eg with a 83% personal vehicle commute mode share for the most mismatched urban dwellers, compared to 93% for the consonant suburban dwellers); the 83% personal vehicle commute mode share of the most mismatched urban residents is considerably higher than the 59% share of their true urbanite neighbours		Commute mode calculated rather than revealed.	Also: Schwanen, T and PL Mokhtarian (2005) What if you live in the wrong neighborhood? The impact of residential neighborhood type dissonance on distance traveled.
Stanbridge, K et al (2004) Travel behaviour change and residential relocation.	Explores the effects of the key event of moving home on people's travel behaviour, and mode choice in eleven in-depth interviews with recent home movers of approx one hour in length in the summer of 2004. Interview discussion addressed a variety of journey	All participants had been in their new home less than a year at the time of the interview. However, age of participants was biased to younger, first time buyers, and only one	Habitual journey focused on commute mode choice. Consideration of alternative modes.	6 of 11 changed usual mode following move – mostly walkers and PT users. Car drivers before the move remained as car drivers following the move. 10 out of the 11 study participants discussed consideration of alternative modes for at least			

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
	purposes focusing on commute, shopping and leisure, reasons for moving, priorities when searching, and general experiences of the moving process, and any other factors that influenced their travel behaviour over the time period of their move.	person from a family took part.		one journey purpose. Created 'residential relocation timeline' showing possible points where consideration of mode choice might enter relocation decision.			
Mokhtarian, P and I Salomon (2001) How derived is the demand for travel? Some conceptual and measurement considerations.	Explores the concept of 'undirected travel' or travel 'for its own sake' – essentially: 'travel is the activity, movement is the object, and a destination, if there is one (or more) in the usual sense of the word, is to varying degrees incidental' – undirected travel is 'for the most part a leisure activity' - suggests an affinity for travel incorporates three elements that are generally confounded: 1) the activities conducted at the destination; 2) the activities that can be conducted while travelling (including 'anti-activity' ie shifting gears, relaxing); 3) the activity of travelling itself - defines excess travel as being undirected and undertaken because travel itself is viewed as having a positive utility.	1998 San Francisco survey – travel liking variables; 13 different 'indicators of excess travel': 'keeping in mind that travel is going any distance by any means, how often do you travel… to explore new places or… to see beautiful scenery or …just for the fun of it' etc, personality traits, attitudes towards travel (eg 'getting there is half the fun' or 'the only good thing about travelling is arriving at your destination', ideal commute time; hypothesise that people have an unobserved desired travel time budget.	Bivariate analysis.	Attitudes towards travel: suggest there is a large group of people with some intrinsic utility for travel; who like travelling, irrespective of whether it is for 'chores', commuting or leisure; who engage in 'excess' travel. >75% of the sample reported sometimes or often travelling 'just for the fun of it' and more than 2/3rds disagreed that 'the only good thing about travelling is arriving at your destination' – do not refute that most travel is derived demand, but argue that humans 'possess an intrinsic desire to travel'. Acknowledge that in self-reports of attitudes toward travel, respondents likely to confound their utility for travelling itself with their utility for the activities at the destination and for activities conducted while travelling.			

B.4 Built environment

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
Badland, H (2007) Transport-related physical activity, health outcomes, and urban design: descriptive evidence. PhD thesis, Chapter 9 (other chapters published as papers and examined separately).	Cross sectional computer assisted telephone interview - Active Friendly Environment Survey (AFES) – employs GIS-derived measures of mixed land use, residential density and street network connectivity to examine transport-related physical activity (TPA) behaviours for adults who commute to place of work/study in AFES sample.	North Shore city white pages; 88-item instrument based on Obstacles to Action survey with TPA component, 2000 adults (31% response rate) – three self-report surveys using adult samples: 1) obstacle to action survey – analysing ability to replace two car trips, 2) n=30 - testing validity/reliability of 19 Q survey on barriers, perception, behaviours related to TPA, 3) telephone survey of 2000 NS adult residents – 88 items.	n/a	How do you usually get to and from your place of work or study? Answers collapsed to three mode categories: motorised, TPA, transit/combined, if not TPA 'do you think that you could access your place of work/study by travelling on foot or cycling?'. Urban design measures: commute route, residential density, mixed land use, street connectivity.	Respondents who lived closer to their place of employment were most likely to actually engage in TPA for commuting. As commute distance increases, respondents less likely to recognise they could or actually employ TPA to access work. More likely to w/c if the modelled route was through a well-connected street network – between 2–5km, 56% of respondents perceived they could access work by TPA; only 9% did so.		Fundamental Q re commute is flawed, as people are categorised by 'usually' (despite asking QAT18 – how often do you walk, run, or cycle to or from your worksite or place of study? (daily, at least once a week, once a week, etc).
Bhat, CR and JY Guo (2006) A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels. Center for Transportation Research, University of Texas at Austin.	To examine the impact of the BE, transportation network attributes, and demographic characteristics on residential choice and car ownership decisions. Model formulation takes the form of a joint mixed multinomial logit response structure that a) accommodates differential sensitivity to the BE and transportation network variables due to both demographic and unobserved HH attributes and b) controls for the self-selection of individuals into NHDs based on own preferences.	Primary data source used in the analysis is the 2000 San Francisco Bay Area Travel Survey (BATS); six other data sets associated with the San Francisco Bay area were used in the current analysis: land-use/demographic coverage data, zone-to-zone travel level-of-service data, a GIS layer of bicycle facilities, the Census 2000 Tiger files, and the Census 2000 Population and Housing Data Summary Files. Geographic area of study in this research is the Alameda County in the San Francisco Bay Area with 233 transport analysis zones.	1) HH with senior adults stay away from high density areas and have a high preference for cars (relative to HH with small children and no senior adults), 2) HH with low income earnings choose to (or are constrained to) locate in NHD with long drive commutes, low drive commute costs, and high ED, and own fewer cars; and 3) single individual HH have a strong preference to locate in areas with high street block density and also own fewer vehicles; a transportation policy to increase street block density would draw a large fraction of single individuals into the NHD. These single individuals are, by nature, also likely to own fewer cars.	HH demographics; avg HH size, HH income, and housing cost in each zone, times and costs by each of the drive and transit modes. Land-use composition measures (percentages of zonal area in residential, commercial and other land uses), housing type measures (fractions of single family, multifamily, duplex and other housing units) and a land-use mix diversity index computed from the land-use composition measures; size of the zone (population, number of housing units, etc) and the density of the zone (# of HH per acre, employment per acre by sector, etc); the number of basic employees, number of retail employees and vacant land acreage, respectively, in zone j.	HH without seniors locate in zones with high HH density, perhaps due to better housing availability in these zones or simply due to population clustering. However, HH with seniors shy away from high housing density developments. The effect of total ED indicates middle and high income HH (HH not in the lowest income quartile) prefer zones with a low ED, while low income HHs are indifferent to ED in their residential choices. Among the zonal land-use structure variables, the results indicate HH with no senior adults tend to stay away from zones with a high fraction of land invested in residential land use, though the reverse holds for HH with senior adults. Further, HH who live in	HH, in general, locate to reduce drive commute time; high income HH, in particular, reside closer to work place, perhaps can afford housing at locations close to work; low income HH locate in zones with low driving costs to work; multiple individual HH are less likely to locate in areas with high street block D, while single individual HH prefer such NHD; when the local transportation network measures are removed, there is negative and strongly significant effects of HH and ED on vown (as obtained in earlier vown studies); high vown among HH whose members have long drive commute time, and low vown among HH whose members have high drive commute cost; about 23% of HH respond to increase	1) Measurement errors in accessibility indices and other BE measures (that is, the measurement errors on these attributes are so large they swamp correlations in residential choice and car ownership propensity due to common unobserved sensitivity effects to these attributes) and/or the 2) non-inclusion of important NHD measures actually considered by households (even though we have made a concerted effort in this research to include a comprehensive set of NHD measures based on data we were able to assemble).

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
					single-family detached housing are drawn to zones with a large share of single family housing units, as one would expect. Interestingly, land-use mix diversity does not influence residential location after controlling for other variables.	in street block D by increasing vown; in context of vown decisions, both HH demographics and BE characteristics are influential; however, HH demographics have > effect. Other demographic factors that impact residential sorting based on vown preferences are presence of senior adults in HH and whether or not a person lives alone.	
Cao, XY (2007) Is alternative development undersupplied? An examination of residential preferences and choices of Northern California movers. *TRB 08-0216*	Self-administered 12 page survey mailed in two rounds in late 2003 to HHs in eight NHD in Northern California. The NHDs were selected to vary systematically on three dimensions: NHD type, size of the metropolitan area and region of the state. Random sample of 500 'movers' residents and 500 non-movers for each NHD. Original database consisted of 8000 addresses but only 6746 valid addresses. The number of responses totalled 1682, for a response rate of 24.5%.	Focused on 594 recent movers only, 'it is unclear whether this sample represents general movers because census data on recent movers are unavailable. Therefore, the results should be interpreted with caution'. (p5)		Variables used in this study include three groups: perceptions of NHD characteristics, preferences for neighbourhood characteristics, and demographics.	Residential preferences measured on 4-point scale: affordable living unit, safe NHD for walking, and low crime rate within NHD are still the three most important characteristics for both home owners and renters – closeness to workplace = highest accessibility to transport system attribute (8th); access to regional shopping mall = lowest; accessibility >important to renters; individuals without a driver licence are more likely to favour good transit service, while those with a driver licence tend to prefer easy access to freeways. Car ownership is negatively associated with preferences for various attributes including transit service, complete sidewalks, bike routes, access to the workplace and to a regional mall. In other words, those who own fewer vehicles are more likely to prefer high accessible living.	Children affected preferences: <age 5 – parks and open spaces; <18 – prefer complete sidewalks, pool and community centre; the share of movers who perceived that the attributes of their NHDs do not meet their preferences (ie the perception of an attribute is smaller than the preference for the attribute); this study suggests if there is an unmet demand for pedestrian- and transit-oriented development, it is not likely to be large and may mostly exist in some niche market.	Measuring residential preferences retrospectively is subject to recall error and memory bias, the latter occurring, eg if individuals' preferences are influenced by their perceptions of the chosen environment to which they moved. Tried to minimise these errors in several ways: measured the residential preferences of recent movers - those who changed their residential location within a year; the measurement of preferences is on a 4-point scale, presumably more reliable than a 5-point or 7-point scale; in the survey, reminded respondents that were asking for their preferences when they were looking for a place to live, and measured their preferences before measuring their perceptions to reduce the influence of the latter on the former. Although this study distinguished home renters and owners, future research should investigate the

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
							preferences and disparities based on various segments (such as the elderly vs the younger and HHs with children vs HH without children).
Cao, XY et al (2005a) The influences of the built environment and residential self-selection on pedestrian behavior. TRB 2005 Annual Meeting CD-ROM.	Explore the role of the built environment and residential self-selection in walking for its own sake (strolling) and walking for utilitarian purposes (to the store); does not establish a causal relationship. Asks 1) Is residential self-selection important in explaining differences in pedestrian behaviour? 2) Do built environment elements affect strolling trips and pedestrian shopping trips in different ways?	Six middle-income NHD in the Austin, TX area were selected based on their development era. Data came from a self-administered survey evenly mailed in late May 1995 to 6000 randomly selected HH in these six NHDs. Ultimately, 1368 surveys were completed and returned by a random adult member in the HH, for a 23% response rate.	Negative binomial regression was used to analyse the relationship of built environment variables, the self-selection variable, and socio-demographic characteristics with both strolling frequency and the frequency of walking to the store; NHD characteristics: analysis of GIS databases, hardcopy maps, aerial photos, and data collected through site visits, were used.	Dependent variables: freq for strolling and for walking to the store in last 30 days; explanatory variables: NHD characteristics (objective assessments as well as respondents' perceptions about the NHD), residential preference, and demographics. The relative importance of a variety of factors potentially influencing their choice of NHD, on a 5-point scale from 'not at all important' to 'extremely important'. Factors include affordability of living unit, quality of living unit, quality of schools, investment potential, stores within walking distance, attractiveness of NHD, level of upkeep in NHD, close to work, and close to friends and family.	Individuals rating stores within walking distance as more important in their decision to live in their current NHD – stroll more frequently; having a pet to walk is the most imp factor affecting the frequency of strolling trips, each BE factor provides a moderate contribution to inducing strolling trips; higher traffic volume in the commercial streets tends to reduce pedestrian trips; providing connections for pedestrians between the street and stores encourages pedestrian shopping trips; distance to nearest store is highly significant in predicting frequency of walking to the store; respondents who have children (under 5 years old), and are women, older, richer and full-time workers tend to walk to the store less frequently than others.		Any response rate <100% c/b non-response bias, or the possibility the individuals who respond to the survey are systematically different from those who choose not to respond; most objective characteristics of the BE were measured at the NHD level and may not be accurate indicators of the BE in the immediate vicinity of each respondent; limited measures available of residential preferences regarding travel impede our understanding of their influence on pedestrian behaviour. Other potentially relevant variables were also not captured, such as attitudes toward physical exercise, time spent on other forms of PA, and relevant personality characteristics.
Cao, XY et al (2005b) The impacts of the built environment and residential self-selection on nonwork travel: a seemingly unrelated regression approach.	As above; to investigate the causal relationship between residential NHD characteristics and home-based non-work travel, controlling for travel and residential attitudes and relaxing the independence assumption. Asks: 1) What aspects of NHD characteristics influence individuals' decisions on non-work travel? 2) Does RSS (as measured by	Six middle-income NHD in the Austin, TX area were selected based on their development era. Data came from a self-administered survey evenly mailed in late May 1995 to 6000 randomly selected HH in these six NHDs. Ultimately, 1368 surveys were completed and returned by a random adult member in the HH, for a 23% response rate.	As above; applied the seemingly unrelated regression equations (SURE) model. The estimation approach is generalised least squares (GLS).	Dependent variables are the frequencies of home-based non-work trip by auto, walking/biking and transit, respectively to selected destinations (details of how data collected under 'methods' worksheet); explanatory variables in four groups: NHD characteristics, NHD preferences, travel attitudes (32 statements on a 5-point scale from 1 ('strongly disagree') to 5	The number of business types within 400m of the residence is negatively associated with auto trip frequency and positively associated with non-motorised trip frequency, and the number of business types within 800m positively impacts transit trip frequency; the perception of physical activity options offered by the NHD		Residential NHD characteristics may be a good predictor for non-motorised travel, but the absence of specific destinations characteristics visited by the respondents may constrain the understanding of the relationship between the BE and auto travel. The nonwork travel analysed is not comprehensive, and the retrospective trip

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
	attitudinal factors) impact individuals' nwk travel choices? 3) If there is an apparent influence of the BE on nonwork travel choice, does RSS account for all of it? 4) Is the assumption of independent error terms valid?			('strongly agree'), and socio-demographics (include gender, age, employment status, educational background, HH income, HH size, the number of children in the HH, mobility constraints, residential tenure).	positively affects individuals' walking/ biking travel; perceived socialising and attractiveness of residential NHDs are positively associated with walking/biking trip frequency. Those who prefer living in a quiet and safe place tend to make more auto trips; preference for good PT service is positively associated with transit trip frequency; preferences for accessibility, physical activity options and outdoor spaciousness significantly influence W/C travel choice. Individuals valuing automobiles as a safe mode are less likely to choose non-motorised modes.		frequencies obtained are not exact numbers but approximates.
Cervero, R (2007) Transit-oriented development's ridership bonus: a product of self-selection and public policies.	Cross-sectional	The analyses draw upon a database of travel (one day travel diary) and other attributes of nearly 1000 residents living in 26 housing projects within a half mile of California urban rail stations who were surveyed in 2003.	Data on socio-demographic, NHD and travel attributes of surveyed TOD residents in California, along with isochronic job-accessibility measures, were combined to estimate mode-choice models. The survey of TOD residents in California compiled commuting data not only for their current locations but also their prior (ie non-TOD) residences. Interviewees were asked how they typically got to work from their previous residence. (Only individuals who did not previously live in a TOD and whose workplace addresses did not change before and after the move were included in the	Travel time and patterns (comparative time for travel on highway vs transit network; presence of trip chaining); job accessibility; workplace policies (flex time; free parking; employer helps with car expenses; connectivity; auto-ownership; levels; access to transit a top factor in choosing residential location.	Workplace variables were generally most influential particularly the availability of flex-time (generally a PT inducement) and employer-provided free parking and car allowances (PT deterrents). Most influential single variable was availability of flex-time at the workplace. 'Before-and-after' findings for 226 survey respondents: TOD residency clearly enhanced accessibility while reducing motorised travel. Based on cumulative counts of jobs within 30 mins travel time (PM peak over highway and transit networks), moving from a non-TOD to a TOD location increasing job	Planners can influence the densities and designs of NHD around rail stations through zoning; however, these and other land-use attributes of station areas did not enter the models as significant predictors. probabilities of rail commuting are very high among all groups when the worker lives in a zero-car household. Adding one car results in probabilities plummeting; they fall most precipitously for those residing and working away from stations. Working near transit and having no cars means there is a very high likelihood, well over 80% of rail commuting for both	Also published as: Lund, H et al (2004) Travel characteristics of transit-focused development in California Bay Area Rapid Transit District and California Department of Transportation, Oaklands, CA.

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
			analysis.)		accessibility, on avg, by 6.5%. Mean commute times went down, in spite of many residents switching to transit modes, in part because of reduced walk access time associated with TOD living. And because of mode shifts from driving to PT usage, the avg mode-adjusted VMT plummeted 42% once people moved to TODs. Est avg daily dollar outlays for getting to and from work fell largely because workers switched from private cars to PT. PT-ridership benefits of PT-based housing come from those with fewer than two cars in the household.	groups. This indicates the transit-ridership benefits of transit-based housing come from those with relatively fewer than two cars in the household.	
Cervero R and J Murakami (2010) Effects of built environments on vehicle miles traveled: evidence from 370 U.S. metropolitan areas.	Do built-environment variables, notably density and destination accessibility, significantly influence VMT per capita, controlling for other predictors, and if so, what is the relative magnitude of influences? Uses structural equation modelling.	VMT data obtained from Highway Statistics, published annually by the Federal Highway Administration were matched with the 2000 census and other data sources; however, geographical inconsistencies across sources forced us to drop 30 cases, resulting in a database with 370 urbanised area observations.		VMT/capita; % commute trips by car; rail passenger miles/capita; road and rail infrastructure density; pop density; employment density; retail density; mean job density (# of jobs in 30 min travel time); mean retail density.	Doubling population density is associated with a 60% decline in VMT per capita. Negative direct effect is offset by positive indirect effects (22%), yielding a net or total, elasticity of -0.381. positive indirect effects: areas with higher population densities tend to also have higher road infrastructure densities, a factor which induces travel and the influences of population density on local retail accessibility and urbanised area size. Dense urban sets tend to enjoy relatively high retail accessibility which, correlates with high VMT/capita. The other positive indirect effects are fairly moderate in size, reflecting influences of basic job access and HH income and local retail density.	We believe for the most part, population density functioned as a surrogate, at least in part, of the other Ds of the built environment, namely designs that are pedestrian friendly and diverse land uses.	

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
Chatman, DG (2005) How the built environment influences non-work travel: theoretical and empirical essays. Dissertation.	Chapter 4: Survey: asked for 24-hour trip/activity diary also Q about moving (didn't matter how long before moving had occurred) 'What were some of the things you looked for?' (+probes) - if their own or another adult's commute or child's commute were prioritised, follow up Q on mode preference. Asks: 1) What share of HH considers non-work access or other kinds of travel access when choosing where to live? 2) Do HH that report seeking access to shops and services, or access for other kinds of purposes, find NHD with higher access than those who do not report doing so? 3) Do respondents with and w/o strong pre-existing travel preference travel differently?	Do any differences appear likely to confound estimates of the effects of BE characteristics on travel in empirical research? A computer-aided telephone survey was administered between November 2003 and April 2004 to a stratified random sample of households living in the San Diego metropolitan area and in the three core counties of the San Francisco-Oakland-San Jose metropolitan area; N=999.	Survey included questions about what respondents considered when choosing their current NHDs, based in part on questions on the Los Angeles Family and Neighborhood Survey; negative binomial model.	Three dependent variables: no. of non-work trips by auto (including motorcycles and carpools), transit (bus or rail), and walk/bike. Respondents' answers to the residential location Q and follow-up Qs about specific modes were used to create dummy variables set equal to one, and otherwise to zero; BE measures consisted of no. of retail workers within a 1/4 mile and a 1-mile radius; residents per road mile within 1-mile; four-way street intersections within 1/4-mile, presence of heavy rail station within 1/2-mile, presence of light rail station within 1/2-mile; distance to the nearest major CBD; and sidewalk on both sides of the street; demographics: HH inc, inc2, children present, paid work, survey day = weekday.	HH seeking good walk or bike access to retail find NHD with an average of 1020 more retail workers in the quarter mile area near home (a one-SD increase in activity density); HH seeking auto access for any purpose find areas with 130 fewer residents per road mile in the mile radius near home (a 1/2-standard-deviation decrease in network load density, implying slightly higher auto speeds); and those seeking transit access to shops or services live an average of 9635 feet (about 1.8 miles) closer to a rail stop; low crime, access to shops and services, access to transit are 3 most common sought-after NHD characteristic; >50% wanted travel access of some kind when choosing NHD; strong relationships between the NHD search criteria and the frequency of non-work trip making by mode. HH seeking walking and bike access for any purpose make only about half as many auto trips as the base group , and those seeking the same type of modal access for shops and services make about 60% as many, while those who sought both auto and transit access for any travel purpose make about 40 % more auto trips.	Apparently preferences play a relatively limited role in determining the choice of residential location over the BE variables of interest. This is not surprising given good reasons to expect poor matches between non-work travel preferences and BE characteristics of the NHD. While interactive effects in the single-equation trip models are less clear and are statistically insignificant across the board, members of mode-preferring subgroups seem to be less sensitive to BE variables. That is, the group with weaker preferences – the 'non-self-selecting' group – may account for some BE and travel relationships because it is larger and more responsive to differences in the BE. Conclusion: Regardless of pre-existing preferences for walking and transit, people make travel choices based on BE characteristics, particularly those affecting auto convenience. (p 169)	(Also article in *Environment & Planning A 2009*).
Chatman, DG (2005) How the built	Chapter 3 presents the lit review and results of an	1-day travel diary and GIS 'straight line distances' –		Built form density (total workers and residents per	Strong evidence that heterogeneous preference	Ch 3: residential network load D may increase auto	KML concluded 'land use policies promoting

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
environment influences non-work travel: theoretical and empirical essays. Dissertation. (cont.)	investigation into the effects of density on non-work travel	collected from 1114 adults in San Francisco area		developed acre); activity density (retail workers per one mile radius; service workers per 1-mile radius); network load density (the number of local users, and/or the prevalence of trip-generating land uses, divided by network capacity).	for travel by diff modes, combined with residential sorting, explains much variation in HH travel for non-work purposes. HH do consider non-work accessibility by different modes when they decide where to live, and they successfully obtain such accuracy at a higher rate than HH who do not report considering such criteria. Reported travel preferences are also highly significant predictors of travel. However, confounding effects of preferences in estimating the relationship of travel choices to respondent's NHD BE are surprisingly small in comparison to the conclusions of previous studies. Found RSS problem is relatively minor, at least with respect to the relationship between the BE and non-work travel. (p113) due to tradeoffs between various functional needs satisfied primarily through housing and residential location choice compounded by multiple HH members there may often be a weak match between characteristics of the chosen NHD and HH preference for proximity to both work and non-work activities. RSS, particularly with respect to BE-related non-work travel accessibility, is likely imperfect. (p118)	trip length, at the same time it reduces auto trip freq – perhaps by driving people, when they do use their cars, out of local area to further-away locations with better parking access if locally slow speeds could be correlated with reduced parking at local establishments. An increase in the time cost of local trips via auto due to parking search and walking access to and from parking has a theoretically ambiguous effect on auto mileage and auto trips. It could increase alternative mode use, increase the length of auto trips while not reducing their number, or reduce the number of auto trips, or any combination of these. Activity D, built form D, and network load D are not always highly correlated. Thus a development policy of 'densification' can bring activities nearer to residences without increasing the time price of auto use. But if road design standards are relaxed, network load D also increases and therefore road speeds decrease and there is a chance that auto use will decline.	higher densities and mixtures may not alter travel demand materially unless residents' attitudes are also changed'. (125, abstract).
Falconer, R et al (2008) Living on the edge - transport sustainability in Perth's liveable	Perth implemented the 'Liveable neighbourhoods' (LN) design code in the late 1990s – key transport-	46 of RESIDE's 74 NHDs were represented in the study, 11 of which were liveable and 35 conventional; travel	The data included perceptions of access to local facilities, the walkability of the local street network and	Access to key destinations; work trip substitutability; network permeability; residential lot density – 'The	No differences in average daily VKT; LN: fewer car driver trips (72% compared with 81%) and more walking	Describes Holtzclaw's (1994, p15) neighbourhood shopping index (NSI) measured 'the fraction of the	

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
neighbourhoods.	related intentions: · Street networks to be more permeable to reduce trip lengths · NHD to be more mixed use and dense to improve access, with services being anchor-points for the community · PT services to be more accessible · NHD to be more self-sufficient, with there being greater opportunity for local trips.	survey – 211 people from 103 HH; perceptual survey: 996 people completed first follow up in 2006.	walking distances to the nearest key destinations: 1) Socio-demographic data were also obtained from the main study.	principal reason for calculating residential lot density rather than population density was that census data, which is organised according to census collection districts (CCDs), could not be matched with households in the study NHDs because the CCDs and NHDs had different boundaries' Holtzclaw's (1994: p15) neighbourhood shopping index (NSI) measured 'the fraction of the community's population which has five critical local commercial establishments within ¼ mile [402m] walking distance'. Local shopping, post, daycare, newsagent, medical (doctor or chemist), PT stop.	(21% compared with 12%. The perception study found virtually no differences in people's perceptions of access, their local street networks or distances to key destinations, including shops, news agencies, childcare, medical facilities, postal facilities and public transport stops; better in LN – distances to daily shopping, news agency; childcare, PT stop, etc. Also basic travel patterns (trip mode, single occupancy vehicle trips, vown, trip length, short trips, daily VKT, daily reported active transport (minutes), density > in LN, but not enough to contribute to transport sustainability. 16.67 lots per site hectare and 8.81 lots per urban hectare in the study LNs are 24% and 41% below the respective lower targets of 22 dwellings per site hectare and 15 dwellings per urban hectare, with higher densities in strategic areas.	community's population which has five critical local commercial establishments within ¼ mile [402m] walking distance'. (Falconer et al used 6); access to a range of facilities, most notably local shopping was much better in conventional NHDs than LNs; LN had more SOV trips (49% compared with 41%); more transport-related PA (20 mins compared with 12) but other PA not controlled; permeability better in LN, but access to destinations better in conventional NHDs; no significant difference in land use between LN & conventional NHDs, leading to lack of significant differences in transport patterns.	
Chapman, J and L Frank L (2004) Integrating travel behavior and urban form data to address transportation and air;quality problems in Atlanta.	Regional activity-based household travel survey instrument; PA survey; survey on market demand for 'smart development', GIS land-use database.	8000 households Atlanta region – stratified to cover areas of different densities well.	None		The mean number of person trips per day varies little over the entire range of RD (3.8 to 3.9 trips per person per day). Yet VMT is from 25% to 33% lower for households in densities above four housing units per acre as compared with those in the lowest density range (0–2 housing units per acre). For daily person minutes of	Walking frequency varied positively with increased NHD net residential density. The net RD of the 81.5% of respondents who walk at least once per week is 4.9 housing units/net-residential acre, compared with a density of 10.2 for the 7.3% of the sample who are daily walkers.	

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
					travel, the comparable results are from 25% to 31% fewer person minutes of travel. Average daily trip rate of walkers increased with increasing net RD, ranging from 1.8 to 2.3 trips per day per person reporting one or more walk trips. Cyclists and walkers have no household vehicles, and fewer multiple vehicles. Walkers more often own a single vehicle. The mean # of daily PT trips per person increase from 11% to 21 % as residential density exceeds four units per acre when compared with those living in the lowest density level.		
Frank, LD et al (2007) Stepping towards causation: Do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity?	Cross-sectional CATI – exploring how factors influencing NHD selection and NHD preferences influence the observed association between BE and walking for non-discretionary (transport) or discretionary (leisure) purposes, vehicle miles travelled and obesity. A significant proportion of the population are mismatched and do not live in their preferred NHD type.	Separate analyses were conducted among 2056 persons in the Atlanta, USA based Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality (SMARTRAQ) travel survey on selection factors and 1466 persons in the SMARTRAQ community preference sub-survey.	The Neighborhood Selection Sample provided responses to a Neighborhood Selection Questionnaire administered via CATI. Eligibility for participation in this sub-survey included being an adult head of household, a renter or owner, and to have moved within the past 3 years. The Neighborhood Preference Sample is based on a more in-depth standalone sub-survey on community preferences.	Socio demographic characteristics including body mass index & HH income, size, number of household vehicles, no. of licensed drivers, 2 day trip diary – discretionary = rec walking vs non-discretionary = transport to school/work/eat/ shop; BE measures – commercial floor area ratio, mixed land use, net residential density, connectivity – walkability index derived. 10 item NHD selection – reasons for moving to one's NHD.	Individuals who preferred and lived in a walkable NHD walked most (33.9%) and drove 25.8 miles per day on average. Individuals who preferred and lived in car dependent NHDs drove the most (43 miles per day) and walked the least (3.3%). Individuals who did not prefer a walkable environment walked little and show no change in obesity prevalence regardless of where they lived. Therefore, promoting physical activity by living in a walkable environment was not likely to be a sufficiently effective intervention for this segment of the population. Preference – adjusted odds of walking, at the 90% confidence level, in the most walkable,	Participants drove less when located in more walkable environments regardless of their demographic characteristics, the importance of the selection factors tested, and preferences for NHD type.	These findings are limited by being cross-sectional. A more potent design would experimentally isolate BE effects, perhaps through examining changes in TB among individuals moving from one type of BE to another, although whether an individual would retain NHD attitudes and preferences across such a move is unknown; there are likely many factors that influence NHD selection and preference not measured in the present study, including availability, cost and other NHD characteristics.

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
					compared with the least walkable parts of the Atlanta region, were: 1.62 (for any purpose); 1.72 (for non-discretionary travel); and 2.14 times (for discretionary travel).		
Frank, LD et al (2005) Linking objectively measured physical activity with objectively measured urban form findings from SMARTRAQ.	To assess how objectively measured levels of physical activity are related with objectively measured aspects of the physical environment around each participant's home while controlling for socio-demographic covariates.	Metropolitan Atlanta – 523 people recruited from higher (6 dwellings per residential acre) and lower (4 per residential acre) density; data collected between 2001 and 2003 – 357 completed accelerometer data.	Objective measures of the BE unique to each household's physical location were developed within a GIS to assess land-use mix, residential density, and street connectivity. These measures were then combined into a Walkability Index. Accelerometers were deployed over a 2-day period to capture objective levels of physical activity in 357 adults.	Measures of land-use mix, residential density, and intersection density were positively related with number of minutes of moderate PA per day. A combined Walkability Index of these UF factors was significant (p 0.002) and explained additional variation in the number of minutes of moderate activity per day over socio-demographic covariates. 37% in the highest Walkability Index quartile met the 30 minutes of PA recommended, compared with only 18% in the lowest walkability quartile. Individuals in the highest walkability quartile were 2.4 times more likely (confidence interval 1.18–4.88) than individuals in the lowest walkability quartile to meet the recommended 30 minutes of moderate PA per day.	The results indicate that when people have many destinations near their homes and can get there in a direct pathway, they are more likely to engage in moderate physical activity for 30 minutes on a random day.	Urban form measures described – net residential density (housing units per residential acre); street connectivity (intersections per km2) land use mix – then weighted.	The Atlanta region has limited variability in land use, but oversampling in more 'walkable' areas enhanced variability. In addition, this cross-sectional study design does not allow us to account for potential effects of SS or attitudinal predeterminants of community choice, or the choice to walk; limited accelerometer use; mostly white participants; seasonal variability.
Goldberg, D et al (2007) New data for a new era - a summary of the SMARTRAQ findings - linking land use, transportation, air quality and health in the Atlanta Region.	Regional activity-based household travel survey instrument; PA survey; survey on market demand for 'smart development'; GIS land use database.	8000 households Atlanta region – stratified to cover areas of different densities well.	None		People who live in NHDs with the lowest walkability, drive an average of 39 miles per person each weekday, 30% more than those who live in areas with the highest walkability. The difference for weekend travel was even greater. On average, residents in the most walkable NHD drive about 40% less on the weekend than their	In all, about a third of metro Atlantans living in conventional suburban development would prefer a more walkable environment, but apparently traded it off for other reasons such as affordability, school quality or perception of crime. 49% said they would prefer a NHD where residents could walk to nearby shopping.	

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
					counterparts in low-walkability NHD. People in closer-in, high-walkability NHDs take more trips by cycling, walking or transit.	55% of respondents would prefer to live in a community that afforded shorter travel distances to work, even if it meant smaller residential lots.	
Handy, S et al (2005) Correlation or causality between the built environment and travel behavior? Evidence from Northern California.	Multivariate analysis of cross-sectional data plus a quasi-longitudinal analysis of changes in travel behaviour and changes in the BE.	Self-administered 12-page survey mailed in two rounds in late 2003 to HHs in eight NHD in Northern California. The NHDs were selected to vary systematically on three dimensions: NHD type, size of the metropolitan area and region of the state. Random sample of 500 'movers' residents and 500 non-movers for each NHD. Original database consisted of 8000 addresses but only 6746 valid addresses. The number of responses totalled 1682, for a response rate of 24.5%.	Mail out, mail back survey completed by any adult HH member who shares in the decision making and who participated in selecting current residence.	Dependent variable: estimated vehicle miles driven; change in TB from either just before the move (for the movers) or from 1 year ago (for the non-movers) was measured using 5-point scales. The explanatory variables are classified into: NHD characteristics and NHD preferences. Respondents were asked to indicate how true 34 characteristics were for their current and previous (only for movers) NHD on a 4-point scale from 1 ('not at all true') to 4 ('entirely true'). The importance of these items to respondents when/if they were looking for a new place to live was also measured on a 4-point scale from 1 ('not at all important') to 4 ('extremely important'). 32 statements for travel attitude; socio-demographic data collected.	Vehicle miles driven by the respondent per week is 18% higher for residents of suburban NHDs than for residents of traditional NHDs.	Because of the skewed distribution of VMD, the natural log of VMD was used as the dependent variable and the model was estimated using ordinary least squares regression. Potential explanatory variables were entered into the model in groups, starting with socio-demographic factors, followed by travel attitudes and preferences for NHD characteristics, then perceived NHD characteristics and accessibility measures. The factor for car dependent attitude had the highest standardised coefficient. Other attitudes were also significant: pro-bike/walk and pro-transit attitudes were negatively associated with driving, and the safety of car attitude and a preference for outdoor spaciousness were positively associated with driving. With these attitudes accounted for, no measures of the actual BE – neither accessibility measures nor perceived characteristics – were significant.	These results highlight the limitations of previous studies that mostly rely on cross-sectional analyses and rarely account for attitudes and preferences – but also suggest that despite these limitations their conclusions are not entirely off the mark. Results of the change model are predicated on the assumption that attitudes (those unmeasured as well as measured) remained constant over time and hence are controlled for.
Handy, S et al (2006) Self-selection in the relationship between the built environment and walking - empirical evidence from	To examine the association between changes in the BE and changes in walking and cycling. Quasi-experimental (2+); simple comparisons of	Neighbourhood community members, Northern California, USA. N=1672 across 8 NHDs, selected to vary systematically: NHD type, size of the metropolitan	In 8 NHDs 1000 residents were targeted; 500 who had recently moved and 500 who had not. Intervention was defined as residents who move from one NHD to	Change in walking and change in biking. Walking was measured in two ways: the number of times residents walked to the store in the previous 30 days, & number of	Estimated relationship between change in BE and change in walking using ordered probit model. Significant variables ($p<0.05$) were: change in walking:	None reported.	Possible selection bias. Possible recall bias; did not measure total levels of physical activity and thus cannot be certain that higher levels of walking are associated

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
northern California.	walking behaviour for traditional and suburban NHDs, cross-sectional multivariate analysis, and quasi-longitudinal multivariate analysis.	area, and region of the state; 34 items on BE – 'perceived NHD characteristics' – objective means of accessibility – distance to various locations.	another; mailout mailback survey, series of reminders.	times respondents strolled around the NHD in the last 30 days; change in W/C) (including walking to the store and strolling as well as other walking in NHD) either from just before the move (for the movers) or from one year ago (for the non-movers) was measured on a 5-point ordinal scale anchored by the categories 'a lot less' & 'a lot more' now; telephone survey.	attractiveness (+ve), number of banks within 800m (+ve), number of types of businesses within 1600m (+ve), spaciousness (-ve). Change in biking: +ve attitude towards biking and walking is most important in explaining changes in biking, but that changes in the BE also contribute.		with higher total levels of physical activity.
Handy, SL and KJ Clifton (2001) Local shopping as a strategy for reducing automobile travel.	Mailout survey; focus groups - address two sets of questions. First, to what degree do residents choose local shopping over more distant opportunities and why? What are the implications for vehicle travel? Second, to what degree do residents choose to walk rather than drive to local shopping and why? What are the implications for vehicle travel?	6 NHD in Texas; N=1368.	Not relevant.	# of walking trips in past 30 days; # of retail outlets within 0.5 mile radius.	In one NHD where 256 stores were located within 0.5 miles radius, 79% of respondents had walked to the store at least once in the past 30 days. However, this result is not consistent: in three other NHD where between 174 and 238 stores were located within 0.5 mile radius – only 39%–48% of respondents had walked to the store at least once in the past 30 days. More markedly, in two NHD with 40 and 55 shops located within a 0.5 mile radius, only 21% and 22% had done the same amount of walking trips	The results of this exploration suggest local shopping will not prove a particularly effective strategy for reducing automobile dependence in the typical US city by either reducing travel distances or encouraging alternative modes of travel. Residents of such places choose more distant stores enough of the time that they increase total driving significantly, and they do not choose alternative modes enough of the time that they reduce total driving significantly.	But while local shopping may not do much to reduce driving it does give residents the option to drive less and this option is something residents clearly value. Local shopping does not show great promise as a strategy for reducing automobile use, but it does show promise as a strategy for enhancing quality of life in NHDs, at least partly by making driving once again a matter of choice.
Lee, C and AV Moudon (2006) Correlates of walking for transportation or recreation purposes.	Survey questions were grouped into nine sections including walking, biking, transit use, physical activity, NHD perception, attitude toward environment and transportation, HH characteristics, demographics and a short section for those initially refusing to respond. The short section included seven	Cross-sectional CATI study used a survey of 438 adults in Seattle and objective environmental measures (developed with GIS data). Multinomial logit models estimated the odds of walking for recreation or transportation purposes.	None		The closer respondents were to a grocery store, restaurant, post office, or bank, the more likely they were to walk for transport purposes. This means these destinations are associated with walking-supportive environments, not that people actually walked to them. Higher parcel-level density was	Both socio-demographic and physical environmental variables had a stronger association with transportation walking than with recreation walking.	

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
	questions asking if they have difficulty in walking (5-point Likert scale), if they walk and bike in a usual week, if they own a bike, and basic demographic information including age, race and income ranges.				positively associated with the odds of walking frequently for transportation, relative to not walking. Neither the parcel-level density nor the area-level density was significant for recreational walking. Route-related variables, such as block size, traffic volume, sidewalk and street trees, did not show a statistically significant association with transportation walking; but longer sidewalks was positively assoc with recreation walking.		
Lund, H (2001) Local accessibility, pedestrian travel and neighbouring: Testing the claims of new urbanism.	Surveyed households in eight NHDs (n=499; 34% response rate to mailout/mailback survey) – hypothesis: walk trip frequency & neighbouring behaviours will be highest in NHD with access to local parks & retail & lowest in NHD with no local amenities.	In Portland Oregon considered to be walkable and compact. All had similar densities, with varying amenities: two had access to a local park and shopping area; two had access to a local park only; two to a local shopping area only and two had no access to either.	Questionnaire (developed by Handy in 1996) asked respondents what they would have done if they had not been able to walk on their last pedestrian trip. Across all NHD accessibility types, respondents were most likely (by far) to have 'driven to the same place' if not walked. The second choice, again across all accessibility types, also involved driving, but these respondents would have driven to a different place. These findings strongly support the notion that pedestrian trips are in fact replacing automobile trips.	Frequency of strolling & destination walk trips; frequency of unplanned interactions among neighbours; weak social ties (# of acquaintances one has within close proximity of home); supportive acts of neighbouring – independent variables: socio-demographic; attitudinal, objective and subjective physical variables, behavioural variables.	Analyses of covariance showed, controlling for correlated socio-demographic characteristics, attitudes toward the importance of walking to daily activities varied significantly across NHD accessibility types ($F[3, 473]=7.65$, $p<.01$). Respondents from retail-accessible NHD (with or without park accessibility) placed significantly higher levels of importance on walking than respondents from NHD with no/few local amenities. # of destination trips made per week linked to importance placed on walking to destination & living in NHD with retail access.	Frequency of strolling trips – regression model does not adequately explain variations in the decision to stroll through NHD – only 11% of variation is explained by importance individual places on walking to daily activities & identifying oneself as a homemaker – less significance: perceptions of walking in NHD (+ve); retail access only (-ve); presence of children 5–12 (-ve). Top two reasons for walking: 1) exercise/fresh air/relaxation, 2) walk children or dogs.	The existence of support cannot be conclusive as cannot determine whether these attitudes formed before or after moving into NHD
Pikora, T et al (2006) The impact of urban design on walking and cycling: the RESIDE Project.	Residential Environment (RESIDE) project is a 5-year longitudinal, prospective study designed to examine the impact of elements of	1803 people in Perth building homes in new housing estates were invited to participate in the study and the sample included 24 LN estates	Baseline data was collected before study participants moved into their new homes, and follow-up surveys will take place at one and		At baseline, few significant differences between the potential LN residents and others ($p>0.05$). Overall, 60% were female, mean age		

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
	urban design on walking for recreation and transport, evaluate the effect of the LN planning guidelines aimed at increasing walking, cycling and public transport use. Follow up at 1 and 3 years.	and 14 hybrid estates (ie housing estates incorporating many of the LN principles).	three years after they move in. Factors influencing choice of NHD were collected at baseline. In all three surveys, recreational and transport-related walking and cycling undertaken both inside and outside the NHD is measured and a pedometer is worn for 7 days.		40 years (SD 12), 82% worked, 45% worked 38 or more hours/week and 18% spent one hour or more travelling to & from work. 53% reported usually walking for recreation in their NHD, but only 36% usually walked for tpt locally. On average, study participants reported having only 6.3 tpt-related destinations within a 15 minute walk from their home. When asked what factors influenced choice of housing estate, the most important reasons cited related to affordability & perceived safety from crime. Other imortant issues included: being close to a park (67%); the estate was designed to be safe for children (66%); streets designed to minimise traffic volume (63%). These issues were rated the same regardless of the type of housing estate. When compared with participants moving into conventional NHDs estates, those moving into LN estates rated living close to shops & services, ease of walking, sense of community, & living close to parks & the beach as more important.		
Pinjari, AR et al (2007) Modeling residential sorting effects to understand the impact of the built environment on commute mode		Primary data source used in the analysis was the 2000 San Francisco Bay Area Travel Survey (BATS); six other data sets associated with the San Francisco Bay area were used in the current	Econometric modelling methodology (lots of detail of formula in s.3) used is an extension of the general joint modelling methodology developed by Bhat and Guo (2005), in which	HH attempt to locate so that this commute time index is reduced as evidenced by the -ve coefficient associated with this variable. The total drive commute cost variable is significant for	Although transit availability +vely influences residential location choice, transit stop access time -vely impacts residential location choice. Finding is not surprising – while	HH with higher vehicle availability are likely to be located in suburban zones with lower street block D; +ve coefficient associated with the interaction term between bicycle facility D and	First, several policy scenario simulations or an elasticity analysis would have provided further insights regarding the benefits obtained by accounting for residential sorting

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
choice.		analysis: land-use/ demographic coverage data, zone-to-zone travel level-of-service (LOS) data, a GIS layer of bicycle facilities, the Census 2000 Tiger files, and the Census 2000 Population and Housing Data Summary Files.	they controlled for the endogeneity of residential location patterns (ie SS effects) to assess the impact of NHD attributes on vown (as an ordered discrete response choice variable). Difference here was that the TB variable of interest (mode choice) was of an unordered discrete response nature.	HH in the lowest quartile suggesting lower income HH are more sensitive to commuting costs than other HH. Among the network level of service measures, street block density, bicycle facility density and transit availability are desirable attributes with respect to residential location choice.	most zones are served by transit, most HH live in suburban locations where access time to a stop is likely to be greater; land-use mix measure is -vely associated with residential location choice; this suggests HH are more prone to live in zones that are rather homogeneous in nature. This finding may also be an artifact of both zoning policies and zone definition strategies. The likelihood of a HH being located in a mixed land-use zone is potentially going to be small simply because such zones are few and far between; a natural SS process that occurs in the housing market. Similar income and ethnic groups, and HH of similar size tend to cluster together. The median housing value has a -ve impact on residential location choice suggesting, as housing prices increase, the likelihood of locating in a zone decreases.	bicycle ownership indicates HH with higher bicycle ownership are likely in zones with higher bicycle D. Higher vehicle availability is associated with auto mode usage while higher bicycle ownership is positively associated with bicycle mode usage. Higher household sizes are associated with the use of shared-ride modes consistent with the greater opportunity and/or need for sharing a ride when there are multiple individuals in a household.	effects in a simultaneous equations modelling framework. Second, commonly used traffic analysis zones are treated as potential spatial residential locations; in reality, decision makers may have a different spatial unit in mind when making residential location decisions. Third, mode choice data limitations prevented the use of a rich mode choice model specification that included attitudinal attributes.
Rauterkus, SY, GI Thrall and E Hangen (2010) Location efficiency and mortgage default. Journal of Sustainable Real Estate 2(1):117-141	Probability of mortgage default based on differences in location efficiency.	Sample of over 40,000 mortgages in Chicago, Jacksonville, and San Francisco, including Walk Score assessment and number of HH vehicles owned.		2 proxy variables used for location efficiency: 1) vehicles per household scaled by income and 2) Walk Score.	Default probability increased with number of vehicles owned after controlling for income. Default probability decreased with higher Walk Scores in high income areas but increased with higher Walk Scores in low income areas. These results suggest some degree of greater mortgage underwriting flexibility could be provided to assist		

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
					households with purchase of location efficient homes, without increasing mortgage default. They also support the notion that government policies around land use, zoning, infrastructure and transportation could have significant impacts on mortgage default rates.		
Suminski, RR et al (2005) Features of the neighborhood environment and walking by US adults.	One-off interview survey – cross-sectional study of relationship between NHD environment and walking in the NHD.	US adults; a random sample of women (n =266) and men (n =208) aged >18 years participated.	Door-to-door interviews were conducted in 2003 to collect information about demographics, walking behaviour, and features of the NHD environment.	Women with an average number of NHD destinations were more likely to walk for transportation in the NHD (odds ratio (OR=5.7, 95% CI=1.63-19.73) than women with a below average number of NHD destinations (p <0.01). Men were less likely to walk for transportation in the NHD if the functional (OR=0.22, 95% CI=0.06-0.89) or aesthetic (OR=0.17, 95% CI=0.03-0.89) features of the NHD were average versus below average.	n/a	None reported	RSS not considered.
Zegras, C (2006) The built environment and motor vehicle ownership and use: evidence from Santiago de Chile.	What role, if any, do factors such as dwelling unit density, land-use mix, street design and proximity to public transportation stations play in determining household motor vehicle ownership? What role does the BE play on household automobile VKT? - cross-sectional.	Travel data from the 2001 HH OD survey carried out for national transportation planning authorities (SECTRA). The survey was based on a randomly generated sample of 15,000 HH: 12,000 surveyed during the 'normal season' and 3000 during the summer time (in total, 1% of Greater Santiago's HH) and covered a single travel day.	The land-use data from year 2001 national tax records and business and land-use permits (as reported to municipal governments) includes information (eg type of use, floor space constructed) for roughly 1.3 million residences and 400,000 non-residential land uses, geo-coded at the street address level or census block level. To determine what influence the BE had on vown, estimated a multinomial logit model of motor vehicle choice by household. The alternatives available to a		The local street network, measured by the number of 4-way intersections per roadway km (a proxy for grid street layout), also influences the choice of two or three-plus vehicles – more 'gridded' street has a negative effect on ownership, again increasing with the number of vehicles chosen; dwelling unit density displays a similar pattern of effects – higher densities have a relatively modest negative effect on the decision to own one vehicle, an effect which increases in strength (by	Via estimation of a multinomial logit model of HH vehicle choice, found income tends to dominate the vehicle choice ('this variable dwarfs all others across all choice sets' - income effects are approximately 6 to 14 times stronger than BE influences). Increased local land use mixes, dwelling unit densities and proximity to the CBD decrease the probability of household vehicle ownership, as do improved bus levels of service relative to the auto. A grid street network begins	The largest shortcoming in this research comes from the inability to infer any true causality – and, in fact, the possibility to infer false associations – in terms of BE and travel behaviour, due to the issue generally referred to as self-selection.

Author, title and date	Study questions, design and research type/ quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/potential sources of bias
			given household were zero, one, two, or three (or more) motor vehicles.		4 times) at the decision to own 3 or more vehicles; apartment living negatively influences the likelihood of owning motor vehicles, with the strength of the negative impact increasing as the number of vehicles to own increases. Also, if a HH lives within 500m of a metro (urban heavy rail) stop, the likelihood of owning 2 or 3 or more vehicles goes down, reflecting the reduced relative utility of auto ownership for a HH that lives near the metro.	influencing the choice to own two or three plus vehicles as does metro proximity.	

B.5 New Zealand publications

Author, title and date	Comment
Auckland City (2003) Behaviour and attitudes and perceptions of residents, workers and visitors in the central city. Report part A.	Reviewed on 'reverse commuting' worksheet
ARTA (2006) Auckland urban density study draft report. Prepared by Brian Waddell, Urbanista Ltd with the assistance of Auckland Regional Council.	Assesses residential, employment and mixed use density for a number of samples in Auckland region – provides aerial maps too, uses 2004 data (not 2006 Census data)
Badland (2007) Transport-related physical activity, health outcomes, and urban design: descriptive evidence. A thesis submitted to Auckland University of Technology.	Reviewed in 'BE' worksheet.
Buchanan et al (2006) The effect of urban growth on commuting patterns in Christchurch.	Reviewed in 'density' worksheet.
Carroll et al (2011) Housing intensification in Auckland New Zealand: implications for children and families.	
DTZ Research (2003) Executive summary of the Auckland Inner City Living Survey. Prepared for Auckland City Council.	Reviewed in 'density' worksheet.
Goodyear (2008) Workforces on the move: an examination of commuting patterns to the cities of Auckland, Wellington and Christchurch.	
Greenaway et al (2008) Reducing CO2 emissions from domestic travel: exploring the social and health impacts.	
Lewis (2007) Reducing the need to travel, what role for land use planning?	Some basic information for density in New Zealand and journey to work by density band using census data – land-use planning focus; not modal.
Lilley (2006) Digging the dirt on density – a study of medium density housing in Christchurch's Living Three zone. Master of Arts thesis.	Reviewed in 'density' worksheet.
Morrison and McMurray (1999) The inner-city apartment versus the suburb: housing sub-markets in a New Zealand city.	
Statistics New Zealand (2010) Apartment Dwellers: 2006 Census Wellington.	
Syme et al (2005) Social implications of housing intensification in the Auckland region: analysis and review of media reports, surveys and literature reviews.	
Van Reenen (2007) Residential intensification in Dunedin: impacts and acceptability. A thesis submitted in partial fulfilment for the degree of Master of Planning.	
Wellington City Council City Planning (2009) Central city apartment dwellers – a summary of results.	

B.6 Density

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Braun Kohlav, M (2009) Everyday travel mode choice and its determinants : trip attributes versus lifestyle.	Explores how lifestyle, indicating preferences towards a particular way of living, affects TB and travel mode choice in particular. Employs a choice model with latent variables, where latent variables capture lifestyles concerning place of residence and NHD preferences and choice model is the travel mode choice on regular trip.	Revealed preference survey of individual travel mode choices administered to 1723 adult individuals including retirees in 7 selected Czech cities and their suburban areas in 2008 who made at least one trip during the previous working day within their urban area. After cleaning, N=1438 individuals.			The more an individual (verbally) prefers good PT access and city lifestyle, the higher is the PT and walk utility with respect to car both as driver and passenger and bicycle. PT cost for them is less important (which could be due to being able to walk or take shorter PT trips).			
Buchanan, N et al (2006) The effect of urban growth on commuting patterns in Christchurch, New Zealand.	The relationship between urban form and transport was investigated in Christchurch through the analysis of journey to work data from 1991 and 2001. Density (low and high) and New Zealand deprivation index (low and high) were two variables added to the analysis.	Christchurch census data from 115 census area units.	None	Trip length; population density; mode; ethnicity.	Low population density (low deprivation) suburban areas generated & received highest % of car trips – though overall growth in car share was greatest in high deprivation/low density areas. Multivariate regression analysis established key variable determining modal split and trip length was the distance the residence was located from the central business district.			
Cervero, R (1996) Mixed land-uses and commuting: evidence from the American Housing Survey.	Explores how the presence of retail activities in NHD influences the commuting choices of residents using data from1985 American Housing Survey.	42,200 housing units.			Specifically, employees with one automobile per household were more likely to use it for commuting purposes if they lived in a low-density NHD (r = 0.78) versus an area with medium to high densification (r = 0.29); having grocery stores and other consumer services within 300 feet of one's residence was found to encourage commuting by mass transit, walking and bicycling, controlling for such factors as residential densities and vehicle ownership levels.	Cervero also detailed that the presence of local shops might operate as a better predictor of TPA engagement than population density.	When retail shops are beyond 300 feet yet within 1 mile of residences, however, they tend to encourage auto-commuting, ostensibly because of the ability to efficiently link work and shop trips by car.'	
Cervero, R and GB Arrington (2008) Vehicle trip	Vehicle trip generation in TOD compared with expected rates.	17 TODs in 5 metro areas – tube traffic counts over two days; built environment characteristics noted	None	Vehicle trip generated per household per 24 hours.	For the morning peak hour, a two-variable regression equation was estimated, showing vehicle trip generation rates fell not only with	Over a typical weekday period, the 17 surveyed TOD housing projects averaged 44% fewer vehicle trips than that	All data provided in comparison with ITE rates and manuals; relied on trip counts & drew connections	

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
reduction impacts of transit-oriented housing.		(proximity to transit, walking distance, # driveways, etc).			residential densities but also lower parking supplies. Residential density is likely serving as a broader surrogate of 'urbanicity', ie denser residential settings tend to have nearby retail and other mixed-use activities, better pedestrian connectivity and often a more socially engaging environment, all factors that moderate automobile travel.	estimated by the Institute of Transport Engineers (ITE) manual (3.754 versus 6.715). The weighted average differentials were even larger during peak periods 49% lower rates during the AM peak and 48% lower rates during the PM peak.	with RSS literature, but no empirical evidence.	
Chatman, DG (2003) How density and mixed uses at the workplace affect personal commercial travel and commute mode choice.	Data from the 1995 Nationwide Personal Transportation Survey used and investigates the influence of workplace employment density and share of retail employment on commute mode choice and VMT to access personal commercial activities.	The initial data set consisted of 34,560 workers with complete work periods and complete mileage information. Test sample restricted to drivers (95% of the sample), who had at least one car available for every driver in the HH (85%), and stated that PT service was available near their residences (64%). Final N=14,478.	None	Personal commercial VMT, choice of mode for commuting, workplace density, residential density, retail density.	Employment density at the workplace found to be associated with a lower likelihood of automobile commuting and reduced personal commercial VMT, while the presence of employment in the retail category did not play a significant role. Workplace density more clearly related to reduced personal commercial VMT and to choice of automobile for commuting than to characteristics of workers' residential NHD – increased residential density reduced the likelihood of car commuting. This relationship was stronger than employment density (increase of employees by 1000 per sq mile decreased car commuting by 3% while increasing residential density by 1000 HH per sq mi reduced likelihood by 12%).	Those who drove to work averaged almost a mile more per day in personal commercial VMT, and their average workplace density, at about 6000 workers per square mile, was far lower than the non-driving group average of 14,500 per square mile.	Respondents' missing data on workplace land use and household income are systematically different from the rest of the sample – former more likely to not use car for commuting & latter make fewer trips for personal commercial purposes – "non-residential development density' could be a proxy for/correlated with unobserved variables such as better PT availability, traffic congestion, high parking costs/ constrained parking availability.	
DTZ Research (2003) Executive summary of the Auckland Inner City Living Survey. Prepared for Auckland City Council.	Surveyed 185 people living in apt in Akl CBD.	67% of respondents were students; majority had lived for less than 2 years in current apt; 57% were women; most New Zealand Euro & Chinese.	Not given.	Not relevant.	Majority came from suburbs in immediate vicinity of central city area. 46% owned cars; 32% had carparking in building; 88% worked or studied in CBD; 71% walked/jogged to work; asked what were their 1st & 2nd most desirable locations for an apt – 53% wanted 1 car park; 40% preferred 2 car parks. 'Why do you live in an inner city apartment?': close to work/ study; close to entertainment; lower transport costs = top 3 reasons.			

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Forsyth, A et al (2009) The built environment, walking, and physical activity: Is the environment more important to some people than others?	Cross-sectional observational study specifically designed to examine the influences of the BE on walking and physical activity using matched sampling to test basic hypotheses about the relationship between density, street connectivity, and walking behaviour. How do D and street pattern affect travel walking, leisure walking, total walking and physical activity (PA) for different types of people? Is the environment more important to some people than others? Examines whether specific types of people are more sensitive to the BE when making a decision to walk or engage in other PA?	716 participants from 36 environmentally diverse, but equivalent-sized NHDs or focus areas in the Twin Cities Walking Study conducted in Minnesota, USA – responded to a survey, kept a travel diary, and wore an accelerometer for 7 days. Subgroups defined by demographic and socio-economic variables, as well as self reported health and weight status.	Multiple methods (2 types of self-report and accelerometry) for assessment of walking and total physical activity - one survey tool-file name 'forsyth_twincitieswalkingsurvey_references'	Focus on gross population density and median block size; ordinal logistic regression.	Most subgroups of people in this study walked more for travel in high D areas. In the adjusted model, there were no significant relationships for leisure walking and the environmental features analysed. Further, the relationship between high D and total walking was significant only for the less healthy. Statistically sig odds ratios for D were in the range of 1.78–2.45 meaning groups were 1.78–2.45 times as likely to walk in higher density areas including: whites, males, those without a college degree, the less healthy, those without children in the household, the unemployed and retired, those with a car, those with a BMI under 30, and the obese. Block size was only sig for non whites with those in large block areas walking more for travel.	Odds ratios for all other groups were in the same direction (more D, more travel walking) and several were close to significance including females, those with a college degree, and those with children. Most obvious is the situation that people without cars walk a great deal for travel. While representing only one study, these findings lend further support to the idea that individuals have a physical activity budget and if they walk more they do less of other things (Rodríguez et al 2006; Krizek et al 2004; Forsyth et al 2008).	A cross-sectional observational design, sample size limitations for subpopulations, and analysis of only density and block size variables, measured at one geography, the focus area, rather than various buffers; also does not account for self-selection of those liking to walk into more walkable areas – however, accounting for this would have only reduced the modest findings still further.	
Gibson M (2002) Sustainable suburban travel - do developers hold the keys?	Used NTS data to analyse relationship btw density and sustainable travel (which is not ever defined)				Found mean HH VMT rises significantly as sector pop density decreases, while there is only a weak correlation btw HH VOWN and residential density - did not (apparently) consider HH size in analysis (person MT), although did examine middle income HH with 1 or more children & found those in higher density travelled fewer HH distance and CD distance.		Doesn't consider central city area, examines purely on density; doesn't consider walk & cycle; done in 2002, and thesis has not been published since.	
Holden, E (2007) Achieving sustainable mobility: everyday and leisure-time travel in the EU.	Posted a self-completion questionnaire in March-April 2003 to randomly sampled individuals (aged 17+) residing in eight residential areas in Oslo, Norway Qs on their own and HH consumption of energy and transport, family structure, housing facilities, income.	Oslo - sent out 2500 surveys to 8 residential areas within Greater Oslo region. Achieved avg of 40% response rate per area. N=1000.		Distance, energy consumption for everyday travel, local mix.	The distance to the city centre and proximity to private and public services affected energy consumption for everyday travel (living further away engendered the use of more energy), and density, distance and local mix of services were found to be strongly correlated. Holden suggested combining high density, close proximity to centre, and also combining good/high local mix of services to reduce energy	In exploring the use of transport (and its energy consumption) during leisure-time, Holden found that density and access to a private garden (eg front or back yard) were highly correlated (in different directions) to airplane and motor vehicle travel during leisure time. People living in higher density situations tended		

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
					consumption in transport. Holden also found while having a 'green attitude' was a clear predictor of everyday mode use being environmentally friendly (eg walking, cycling and taking public transport), such an attitude did not seem to affect their travelling for leisure-time activities as measured by long-distance leisure-time travel by airplane.	to travel more frequently by plane for leisure. At the same time, having access to a private garden reduced the desire to travel by plane or motor vehicle, reducing their overall energy consumption.		
Kim, JH et al (2005) The intention to move and residential location choice behaviour.	This study explores the hierarchically nested structure of the decision to move and the choice of residence including dwelling and location using a cross-sectional; stated preference survey.	A set of 360 self-completion questionnaires was distributed to owner-occupied households in Oxfordshire; 106 responses were received (29.4 % response rate) of which 96 (26.7% response rate) constituted usable replies.	Each respondent considered 16 scenarios with specified attributes and choice to move to house A; move to house B; stay in current house.	Attributes: house price; travel time to work; travel cost to work; location (city or suburb); population density; travel cost to shop; school quality.	The estimation results show the trade-off process between house price, transport and NHD amenities in that individuals prefer a residential location with a combination of shorter commuting time, lower transport costs, lower density, higher quality of school and lower price. The results also indicate both accessibility and NHD amenities are significant in housing location choice behaviour.	Quality of school is one of the most attractive amenities to households with children according to other studies.	Small sample size; sample might be biased; SP methodology might be biased through omitted variables, non-commitment bias, instrument bias.	
Krizek, KJ (2003) Residential relocation and changes in urban travel: does neighbor-hood-scale urban form matter?	Drawing on 1989-1997 Puget Sound Transportation Panel (incl 2-day trip diary by HH members aged 15+), includes VMT, person MT, tour frequency, tour complexity. Plus urban form data on density, land-use mix and street patterns.	Washington n=6144 households plus a subset of 430 household who relocated between survey waves.		VMT, person MT, number of trips, number of tours; socio-demographic: HH income; vehicle ownership, number of adults, children, employees, commute distance.	Many of 430 HH shifted close to initial location. Propensity of HH to change their travel behaviour between waves was dependent on their socio-demographics at baseline - baseline travel behaviour was the largest influence: eg the higher the value at baseline, the more likely a HH decreases it. NHD accessibility also significant: higher accessibility = more likely to decrease VMT/PMT and number of trips per tour. If HH commute shortens, then more likely to do more tours in a day. Shifters: increased NHD accessibility and/or regional accessibility = reduced VMT. # of tours actually increases (and tour complexity declines) in higher NHD accessibility.	Effect of urban form on trip generation is inconclusive; while its effect on mode split appears neutral (no change).		
Li, F et al (2005) Multilevel modeling of built environment	Survey; existing geographical databases from regional land information system - multilevel modelling.	577 adults 65 yr or older in 56 NHDs in Portland, Oregon		Objective number of residential households, places of employment, street intersections; total	1) Higher walking activity at NHD level related to higher employment place and residential household density, more street intersections, and more green and open space; 2)		No covariates.	

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
characteristics related to neighbor-hood walking activity in older adults.				green and open spaces for recreation (area); perceived proximity to local recreational facilities, walking and traffic safety, and number of nearby recreational facilities.	Higher walking activity at resident level related to more NHD recreational facilities and better walking safety; higher walking activity among residents reporting more traffic safety in NHDs with more street intersections (interaction).			
Lilley, SJ (2006) Digging the dirt on density - a study of medium density housing in Christchurch's living three zone. Master of Arts thesis.	Mix of survey and interview techniques to determine the acceptability of 'medium density' developments to residents, and to understand the practices and motivations of housing developers in Christchurch's Living 3 zone.	Distributed surveys to 103 units, with a 42 surveys being completed (in some cases, more than one respondent per housing unit completed the survey). Most respondents (n=26) were 15–34 years old, with the remainder aged 35–64.	n/a	Range of variables examined, transport was a small component	Half of respondents travelled to the central business district for work. Of these 22 people, 11 travelled to work by car. Few of the households had bicycles and generally they had as many motor vehicles as adults. All age groups preferred to shop in locations fairly close to their residence, although there was variation (by age group) as to which shopping area was favoured. Younger age groups wanted to access shops without having to use a private car.	n/a	Respondents were self-selected; unclear how many were the decision-makers (actually chose where to live). Also unclear who worked and who studied.	
Maat, K and H Timmermans (2006) Autobezit van huishoudens in samenhang met de woon- en de werklocatie.	Examines the extent to which land-use factors relating to the residential and work location affect households' car ownership decisions, especially why particular households do not own a car, while others own more than one. The analysis looks explicitly at the interaction between the spouses, broken down into non-earners, single earners and dual earners. Hypothesise that second car ownership is mainly due to having two earners in HH - further enhanced by presence of children and higher incomes.	Entire survey involved just under 3000 respondents, the work location was only known in the case of 1630 of them. Selection by complete HH finally left 1222 respondents, divided up among 738 HH, comprising 488 couples and 254 singles. The respondents completed a questionnaire on individual and HH factors and kept a diary for two days.	None – used multinomial logit models.	Urban density within 400m, 2.5km, 10km, distance to railway station, distance and travel time to work, worker status, children, income.	The higher the density of the residential environment, the greater the probability the household will not have a car. A single-family dwelling reduces the likelihood of there being no car. Workplace density was not observed to have any significant effects, though distance from the station was: the greater the distance between the station and the workplace of male dual earners, the higher the probability of there being a second car.	The larger the density of the residential NHD and the smaller the distance from the station, the higher was the probability of the household not having a car. Dual earners were more likely to have a car and more likely to have two cars than single earners.		
Maat, K and H Timmermans (2009) A causal model relating urban form	Assume individual and household characteristics have their influence on residential and work location choice and on activity and travel decisions, while simultaneously	Entire survey involved just under 3000 respondents, the work location was only known in the case of 1630 of them. Selection by complete	As distances are not travel choices in themselves, but the consequence of other decisions, authors tested a causal model that did not relate urban		The direct effect from residential density, suggesting that people in a dense residential environment travel a little less, although this effect is partly cancelled out by extra activities. Workplace density	For residential density a negative effect occurs with car ownership, indicating the number of cars in a household is associated with residential density.		

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
with daily travel distance through activity/travel decisions.	controlling total travel time. Daily travel distance is just an outcome of the decision-making process, as individuals do not plan their activities and travel within a certain number of kms. It is assumed households, when deciding where to live and work, choose for environments that fit with their desired mode of travel – used structural equation models.	HH finally left 1211 individuals. The respondents completed a questionnaire on individual and HH factors and kept a diary for two days.	form directly with daily travel distance, but indirectly through a series of decisions. A structural equation model was developed to simultaneously estimate direct and indirect causal relationships.'		and mix show a small positive effect – attributed to fact that workers in higher densities make more extra trips. Overall, effect of density on travel behaviour would mean aiming at higher densities does slightly reduce KT, although effects are not substantial.	Higher income is related with higher densities, probably because high income workers more often work in (on average intensively used) offices rather than (extensively used) industrial estates. As the car is more often used for suburban and low-density work locations, the effect on car ownership is negative.		
Melia, S (2007) Potential for carfree development in the UK. Master of Arts thesis.	Hypothesis: groups already known to be pre-disposed to reducing car use could contain people who would be willing to live in car-free environments. Identified three groups (car-free choosers, car-free potentials and car limiters) that could be targeted for car-free developments in the UK – used online survey for cyclist/environmental; mail out/mail back surveys for Camden (inner London borough, high density, low car ownership) & Poole (travel plan-designed area).	UK – cyclists and environmentalists: no specific location (n=822, Camden (n=199 – 9% rr), Poole (n=57).	n/a - attitudinal & behavioural surveys.		Confirmed some respondents were already 'car-free choosers' (living without a car by choice) and others were 'car-free potentials' (who had chosen or could choose to not own cars under certain circumstances). Reasons for these choices varied: in the high density area of Camden, most people selected 'no need for a car' when asked 'what are the reasons why you live without a car?' (n=118 respondents with zero cars in their household). 'Cost' was the second most commonly selected reason. 77 of the 118 respondents without household cars had never owned a car; and 36 had owned cars prior to living in London. By contrast, for the 221 cyclists/environmentalists who selected 'I live without a car by choice' (and who were not necessarily living in high density areas), 'environmental reasons'; 'no need for a car' and 'don't like driving or prefer other means of travel' were the three main reasons for living without a car.	Among the quarter who drove in Camden, two-thirds had some experience of living without a car (Q.12) but 42% said they would not want to give up their car under any circumstances (Q. 13) – compared to just 11% in the cyclist/ environmentalist group. Half of the non-drivers said they had never owned a car (Q. 15). Three quarters said they lived without a car by choice (Q. 16).	Failed to consider whether or not there were similar people in the general population, or whether those pre-disposed to reducing car use had already done so to significant degree (hence there would be no change to their travel patterns if they moved to a car-free environment; didn't document actual mode use (other than 'most days') for key trips, making comparisons difficult.	
Norman, D and K Sanderson (2010) Relationships between passenger	Examines the relationship between a range of demand-side variables and the demand for PT. The particular focus is to investigate what, if any, links there are between	The project studied 1054 census area units, representing the 18 largest urban centres in New Zealand. It examined a range of socio-	None: the 18 urban centres identified – Auckland split into 5 zones while Wellington 'metro' includes 4 cities and Kapiti Coast – severely compromising		Wellington metro has highest proportion of PT use for journey to work: 14.5% while Auckland metro has 5.8%. Modelling various census variables and find: strong relationship between the	Within multiple variable model: access to one additional motor vehicle reduces PT uptake by 9.6 percentage points across the 1054 census area units; an increase of		

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
transport use and urban form in New Zealand. Working paper ref #4756. Wellington: BERL Economics.	urban form variables, which include urban size (the size of the urban centre population) and urban density (the number of residents or workers per hectare).	economic variables in addition to urban form variables in order to build a series of multiple variable models to explain PT uptake.	anything they might say about density.		population of the urban centre and PT uptake; on its own, increasing residential density by 7.3 people per hectare raises PT uptake by 1%, however in multi-variable model, it is insignificant – could be related to walk/cycle? *Author's thought: related to proximity to activities, which means walking is easier than PT.*	around $2780 is associated with a one percentage point increase in PT use; an increase of 5.6% in the share of people aged 15–24 is associated with a 1% rise in PT uptake (also relates to low vehicle ownership rates). Looking at PT uptake in Akl & Wlg separately, find that in Akl, as residential density rises, PT uptake rises. As workplace density rises, PT uptake falls (and active mode use increases). Wlg does not show residential or employment density as significant in its model.		
Oakes, JM et al (2007) The effects of -orhood density and street connectivity on walking behavior: the Twin Cities walking study.	Refer Forsyth, A et al (2009) for details of methodology – examine the influences of the built environment on walking and physical activity.	Three city residential areas were selected from the environmentally diverse but demographically homogenous northern sector (the so-called '35W corridor') of the Minneapolis – St. Paul metropolitan area.	Multiple methods (2 types of self-report and accelerometry) for assessment of walking and total physical activity.	1) travel walking, 2) leisure walking, 3) mean miles walked per day and 4) total physical activity per day; street connectivity as median block size, where larger blocks reflect less connected streets. High density was defined as greater than 24.7 persons per gross hectare (ha) excluding water bodies only; low density was defined as less than 12.4 persons/ha.	While crude differences are evident across all outcomes, adjusted effects show increased odds of travel walking in higher-density areas and of leisure walking in low-connectivity areas, but neither density nor street connectivity are meaningfully related to overall mean miles walked per day or increased total physical activity. Contrary to prior research, the authors conclude the effects of density and block size on total walking and physical activity are modest to non-existent, if not contrapositive to hypotheses. Divergent findings are attributed to this study's sampling design, which tends to mitigate residual confounding by socio-economic status.		Took care to avoid confounding factors: selected areas with similar socio-economic stratum (SES) so that population could be considered exchangeable between areas & used multiple methods to assess W & PA.	Accessed February 2009 from www.epi-perspectives.com/content/4/1/16
Ryley, T (2005) Use of non-motorised modes and life stage in Edinburgh.	Applied cluster analysis to six demographic variables (# of adults in HH, HH income, house type, life stage of individual, gender and # of children in HH) from a Scottish HTS survey.	4016 Edinburgh adults.	Statistical analysis.	Mode use; utility vs leisure trips; relationship to life stage.	Presence of children increases propensity to own and use motor car; own but not use bikes; leisure not utility cycling. Individuals in flats more likely to W/C, particularly for JTW; lower car ownership	n/a	Very small # of cycling segments means any cycling results are questionable – more relevant to consider 'active modes'.	

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
	Cluster analysis largely focused on life stage (gaining employment; having children; retired) and influence on individual TB.				rates – flats in Edinburgh are located towards city centre – tends to be those living in flatting arrangements.			
Schwanen, T and PL Mokhtarian (2007) Attitudes toward travel and land use and choice of residential neighbor-hood type: evidence from the San Francisco Bay Area.	Line1 (conclusions in next line): to analyse how predispositions toward travel and land use affect the choice of residential NHD type. Apply binary and nested logit models to data from the San Francisco Bay Area. Control for socio-demographics, personality/lifestyle and auto availability.	Collect data from 1) a relatively familiar region (the San Francisco Bay Area), 2) a small number of NHDs, and 3) NHDs representative of the two basic types (urban and suburban); the three NHDs differ in terms of population, housing and physical urban structure characteristics.	14-page questionnaire that collected information on a variety of travel and related issues. About 2000 surveys returned, a 25% response rate. A subset of 1358 respondents identified as workers commuting at least once a month is used: the morning and evening commutes function as structural determinants of daily travel behaviour, and most commuters travel during peak hours when congestion is at its worst.		Another drawback is that attitudes toward land use and travel and personality/lifestyle are measured for only one person in the HH, whereas decisions about residential location are made at the HH level. Likely there is some agreement among adult HH members about residential preferences, but not guaranteed. Further, the person who completed Qre may not make residential location decisions for the HH (eg could be an adult child living with a parent). These discrepancies may corrupt the results. Since the associations between the attitudinal factors and residential NHD choice are plausible and largely in line with expectations and since only around 8 % of HH nationwide contain an adult child living with a parent, this issue not expected to have a profound influence on the outcomes.	Those who consider their car more than a simple means of getting from A to B appear to locate in NHDs facilitating the display of their status symbol; the commute benefit factor is +vely associated with the choice to live in an urban location. Individuals who value the ability to commute by modes other than by car (so they receive more utility from commuting) may, all else being equal, be more inclined to live in a NHD that provides better accessibility by such modes; higher-income HH more likely to reside in high density area close to CBD, suggesting HH income acts as a proxy variable for housing costs. The model also shows one-person HH and dual-worker couples are more likely to reside in high density area close to CBD, suggesting these variables in part act as proxies for dwelling size and type. HH with fewer cars per driver are more likely to reside in North San Francisco; family HH gravitate toward suburban localities, while young, smaller HH tend to be drawn to the city.	Information on important factors known to affect residential location choice is missing because the data were not collected with the current analysis in mind. In particular, the data does not include information about the race/ethnicity of the respondents and housing/NHD characteristics like price or value, type and size of dwelling, and school quality; analysis is based on people's current residential NHD and does not consider how long ago they moved into the area. Respondents' consideration of alternatives is also unknown, hence, do not know whether a given urban resident would really consider living in a suburban location. This is, however, a common problem when revealed behaviour data are used.	

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Schwanen, T and PL Mokhtarian (2007) Attitudes toward travel and land use and choice of residential neighbor-hood type: evidence from the San Francisco Bay Area.	Line 2				On the basis of the results for the travel attitude factors, it is possible to identify several inter-dependencies of travel attitudes and residential NHD (and daily travel choices) or manifestations of RSS: 1) Individuals may opt for higher-density living because they are willing to reduce their current auto use for the sake of the environment and because living in a traditional or neo-traditional NHD enables them to drive less (the pro-environmental solutions factor). 2) Individuals may choose higher-density living because they can commute by using something other than a private car, which makes it easier for them to use their commutes productively and/or relax or enjoy their environment while commuting (the commute benefit factor).	3) Individuals may choose to live in a lower-density, suburban location because this type of NHD facilitates fast, flexible and comfortable travel by car (the travel freedom factor and to a lesser degree the pro-highway travel factor, which did not appear in any of the models but yielded statistically significant differences in the descriptive analysis). To these interdependencies, a fourth, which surfaced in the descriptive analysis but not in the models presented in this article, can be added: 4) Individuals may choose to locate in a lower-density environment because such a NHD makes it easier to show off their car or cars as an object of status and prestige (the status-seeker factor).	Several issues should be addressed in future research. 1) Instead of surveying residents of a traditional NHD researchers should interview residents of a variety of neotraditional developments differing in density, land-use mix, and accessibility by auto, transit and walking/bicycling about their reasons for moving there. 2) Such a study should embed the relationships among NHD choice, attitudes toward land use and travel, and travel choices in an integral study of housing choices. This would imply that preferences and constraints with regard to housing costs and values; dwelling size and type; tenure and access to workplaces, schools, stores and other destinations, as well as the social composition of NHD populations, are given a prominent place in the research.	
Schwanen, T et al (2005) The relationship between land use and travel patterns: variations by household type. In: K.	Does the direction and/or magnitude of the influence of urban form on travel vary across different household types? Investigates differences in the effect of urban form, or residential context, on trip frequency and travel time across six household types: single workers, two- and	Sample drawn from 2001 Netherlands National Travel Study. HH classification based on households' time budgets: # of adults in the HH; the number of employed adults; and the presence of children younger than 12.			For maintenance travel, and certainly for commuting, the conclusion should be that the impact of residential setting on travel time is characterised more by similarity than by differences across HH types with respect to the direction of the influence. For most HH types, travel times for these purposes are higher in the cities and growth centres and	The analysis suggests opportunities for efficient travel or easy access to relevant destinations seem to be of modest importance in decisions about where to live.		

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Williams (Ed) Spatial planning, urban form and sustainable transport.	one-worker couples, two- and one-worker families and senior households. The analysis of travel time is segmented by trip purpose: we differentiate between commuting times, 'maintenance' times (eg trips running household errands, moving goods, shopping, giving lifts to people etc) and leisure travel times.				lower outside the Randstad in general and in the less urbanised municipalities in particular. Reasons for the relative absence of long commutes in the suburbs appear to be the lower inclination to travel by PT in general, and by train in particular, as well as the less severe parking problems and congestion on the local road network. The magnitude of the differences between residential settings varies across HH types for maintenance travel time. The differences tend to be larger for HH types with larger time budgets, such as retired HH and one-worker couple.			
Snellen, D (1999) The relationship between urban form and activity patterns multi-variate analysis of frequently made trips. Proceedings of the European Transport Conference, Cambridge, 1999	Explored various hypotheses: higher density influences mode choice; short distances favouring non-motorised modes; different demographic and other characteristics influence mode choice. Multivariate analysis of the data focusing on the mode choice for four types of frequently made trips, eg home-to-work trips, grocery shopping trips, other shopping trips and recurring trips for sports and/or club activities. All trip data studied concerned home-based trips. Information was also collected for each city and NHD about their physical structure.	Survey collected activity and trip data (including 2-day travel diary in several NHDs in 9 Dutch cities across the country – N=344 HH and 586 respondents. Estimated MNL models for each destination.			Density was not found to be an important determinant of mode use. Distance to the chosen location was a significant variable in all estimated models, indicating a clear increase in the use of motorised transport modes and public transport with increasing distances. The effects of locally available services (concentration of jobs, shops, etc) are much less clear. The number of shops locally available does have an effect on mode choice for grocery and other shopping. Thus, when there are fewer local facilities, people tend to do their grocery shopping elsewhere by car. For other shopping a similar effect is found. Having local facilities does not guarantee the car will not be favoured.	Distance and availability of motorised transport are the main, and most consistent, factors influencing mode choice. It was found shorter distances favour non-motorised transport modes, while car availability yields the opposite effect. Important to notice is that both these factors are difficult to influence. Results show, for instance, that nearby available facilities are often not chosen as a destination by NHD inhabitants.		
Snellen, D (2001) Urban form and activity-travel patterns an activity-based approach to travel in a spatial context. PhD thesis,	Aim of this study was to test the claims in current Dutch mobility reduction policies that urban form characteristics can help reduce (motorised) mobility. Quasi-experimental design; travel diaries; multi-level analysis.	In 19 selected NHDs in 9 Dutch cities, data on activity and travel patterns collected included both activity-travel diary data and travel data on a set of frequently conducted activities – 355 HH completed 586 Qres – originally sent to 5700 HH.			Concludes that the potential of urban design measures to reduce trips made and KT, and to induce a shift in the modal split is limited. The evaluation of the activity-travel diary data distinguished between weekday data and all data. It was found differences in travel distance on weekdays can be rather sizable for certain UF characteristics (in combination	The analysis of complete activity-travel diaries can lead to different conclusions than the analysis of motive-specific trips. Given that the analysis of travel behaviour for specific motives does not yield results similar to the analysis of diaries, and given that activity-travel	Cultural background or personal attitudes of HH and individuals, group attitudes and influence and other social and psychological factors have not been taken into account.	Also published as: Snellen, D et al (2002) Urban form, road network type, and mode choice for frequently

Author, title and date	Study design and research type/quality	Study population, setting, country, sample size	Description of intervention	Outcome variables (inc measures)	Primary findings	Non-physical activity outcomes	Confounders/ potential sources of bias	Source
Eindhoven University of Technology, Urban Planning group					with some socio-economic characteristics). In the analysis of diary data for all days, these effects disappear. This is an indication of compensation behaviour in weekends. It appears that what is gained by influencing weekday trips, is mostly lost in the total travel pattern.	diaries give a more comprehensive picture of travel behaviour, we argue that the analysis of activity-travel diaries is to be preferred over the analysis of motive-specific trips when studying the influence of the spatial environment.		conducted activities: a multilevel analysis using quasi-experimental design data.
Van de Coevering, P and T Schwanen (2006) Re-evaluating the impact of urban form on travel patterns in Europe and North-America.	Kenworthy et al (1989, 1999) analysis of land use/urban form and travel identified the inverse relationship of population density and energy use for transport, positing that population density was the key factor to TB. Argue that Kenworthy and colleagues in their empiric alanalytical work pay insufficient attention to individual travellers and to the influence of the space-time context mitigating the relations between land use and transport. Aim to gain insight into the relative importance of urban form in explaining (in a statistical sense) variations in metropolitan-wide travel patterns vis-a-vis cities' development history, housing and socio-demographic situation. Ascertain to what extent the relations between urban form and metropolitan-wide travel patterns differ across regional contexts.	Use Kenworthy et al data augmented with information on cities' development history, housing conditions and socio-demographic situation allows us to gain more detailed insights in the strength of the land use and transportation link in 31 of the cities considered by Kenworthy and colleagues.			HD areas tend to travel fewer vehicle km, the centrality of employment has an effect: higher percentage of jobs in the CBD tends to reduce the distance travelled by car and contributes to shorter commuting distances, albeit longer commuting times (possibly explained by greater congestion which reduces travel speeds and greater use of PT, walking & cycling, also reducing travel speeds). Larger distances are travelled by public transport in metropolitan areas with more jobs per hectare in the core – most important is the ratio of PT to road supply and rail density – PT use also increases as parking supply in CBD declines. Greater proportion of workers in population leads to less VKT & greater PT KT. Population size is positively correlated with the average commuting distance and commuting time.	Historical conditions matter to travel patterns: the land-use characteristics of the inner area (% built prior to WWII; rental patterns) – that part of the city built prior to WW II seem to be more directly associated with aggregate-level travel patterns than metropolitan-wide population density. Also, some population characteristics (particularly % of workers) affect travel patterns – not just urban form.	Number of cities in sample is small, should be augmented; additional data would be useful – care still required before inferring causality from any results.	

B.7 Reviews

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
Badland, H and G Schofield (2005b) Transport, urban design and physical activity: an evidence-based update.	Review – inclusion (limited to academic publications) exclusion criteria not defined – systematically draws together the evidence surrounding NHD differences and traffic calming effects based on urban design fundamentals, the impact of the localised environment for at-risk populations, non-motorised travel characteristics, and measurement issues associated with merging physical activity, urban design and transport research.		Urban design features attributable to transport-related physical activity are density, subdivision age, street connectivity and mixed land use.	Shorter distance to destinations or transport, gender, social status, aesthetic factors and access to public open spaces.		Majority of existing research is based on country-specific, self-report cross-sectional designs, which have led to inherent flaws and no establishment of causality; paucity of research has been highlighted around trip chaining, traffic calming and a comprehensive understanding of how the environment impacts on travel mode choices.
Badland, H and G Schofield (2005a) The built environment and transport-related physical activity: what we do and do not know.	Information was sourced from major health databases. The remainder of the literature was directed from citations in articles accessed from the initial search. Note: six of the studies analysed by Badlands were included in Bauman and Bull 2007	Clear health benefits result from regular TPA engagement, with opportunities closely linked to accessible urban design infrastructure.	Looked at papers addressing links between TPA and health; and specifically walking & health benefits. Considered urban design & TPA links: street design; urban density; mixed land use; modal choice.	Refers to Handy and Clifton (2001) - already reviewed	Other researchers (such as Holtzclaw 1994 and Cervero 1996) are reported to have found that density shows an exponential association to TPA and transit and an inverse relationship with vehicle ownership, and commuting use.	Much of the existing evidence, however, has been extracted from cross-sectional research, rather than interventions. As such, drawing causal relationships is not yet possible.
Bauman, AE and FC Bull (2007) Environmental correlates of physical activity and walking in adults and children: a review of reviews.	13 reviews represent in excess of 100 primary studies. Most evidence describes correlates of physical activity from cross-sectional study designs and thus not possible to infer a causal or true 'determinants' relationship. Limiting the review to a review of reviews, including studies published only in English between 2002-2006 and applying search terms to only title and key words. Searching the abstracts was excluded.	The total variance explained by environmental factors is still limited, with no more than about 5%–10% of the variance in physical activity, even when all the environmental correlates are included together in statistical models. This means much of the variation remains unexplained; eithercorrelates are insufficient, or are poorly measured and assessed.			Significant number of psychological, cognitive, emotional factors and perceptual barriers to being physically active have been identified (p8)	Many studies used representative population samples; studies are almost all cross sectional in design, and are reporting statistical associationsonly; sometimes these estimates are unadjusted for potential confounders; lack of longitudinal data means causal inferences about the relationship between environments and physical activity are not strong; measurement issues are complex; self report or perceived environments may relate tophysical activity in similar or different ways compared to objective measures of the same environment; lack of standardisation of

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
						measurement of environments (or of physical activity), making comparisons among studies difficult.
Cao, XY (2006) The causal relationship between the BE and personal travel choice: evidence from Northern California.	Literature review (empirical work is compiled in RSS worksheet). Self-selection in this context refers to 'the tendency of people to choose locations based on their travel abilities, needs and preferences'. RSS generally results from two sources: attitudes and socio-demographic traits. It is known that individuals with a preference for walking tend to selectively live in a NHD conducive to walking (eg Handy and Clifton 2001).		Cao reports Hess and Ong (2002) studied urban form and auto ownership in Portland, Oregon found that as land-use mix changes from homogeneous to diverse, the probability of owning an automobile decreases by 31%, after accounting for income and other factors. The conclusion was that traditional NHDs gave households the 'opportunity to express their preferences to avoid automobile ownership' (p35). Accordingly, individuals' attitudes, especially travel attitudes and residential preferences likely to be antecedent factors of both residential choices and vown decisions. Another study found the performance of vown choice models improved by incorporating attitudes towards veh ownership. The implication is that the effectiveness of influencing vown and use through the BE may be largely limited to the market share of individuals whose attitudes are favorable towards alternative modes and traditional NHDs to begin with.	The relationships between the BE and vown have not been extensively studied. Available evidence from several studies suggests HH living in single-family dwellings, homogeneous and/or suburban types of NHD, typically located farther away from employment sites, tend to own more vehicles (and use them more often) than HH living in denser NHD and/or closer to CBD. An overview of international cities found that higher urban density is consistently associated with lower vown rate. Similarly, case studies of Chicago, LA, and SF concluded that vown was significantly correlated with NHD residential density, after accounting for average per capita income, average family size, and availability of public transit. However, the way in which individual elements of the BE affect vown choices is not well understood.	Cao cites the conclusions of Ewing and Cervero (2001) as important: 1) Trip frequencies appear to be primarily a function of the socio-economic characteristics of travellers, and secondarily a function of the BE; 2) Trip lengths are primarily a function of the BE and secondarily a function of socio-economic characteristics; 3) Mode choices depend on both socio-economic characteristics and BE characteristics, though probably more on the former; 4) The BE characteristics are much more significant predictors of VMT, which is the outcome of the combination of trip lengths, trip frequencies and mode choice.	
Cao XY et al (2009) Examining the impacts of residential self-selection on travel behaviour: a focus on empirical findings.	Reviews 38 studies testing whether observed patterns of travel behaviour can be attributed to the residential BE itself, as opposed to attitude-induced residential self-election - drawn from nine methodological categories: direct questioning, statistical control, instrumental variables, sample selection, propensity score, joint discrete choice models, structural equations models, mutually dependent discrete choice models and longitudinal designs.		Almost all of the 38 studies found statistically significant influence of the BE on TB remaining even after RSS accounted for. Clearly, influence of BE diminishes once RSS is taken into account (hence if RSS ignored, BE effects will be over-estimated). Direct questioning method qualitatively found some evidence for RSS. Statistical control approach studies consistently found confounding influence of RSS in association with BE & TB as well as finding BE had independent influence on TB. Instrumental	One study found that in a group of 90 respondents living in Century Wharf, Cardiff, UK, 18% chose their preferred mode to work before selecting their residential location, while 39% chose their residence and commute mode concurrently. Based on his descriptive analysis (rather than statistical tests), the researcher concluded that for more than half the sample, residential choice is either conditional on or interacts with commute	As yet unclear how big the 'true influence' of BE on TB is – speculate it is relatively small compared with socio-demographic and unmeasured variables. Also, cannot specify the nature and extent of the causality between BE and TB, particularly since the relationship appears to vary by mode, trip purpose, and population segment; and depends on what elements of the BE are being captured (eg NHD-specific characteristics like density	Only 10 of 38 studies considered the relative strengths of BE or RSS in influencing TB.

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
			variables regression & sample selection models found BE had an impact after controlling for RSS; nested logit applications reported sizeable influence of RSS on TB, with BE having a direct influence beyond that. Mixed results in joint discrete choice model and structural equations model. Longitudinal design: BE has a causal influence on TB, may be influence of attitudinal factors.	mode choice and that people selectively locate in their NHD to realise travel preferences.	and land-use mix versus regional location). Recommends longitudinal structural equations modelling approach which can combine measurement of attitudes, allows multiple directions of causality, and measurements at multiple points in time, in conjunction with control groups.	
Cao, XY et al (2008) Examining the impacts of residential self-selection on travel behavior: methodologies and empirical findings.	This report reviews and evaluates these alternative approaches addressing this attitudinal SS issue fall into nine categories: direct questioning, statistical control, instrumental variables models, sample selection models, propensity score, joint discrete choice models, structural equations models, mutually dependent discrete choice models, and longitudinal designs.		Recommends usage of longitudinal structural equations modelling with control groups, a design which is strong with respect to all causality requisites. Future studies adopting research designs that more closely resemble a true experimental design will lead to more definitive inferences regarding causality.	Two types of studies are important (both of them ideally to include comparison groups of unaffected individuals similar in other relevant ways): 1) true panel studies of residents who move from one type of NHD to another, with measurements of attitudes as well as socio-demographic traits and travel behaviour before and after, and further exploration of the reasons behind the move; and 2) natural experiments that examine the impact on travel behavior in response to a change in the built environment, such as the implementation of a traffic calming programme.	In Merriam-Webster online dictionary, causality is defined as 'the relation between a cause and its effect or regularly correlated events or phenomena'. To robustly infer causality, scientific research generally requires at least four kinds of evidence: association, non-spuriousness (establish non-spuriousness in a non-experimental study, an appropriate method is to show the relationship still holds when all third party variables are controlled for (statistical control), time precedence (direction of influence), and causal mechanism (definitions provided).	This report has been summarised in the following two papers: Cao, XY et al (2009) Examining the impacts of residential self-selection on travel behavior: A focus on empirical findings. Mokhtarian, PL and XY Cao X (2008) Examining the impacts of residential self-selection on travel behavior: a focus on methodologies.
Frank, L et al (2006) Promoting public health through Smart Growth building healthier communities through transportation and land use policies and practices.	Review of evidence to support the statement 'Smart growth communities are healthier places to live'. Also provides evidence of other benefits. This report looks at community health through the lens of urban design and planning. Considers causality and self-selection; looks at land use impacts on travel behaviour (eg density; connectivity; transit; interim strategies (eg TDM, parking management); impacts on public health objectives (mental, obesity, air, noise,		Krizek (2003) found, although (VMT) and number of stops per trip decreased when people moved from a less to a more walkable location, effects on other transportation modes were not statistically significant – suggests the VMT reductions could be because the new locations are closer to more destinations, not because walking trips are substituting for driving trips. Some research has documented that a significant proportion of residents in sprawl would prefer to be in more walkable environments, but trade		Other researchers identified confounding factors such as the concentration of poverty in older urban NHDs.	

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
	safety, water).		it off for reasons including spousal preferences, work location, and cost.			
Halcrow Group et al (2008) Land use and transport: settlement patterns and the demand for travel. Stage 2: final report.	Literature review covering some 250 papers and publications; contextual travel patterns - using NTS data, aggregated to regional level or higher; land use and transport planner interviews at a selection of case study locations – regionally based – lit review reporting very generalised, though some useful tables at the end; NTS analysis too 'large area'; practitioner evidence – again at a large area level and general; synthesis focuses on planning and planning guidance (outside of scope of current study).	Urban structure variables: population density, population size, jobs-housing balance and development location; travel behaviour: trip frequency, trip length (distance and time), mode choice or vehicle km and vehicle hours travelled; energy consumption and & CO2 emissions.	Trip lengths are shorter in traditional urban settings – the central locations, fine land use mixes, grid-like street networks produce shorter trips. Walking and, to a lesser degree, public transport is more prevalent. This holds for both the home end (residential NHDs) and non-home end (activity centres) of trips; resident population density and travel, pp97-101 – cites a no. of conclusions of theoretical and empirical research papers generally finding some relationship between a travel variable and (usually) residential density; location and travel – generally state that development closer to urban areas associated with lower vown & less car travel, but some disagreement (pp104–105).		The most recent work in the USA has started to tackle the difficult empirical issues ... the direction of causality and 'self-selection' (whether urban structure influences travel, or whether travel preferences influence the choice of location). Two early analyses of the UK National Travel Survey (NTS) dataset found there are relationships with density and settlement size and travel. Trip length and mode share are the most likely of the travel variables to be affected by the form of the built environment.	Much of the current available analyses are based on cross sectional data, allowing a view of one 'snapshot' in time.
Krizek K et al (2009) Walking and cycling international literature review.	Comprehensive review of international walking and cycling literature (>300 papers) prepared for the Victoria Department of Transport (Australia). Specific aim to provide professionals and other researchers with an understanding of the barriers to walking and cycling, as well as the infrastructure and policy supports for non-motorised transportation.		Overall density, related to the clustering of destinations including other housing units, is associated with travel walking in most studies. Specific destinations seen as important in various studies but destinations differ between studies. Street patterns important in some studies – may be a measurement issue or be due to the use of space (for instance in suburban areas pedestrians may cut through large blocks on paths not identified in the data collection nor known in most network measures). Infrastructure has some importance in travel walking—sidewalks, lighting—but merely building a sidewalk will not make an environment walkable. (p37)			
Litman, T (2008a) Land-use impacts on transport: how land-use factors	How specific land-use patterns affect travel.	Traffic calming: traffic studies found for every 1m increase in street width, the 85th percentile	Transit accessibility: several citations re living close to transit services reduces VMT & car trips. Reported Bailey (2007) found that HH located within ¾-	Litman reports Dill (2004) found residents of Fairview Village, a new urbanist NHD, own about 10% fewer cars per adult, drive 20%	Litman reports Reconnecting America (2004) studied demographic and transport patterns in transit zones, defined as	These higher rates of transit and walking travel may partly reflect RSS. Many TOD residents, particularly those who commuted by transit,

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
affect travel behavior.		vehicle traffic speed increased 1.6km/h, and the number of vehicles travelling 8-16km/h [5 or 10 mph] or more above the speed limit increased geometrically. Various studies (not specified!) indicated an elasticity of vehicle travel with respect to travel time of -0.5 in the short run and -1.0 over the long run, meaning a 20% reduction in average traffic speeds would reduce total vehicle travel by 10% during the first few years, and up to 20% over a longer period.	mile of high-quality public transit service averaged 11.3 fewer daily vehicle-miles, regardless of land-use density and vehicle ownership rates. Analysis indicated a typical HH reduced its annual mileage 45% by shifting from an automobile-dependent location, with poor travel options that required ownership of two cars, to a transit-oriented NHD, which offered quality transit service and required ownership of just one car. This saved 512 gallons of fuel annually, worth $1400 at $2.73 per gallon. Frank et al (2006) developed a walkability index that reflected the quality of walking conditions - in King County, Washington a 5% increase in their walkability index was associated with a 32.1% increase in time spent in active transport (WC), a 0.23 point reduction in body mass index, a 6.5% reduction in VMT, and similar reductions in air pollution emissions.	fewer miles per adult, and make about four times as many walking trips than residents of more sprawled NHDs.	areas within a half-mile of existing transit stations in US cities. It found that HH in transit zones owned an average of 0.9 cars, compared with an average of 1.6 cars in the metro regions as a whole, and that automobile travel was also much lower in transit zones. Litman reports Lawton (2001) used Portland, Oregon data to model the effects of land use density, mix, and road network connectivity on personal travel. He found these factors significantly affected residents' vown, mode split and per capita VMT. Adults in the least urbanised areas of the city averaged about 20 VMT each day, compared with about 6 VMT/day for residents of the most urbanised areas, due to fewer and shorter motor vehicle trips.	placed a high importance on transit and walking accessibility when choosing their home. However, studies that account for self-selection, using statistical methods or linear studies that tracked travel activity before and after people move to a new location, indicated that land-use factors did affect travel behavior. Even if self-selection explained a portion of differences in travel behavior between different land use types, this should not detract from the finding that such land-use patterns and resulting travel behaviors provided consumer benefits.
Litman, T (2010) Land use impacts on transport how land use factors affect travel behavior.		How these land use factors affect travel behavior, including per capita motor vehicle ownership and use (vehicle trips and vehicle travel, measured as vehicle miles of travel or VMT), mode split (the portion of trips by different modes, including walk, cycling, driving, ridesharing and public transit), use of non-motorised modes (walking and cycling) and accessibility by people who are physically or economically disadvantaged.	Using Davis, California as an example (figure 1), people who live in a central location typically drive 20%-40% less and walk, cycle and use public transit two to four times more than they would at a suburban urban fringe location.' 'Increased density tends to reduce traffic speeds, increase congestion and reduce parking supply, making driving less attractive compared with other modes.' Increased density tends to reduce per capita vehicle ownership and use, and increase use of alternative modes. Litman reported Manville and Shoup (2005) found the coefficient between urban population density and per capita annual vehicle mileage is -0.58, meaning each 1% increase in population density is associated with a 0.58% reduction in VMT, and the	The LUTAQH (Land Use, Transportation, Air Quality and Health) research project sponsored by the Puget Sound Regional Council also found per HH VMT declined with increased street connectivity. It concluded that a 10% increase in intersection density reduced VMT by about 0.5%; W/C conditions can increase W/C - some recreational use, some transport related. Most concrete evidence for cycle lanes (cites Handy et al 2006 & Krizek 2006 - already reviewed)	Regional accessibility tends to have little effect on total trip generation but a major effect on trip length and thus per capita vehicle travel. Litman notes that Kockelman (1997) found accessibility (measured as the number of jobs within a 30-minute travel distance) was one of the strongest predictors of HH vehicle travel, stronger than land use D; residents further away from CBD &/or employment centres tended to have longer commute distances/travel time; increased workplace D reduced car commute. Jobs/ housing balance refers to the ratio of residents and jobs in an area. Two other research projects found a jobs/housing balance of	

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
			coefficient between density and VMT per square mile is 0.90.		about 1.0 tended to reduce average commute distance and per capita vehicle travel.	
Litman, T (2008) Land use density and clustering.	General review of density and clustering – have reviewed some key sources separately.		Definitions of clustering and density – units per acre, occupants per unit. An earlier survey was reported to have 'found 83% of consumers prefer suburban housing, but the features respondents value most are NHD security, quality schools and NHD quality. This suggests some households would choose higher density, multi-modal locations if they had such amenities'.	Refer Turcotte 2008	Similarly, a [1994] survey of the Puget Sound region housing market found although the majority of respondents prefer a detached home, most care more about the quality of their NHD and owning their own home than about housing type, and more than 90% would willingly trade low-density housing for a medium or high density home if it had other desirable features'	
Brownstone (2008) Key relationships between the built environment and VMT. Special report 298: driving and the built environment: the effects of compact development on motorized travel, energy use, and CO2 emissions. Paper prepared for the Committee on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption.	Examines the relationship between land development patterns, often referred to as the built environment, and motor vehicle travel in the USA – assesses whether petroleum use, and by extension carbon dioxide (CO2) emissions, could be reduced by more compact, mixed-use development, the term used in the report to describe development at higher densities with mixing of land uses. Methodology not clearly specified – series of 'expert' review papers prepared and literature reviews undertaken followed by modelling of effect of increasing density on VMT, etc.	VMT, energy use, CO2 emissions	More compact development patterns are likely to reduce VMT. The most reliable studies estimate that doubling residential density across a metropolitan area might lower household VMT by 5%–12% and up to 25%, if coupled with higher employment concentrations, significant PT improvements, mixed uses and other supportive demand management measures – weakness of this finding is most studies tend to be cross-sectional (at one point in time, no causality), do not account for RSS or for different types of density changes.	Recommended future research: a) longitudinal studies based on panel data to help isolate the effects of different types of development patterns on travel behaviour; studies of changes in metropolitan areas at finer levels of spatial detail to help inform the needs and opportunities for policy intervention; c) careful before-and-after studies of policy interventions to promote more compact, mixed-used development to help determine what works and what does not; d) studies of threshold population and employment densities to support rail and bus transit and walking and bicycling, which would update old references and help guide infrastructure investments as well as zoning and land use plans; and e) studies of changing housing preferences and travel patterns of an aging population, new immigrant groups, and young adults to help determine whether		

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
				future trends will differ from those of the past.		
Saelens, BE and SL Handy (2008) Built environment correlates of walking: a review. Medicine &. Science in Sports & Exercise 40(7 Suppl):S550-66	Split into two rows: This one on the review of reviews & next one on review of new research – 13 reviews published between 2002 and 2006. Results were summarised based on specific characteristics of the BE and transportation W versus recreational W.		The most consistent set of conclusions relates to proximity to potential destinations. 5R found sufficient evidence to conclude accessibility based on distance to destinations was associated with more walking. 3R concluded mixed land use was also associated with more walking. Because mixed land use means destinations are within closer proximity, this finding is consistent with the findings for accessibility. 3R point to density as an important correlate of walking. This finding is also probably related to proximity: in areas with higher density, destinations can be closer together because the number of people needed to support any activity is found within a smaller area. However, both mixed land use and density might also influence the aesthetic qualities of the walking environment and thus as correlates of walking would reflect the combined effect of proximity and aesthetics.	Adults 18+ years old living in areas with higher residential density (eg the number of people living within an acre) and greater land-use mix and closer proximity between residential and non-residential land uses (eg retail, other commercial, services) are consistently related to more active transportation, mostly walking.	Cross-sectional studies of the BE and W have been most criticised on the issue of RSS, observed associations between the BE and walking were potentially explained by the prior self-selection of residents into a BE consistent with their predispositions toward walking. The limited evidence available suggests RSS occurs but that the BE influences walking even after accounting for self-selection. Several different methods other than prospective design have been used to control for self-selection in the transportation planning field; these studies also point to an impact of the BE after controlling for SS, though the magnitude of the effect varies across studies.	No rigorous quantitative review (eg meta-analysis) of this evidence; many reviews point to need for better conceptual models to guide future studies (2, 29, 32, 37, 54, 58). Most generally, researchers need to look at 'structural relationships between variables' and undertake a 'deeper examination of direct and indirect relationships, interactions, and hypothesized paths of causality' (52). Researchers must give further consideration to confounding factors, which have been inconsistently evaluated in previous studies (44, 58); do not account for the possibility that walking, particularly transportation walking, substitutes for other forms of PA – - it is possible an increase in transportation walking resulting from a change to the BE substitutes for other forms of PA without increasing overall PA.
Saelens BE and Handy SL (2008) Built environment correlates of walking: a review. Medicine &. Science in Sports & Exercise 40(7 Suppl):S550-66	Split into two rows: one above on the review of reviews & this one on review of new research – systematic search & inclusion criteria (good example for report). 29 original studies published in 2005 and up through May 2006. Results were summarised based on specific characteristics of the BE and transportation walking versus recreational walking.		Findings for route/network connectivity, parks and open space, and personal safety are more equivocal with approximately equal numbers of expected versus null/ unexpected results. Little or no evidence for relations between TW and pedestrian infrastructure conditions, traffic-related issues, aesthetics, or accessibility of physical activity facilities.	Document consistent positive relations between walking for transportation and density (6 studies), distance to nonresidential destinations (7 studies), and land use mix (8 studies).	The issue on which researchers have made the least progress in examining relations between environment and walking is causality. Further, the measurement and control for potential confounding factors in the relation between BE and walking, including demographic and SS factors, lends more credence to a true causal relationship; common in recent studies to include demographic covariates (eg age, gender, income/ education level), with some variability in the specific demo factors considered across studies, but less common to include	Need to evaluate and analyse demo and other potential confounding variables at both the individual respondent and larger environmental level (eg NHD). This is particularly important given the multilevel nature of the data and the need for corresponding multilevel analyses, with such type of analyses not universal in the studies reviewed.

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
					psychosocial correlates of PA and SS as potential confounders.	
Saelens, BE and C Papadopoulos (2008) The importance of the built environment in older adults' physical activity: a review of the literature.	Review - in some cases, of reviews of current research literature (since 2004) on the importance of the BE on physical activity of older adults. This review article also examines the correlation between characteristics of the physical environment and PA in this population.		One study found employment and household density were related to greater walking among older adults. Three studies found having closer retail destinations and services to one's residence was related to older adults' physical activity and particularly walking for transportation. However, one study found that older women living in areas of more mixed land uses reported less walking than older women in residential-only areas.	Evidence regarding associations between levels of perceived personal safety concerns and actual physical activity among older adults though is equivocal.	In one study, various built environment factors were found related to seniors' physical activity. After accounting for social cohesion, some of these associations were significantly reduced, suggesting social cohesion was more important than BE in influencing seniors' physical activity (King 2008).	More evidence needed. Stronger research designs will help to determine whether changes in NHD environment would lead to increases in seniors' PA.
Ewing, R and R Cervero (2010) Travel and the built environment.	Meta-analysis of the BE & TB literature to end of 2009 in order to draw generalisable conclusions for practice. Quantified effect sizes for more than 50 studies, including walking and PT outcome measures in addition to VMT and vehicle trips, and addressed the methodological issue of self-selection, computed elasticities for individual studies and pooled them to produce weighted averages. 2001 study was updated.	D's as a measure of BE: density; diversity (aka land use mix); design (eg connectivity, footpath availability, crossings etc); destination accessibility; distance to PT – could incl demand management and demographics. Trip frequency, trip length, mode choice and VMT – calculated weighted average elasticities for VMT, walking trips, PT trips based on the 5 Ds.	The >50 studies chosen all analyse effects of the BE with good data on travel choices while controlling statistically for confounding influences (particularly demographics) on TB. VMT: destination accessibility = most relevant - job accessibility by auto (-0.20) and distance to downtown (-0.22 – as distance to downtown decreases, so does VMT) – job density has 0.0 (no effect) on VMT; destination design (street connectivity and intersections) (-0.12). Living near a bus stop appears to be an inducement to ride transit; Next in importance are road network variables and, then, measures of land use mix; intersection density & connectivity. Controls for residential self-selection appear to increase the absolute magnitude of elasticities if they have any effect at all – notes that this is a contradictory result to that of Cao et al (2009), possibly due to choice of studies or the methodology employed here.	Mode share and likelihood of walk trips are most strongly associated with the design and diversity dimensions of built environments. Intersection density, jobs-housing balance, and distance to stores have the greatest elasticities. jobs-housing balance has a stronger relationship to walking than the more common land-use mix (entropy) variable job density is less strongly related to walking than is population density; having PT stops nearby may encourage walking.		Sample sizes are small; do not know/have confidence intervals for elasticities or meta analysis results; number of studies controlling for residential preferences & attitudes is small.
OECD (2008) Household behaviour and the environment: reviewing the evidence. Accessed	Reviews recent empirical literature, focusing on two types of explanatory variables: those describing the characteristics of the individuals and their residential location and those relating to the characteristics		Vehicle ownership: increases with income; lower where living in close proximity to CBD; lower <25 or >55 years old; increases with HH size (adults &/or children, though lots of children in HH reduces ownership) and if there is an adult male in the HH.	Taxation or price charges (as policy measures) may influence TB, work, and residential location choices in the medium to long term.	From the empirical studies presented in the previous section, some conclusions can be drawn about the characteristics of individuals who are more likely to have travel behaviour patterns which can be considered	

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
August 2010 from www.oecd.org	of the transport system. Explanatory & dependent variables vary by study; most are based on disaggregate survey data - *lots of reporting on demographics and policy measures and their perceived effects, focus here on BE & tpt use.*		Car use: lower in denser areas; where frequent PT services; local access to shops (within 10 mins walk); larger urban areas. PT use greater in large cities; and by those living in denser, central and mixed-use areas; younger and older people; by those with a concern for the environment. Inconclusive results in material reviewed on total travel.		more environmentally friendly, in the sense they travel less, particularly by car. On the basis of this definition, the travel behaviour of women, the young, the elderly, the less-educated, those living in urban areas and those with lower incomes is more environment-friendly than the travel behaviour of men, those in middle age, the more-educated, those living in rural or suburban areas and those with high incomes. However, this difference is not necessarily a result of conscious environmental choices, but primarily reflects differences in transport needs and options available to different individuals. Those with low incomes, for example, travel less by car not because they are more concerned for the environment, but because they cannot afford cars.	
Turcotte, M (2008) Dependence on cars in urban neighbourhoods . Canadian Social Trends, vol 85 (Summer 2008). pp 20-31. Accessed March 2009 from www.statcan.ca	Uses a subset of data from the 2005 General Social Survey (total dataset N=19597) on time use to examine motor vehicle use by Canadians aged 18 and over who made at least one trip commuting and/or running errands on the survey reference day looks at relationship between the types of NHD in which people live and the use of cars for daily travel.		Those who lived 25km from the centre of a census metropolitan area (CMA) spent an average of 83 minutes per day in the car. In comparison, those who lived within 5km of the centre of their CMA spent an average of just 55 minutes travelling by car, whether as the driver or a passenger. 61% of people living in a central NHD got behind the wheel, compared with 73% of people living between 10 and 14km from the city centre and 81% of people living 25km+ from the centre. 80% of those in low density NHD made at least 1 car trip on the survey day, while less than one-half of those in high density NHD did so.	Travelling exclusively by driving was far more common in low density NHDs. Only about one-third of residents in very high density NHD made all their trips by car on the survey day, compared with more than 2/3s of low density NHD. Driver behaviour in smaller 'census metropolitan areas' was more like low density NHD than in large CMAs (higher density, better PT, etc). When the density of residential NHD and other factors in the statistical model were kept constant, the odds that people aged 45–54 drove a car on all the trips they made in a given day was 2.5 times higher than the odds for 18- to 24-	Holding the effect of age, sex, income and so on constant, still found the odds indicated that residents in low density NHD and residents further from CMA were more likely to have at least one driving trip, or all trips by driving or all trips by driving or passenger. Keeping constant all factors associated with vehicle use, found that in central and near-peripheral NHDs 5 to 9 km from the city centre, living in a low density NHD was associated with a higher predicted probability of using a car for all trips. However, beyond 10km from the city centre, no statistically significant correlate between density	

Author, title and date	Review design and research type/ quality	Outcome variables (inc measures)	Primary findings	Active transport factors	Non-physical activity outcomes	Confounders/ potential sources of bias
				year olds. People with children aged 5 to 12 also had odds 1.6 times higher than people without children that age to have driven on at least one trip. Main conclusion: the overall patterns are very similar in CMAs of all sizes: the greater the distance from the city centre, and the greater the prevalence of traditional suburban dwellings, the higher the proportion of people who made their trips by car as the driver or a passenger.	and car use (possibly due to less mixed use in NHDs). Car use for all trips common whatever the density.	
van Wee, B (2009) Self-selection: a key to a better understanding of location choices, travel behaviour and transport externalities? Transport Reviews 29(3):279–292.	Argues self-selection may be key to a better understanding of people's choices that are relevant for travel behaviour and the external effects of transport. The theory of self-selection is relatively simple. People's choices are based on 1) variables included in a model (including interactions between the variables); 2) variables not included in the model ('omitted variables') (including their mutual interactions); and 3) interactions between the variables from 1) and 2). A problem is that 3) can exist: the unobserved variables can be correlated with the observed variables.		Main messages: 1) that people can SS in many more ways than with respect to residential choice, and 2) understanding SS (either residential or in other ways) could significantly contribute to our understanding of TB, location choices and transport externalities. Options for SS include locations & activities (eg work or residential location, non-work destinations); travel behaviour preferences (mode choice, travel frequency, travel time, travel distances); exposure to transport externalities (congestion, safety/risk, noise); vehicle choice and driving behaviour. Remainder of article speculates on how the various SS options might impact on TB. Also discusses potential research methods: preference quantitative model-based, could be qualitative.	Ignoring self-selection generally (but certainly not always) leads to an overestimation of the importance of variables included in models for location choice and travel behaviour.		
Tal, G, Handy S and Boarnet M (2010) Network Connectivity (2 draft mini-papers)	Selected review of studies on effect of connectivity on VMT.	Various – not consistent.	Every study used a different measure of connectivity, focused on street network (ie excluded rail) and residential areas in determining effect on VMT. Did not consider destination connectivity, which could affect VMT or changes in connectivity over time.	Suggests a high level of uncertainty about the effect of connectivity, from a very small effect to a substantial effect. The higher estimated effects are likely to reflect differences between NHDs other than just connectivity between different residential areas.		

B.8 Excluded studies

Study reference	Reason for exclusion
Alford, G and J Whiteman (2008) Macro-urban form and transport energy outcomes – investigations for Melbourne. ATRF.	A discussion of some of the results from the Department's modelling of transport energy outcomes for the Melbourne region, with a focus on the impacts of different macro-urban form typologies on transport energy trip usage.
Antipova, A (2010) Land use, individual attributes, and travel behavior in Baton Rouge, Louisiana. PhD thesis, The Department of Geography and Anthropology, Louisiana State University.	Uses existing US PTS data – too high level/aggregated to be particularly useful
Arrington, GB and R Cervero (2008) Effects of TOD on housing, parking and travel. *TCRP report 128*. US: Transportation Research Board	In literature review – some good summaries of earlier studies and mode share resulting from TOD; empirical work – mode share and vehicle trip generation rates; impact of density and parking; some 'drawings' of 'good' TOD design/standards.
Aytur, SA, DA Rodriguez, KR Evenson, DJ Catellier and WD Rosamond (2007) Promoting active community environments through land use and transportation planning. *Health Promotion 21, no.4S: 397–407*.	Cross-sectional design considering relationship between policy (planning and implementation) and propensity to PA – assesses what is on paper, rather than actual implementation on the ground.
Banister, C (1993) The greening of urban transport – planning for walking and cycling in western cities. *Transport Reviews 13*, no.4: 375–376.	Not an intervention study – book review.
Ben-Akiva, E Moshe and JL Bowman (1998) Integration of an activity-based model system and a residential location model. *Urban Studies 35*, no.7: 1231–1253.	Not an intervention study – models residential location relationship using travel survey data only.
Bennett, JM and NP Isaacs (2009) New Zealand apartment living: developing a liveability index. *The Built & Human Environment Review 2*, no.1: 58–70.	Interesting, but not relevant.
Bhat, CR and JY Guo (2006) An innovative methodological framework to analyze the impact of built environment characteristics on activity-travel choices.	Superseded by Bhat and Guo (2006) A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels. (see chapter 8 References)
Biddle, T, T Bertoia, S Greaves and P Stopher (2006) The costs of infill versus greenfield development – a review of recent literature. *Paper presented at the 29th Australasian Transport Research Forum, Gold Coast*, September 2006.	Some useful definitions; reviews recent literature related to assessments of the total community costs of developing infill versus greenfield areas. The selection of reviewed studies offered different approaches to quantifying the comparative costs.
Boodoo, A (2010) Designing walkable environments: the impact of urban form on pedestrian perception. Accessed November 2010 from *www.worldcarfree.net/conference/2010/programme_full.php*	Outside scope.
Brunner, B and U Haefeli (2008) Moving towards sustainability? The consequences of residential relocation for mobility and the built environment – methodological aspects of our experimental intervention study. *8th International Conference on Survey Methods in Transport*, Annecy, France, 25–31 May 2008.	TB change interventions at time of moving house – paper focuses on the evaluation methodology.
Buchanan, N, R Barnett, S Kingham and D Johnston (2006) The effect of urban growth on commuting patterns in Christchurch. *Journal of Transport Geography 14*: 342–354.	Interesting, but not relevant.
Buehler, R (2008) Transport policies, travel behavior, and sustainability: a comparison of Germany and the US. PhD thesis. Graduate School, New Brunswick Rutgers, The State University of New Jersey.	Influence of transport policies on individual travel behaviour in Germany and the USA.
Built environment and active transportation (BEAT). Fall 2008. BEAT the path to health. Accessed February 2009 from *www.PhysicalActivityStrategy.ca*	Benefits of investment in active transport.
Cao, XY, PL Mokhtarian and SL Handy (2009) Examining the impacts of residential self-selection on travel behavior: a focus on empirical findings. Transport Reviews	Included in Cao et al 2008.
Chatman, DG (2009) Residential choice, the built environment, and nonwork travel: evidence using new data and methods. Environment and Planning A 41 (forthcoming)	Included in Chatman 2005.
Committee on Physical Activity, Health Transportation, and Land Use (2005) Does the built environment influence physical activity? Examining the evidence.	Not an intervention study – descriptive review and recommendations.

Study reference	Reason for exclusion
Cote, A and S Coffey (2001) The best cycling cities: meet 10 urban places that do cycling right - population, sprawl and congestion be damned! *Bicycling.* 42, no.11: 32–39.	Not an intervention study – magazine article.
Cunningham, G and Y Michael (2004) Concepts guiding the study of the built environment on physical activity for older adults: a review of the literature. *American Journal of Public Health 18*, no.6: 435–43.	Included in Bauman and Bull 2007; Saelens and Handy 2008.
Davidson, KK and C Lawson (2006) Do attributes of the physical environment influence children's level of physical activity? International Journal of *Behavioural Nutrition and Physical Activity 3*, no.19: 1–17.	Included in Bauman and Bull 2007.
Designing Communities for Active Living (2004) *The Journal of Physical Education, Recreation & Dance 75*, no.2: 8.	Not an intervention study.
DFT (2008) Building sustainable transport into new developments: a menu of options for growth points and eco-towns.	Advice on how to build an effective sustainable transport system in new developments, from the planning to the implementation stage.
Dill, J. Where do people bicycle? The role of infrastructure in determining bicycling behavior. Powerpoint presentation. Accessed from *http://web.pdx.edu/~jdill/*	Simply about biking habits.
Dublanko, N (2009) Long-term urban change around SkyTrain stations in Vancouver, BC: A demographic shift-share analysis.	How Vancouver Sky Train has shaped urban form – outside purview of project.
Duncan, MS and K Mummery (2005) Perceived environment and physical activity: a meta-analysis of selected environmental characteristics. International *Journal of Behavioural Nutrition and Physical Activity 5*: 2–11.	Included in Bauman and Bull 2007.
Egan, M, M Petticrew, D Ogilvie and V Hamilton (2003) New roads and human health: a systematic review. *American Journal of Public Health American Public Health Association, Washington 9*: 1471.	Review (non-specific).
Ettema, D (2010) The impact of telecommuting on residential relocation and residential preferences – a latent class modeling approach. *The Journal of Transport and Land Use 3*, no.1: 7–24.	Outside scope: focus on residential location decisions of telecommuters vs commuters.
Falconer, R, B Giles-Corti and T Lyons (2007) Exhausting the city: implications of land use and transport in Perth, Australia. *World Transport Policy & Practice 13*, no.2: 78–105.	Sets context/history leading up to LN and TravelSmart.
Falconer, R, J Kenworth and B Giles-Corti (2006) Model suburbs? Investigating transport, health and quality outcomes in Perth/Peel's 'liveable neighbourhoods'. Accessed February 2009 from *www.patrec.org/conferences*	Describes (evaluative) research method and few preliminary results.
Forsyth, A, JM Oakes et al (2007) Does residential density increase walking and other physical activity? *Urban Studies 44*, no.4: 679–697.	Have not obtained – is reporting on same study as other articles.
Forsyth, A, M Hears, J Oakes and MK Schmitz (2008) Design and destinations: factors influencing walking and total physical activity (2008) *Urban Studies 45*, no.9: 1973–1996.	Have not obtained – is reporting on same study as other articles.
Foster, C and M Hillsdon (2004) Changing the environment to promote health-enhancing physical activity. *Journal of Sports Science 22*, no.8: 755–769.	Review (non specific) – 3/17 studies may be relevant.
Frank, LD and PO Engelke (2001) *How land use and transportation systems impact public health: A literature review of the relationship between physical activity and built form*. Atlanta, GA: Centre for Disease Control and Prevention.	Not an intervention study.
Frank, LD (2004) Public health and the built environment: emerging evidence and complexity. *Canadian Journal of Dietetic Practice & Research 65*, no.2: 4.	Not an intervention study.
Garrett, N, L Mackay, H Badland, C Svendsen and G Schofield (2007) Active friendly environments: physical activity and the built environment research. Executive summary.	Examined relationship between PA and urban environment. Executive summary is very general - considered TPA as part of overall PA.
Gauvin, L, L Richard, CL Craig et al (2005) From walkability to active living potential: an 'ecometric' validation study. *American Journal of Preventive Medicine 28*: 126–33.	Included in Saelens and Handy (2008) - trialling a methodology to assess neighbourhood walkability – 10 point scale assessed by pairs of observers. Assessment items very generalised.
Gibson, M (2002) Sustainable suburban travel – do developers hold the keys?	
Giles-Corti, B and RJ Donovan, (2003) Relative influences of individual, social environmental and physical environmental correlates of walking. *American Journal of Public Health 93*: 1583–1589.	Perth study – PA levels; walking definitions vs restrictive hence results not that relevant.

Study reference	Reason for exclusion
Giulano, G, HH Hu and K Lee (2003) Travel patterns of the elderly: the role of land use. Final report. Metrans Project 00-8.	NPTS analysis of older people's travel patterns, then commentary on impact of transit-oriented development and mixed use development on them.
Gordon, I (1997) Densities, urban form and travel behavior. *Town and Country Planning 66,* no.9.	Have 2008 paper - similar subject (and not relevant).
Gordon, I (2008) Density and the built environment. *Energy Policy 36*: 4652–4656	Literature review, speculation and suggestions for future research.
Gustat, J et al (nd) Neighborhood predictors of walking for transportation and exercise: the New Orleans PACE Project Powerpoint presentation.	Very specific target group (African American) – does have some characteristics of NHD re safety – walk for leisure vs walk for transport.
Guy, C (2007) Fine words. *Town & Country Planning*.	Editorial/think piece – accessing 3/10 refs.
Handy, S (2004) Health and community design: the impact of the built environment on physical activity. *Journal of American Planning Association 70*, no.3: 375–376.	Not an intervention study – book review.
Handy, S (2005) Critical assessment of the literature on the relationships among transportation, land use, and physical activity. TRB Special Report 282: Does the built environment influence physical activity? Examining the evidence. Paper prepared for the Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use. Accessed February 2009 from *trb.org/publications/sr/sr282.pdf*	
Hart, J (2008) Driven to excess: impacts of motor vehicle traffic on residential quality of life in Bristol, UK. MSC thesis (transport planning), University of the West of England, Bristol.	As traffic increases, social interaction and perceptions of safety in a NHD decreases.
Heath, GW, RC Brownson, J Kruger, K Miles, KE Powell, LT Ramsey and the Task Force on Community Preventive Services (2006) The effectiveness of urban design and land use and transport policies and practices to increase physical activity: A systematic review. *Journal of Physical Activity & Health 3*: S55–S76.	Included in Saelens and Handy (2008).
Hooker, ST et al (nd) Population survey of pedestrian activity in California adults: who is active when, where, and why.	Large NZHTS type survey, also included factors considered when deciding to engage in pedestrian activity.
Humpel, N, N Owen and E Leslie (2002). Environmental factors associated with adults' participation in physical activity. *American Journal of Preventive Medicine 22*, no.3: 188–99.	Included in Bauman and Bull 2007, Badland and Schofield (2005a) and Saelens and Handy (2008).
Jackson, RJ (2003) The impact of the built environment on health: an emerging field. *American Journal of Public Health 93*, no.9: 1382–1384.	Not an intervention study - opinion/ descriptive overview
Kerr, J (2008) Designing for active living among adults. Research summary. Accessed from *www.activelivingresearch.org*	Literature review relating levels of PA and/or walking to BE. No intervention.
Kim, J-H, F Pagliara and J Preston (2005) The intention to move and residential location choice behaviour. *Urban Studies Journal 42*, no.9: 1621–1636.	While density is referred to, not about mode choice or effect.
Krizek, K and P Waddell (2003) Analysis of lifestyle choices: neighborhood type, travel patterns, and activity participation. *Journal of the Transportation Research Board, Transportation Research Record 1807*: pp119–128.	Have Krizek (2006) paper – very similar.
Kumar, AM (2009) The effect of the neighbourhood built environment on obesity in Christchurch. Masters of Science thesis, University of Canterbury, Christchurch.	How BE (eg green space or food premises) vary by neighbourhood and could influence obesity – conclusions questionable?
Lawrence Frank and Company (2008) Reducing global warming and air pollution: the role of green development in California. Prepared for Environmental Defense Fund.	Review – synthesises literature on the relationship between land use, travel behaviour and vehicle emissions-- 'indirect source rule' proposed solution to reducing GHG and other pollution.
Layfield, R, L Chinn and D Nicholls (2003) *Pilot home zone schemes: evaluation of The Methleys, Leeds*. Transport Research Laboratory, UK.	Home zone evaluation.
Lee, C and A Moudon (2004) Physical activity and environment research in the health field: implications for urban and transport planning practice and research. *Journal of Planning Literature19*, no.2: 147–81.	Included in Bauman and Bull 2007; Saelens and Handy (2008).
Litman, T (2004) Understanding smart growth savings. What we know about public infrastructure and service cost savings, and how they are misrepresented by critics. Victoria Transport Policy Institute Accessed from *www.vtpi.org*.	Compares costs of providing infrastructure and other services in a 'sprawl' setting vs 'smart growth'. Specifically a critique of Cox and Utt.
Litman, T (2008) Evaluating transportation land use impacts. Victoria Transport Policy Institute. Accessed from *www.vtpi.org*.	Transport development patterns – transport planning resulting in particular land uses and how to evaluate their impacts.

Study reference	Reason for exclusion
Litman, T (2008) Smart growth reforms changing planning, regulatory and fiscal practices to support more efficient land use. Victoria Transport Policy Institute. Accessed from *www.vtpi.org*.	Describes 15 categories of 'smart growth' reforms and dozens of specific implementation strategies.
McCormack, B Giles-Corti, A Lange, T Smith, K Martin and T Opikora (2004) An update of recent evidence of the relationship between objective and self report measures of the physical environment and physical activity behaviours. *Journal of Science and Medicine in Sport 7*, no.1: 81–92.	Included in Bauman and Bull 2007; Badland and Schofield (2005a); Saelens and Handy (2008).
Mees, P (2009) Density and transport mode choice in Australian, Canadian and US cities. In *Proceedings from Australasian Transportation Research Forum,* Auckland, New Zealand, 29 Sept – 1 Oct 2009,.	Not relevant – revisits Kenworthy and Newman with more recent accurately measured data and finds that population density is only very weakly related to PT use and not at all linked with W/C.
Mokhtarian, PL and XY Cao (2008). Examining the impacts of residential self-selection on travel behavior: A focus on methodologies. *Transportation Research B 42*, no.3: 204–228.	Included in Cao et al (2008).
Mokhtarian, PL, DT Ory and XY Cao (2008) Shopping-related attitudes: a factor and cluster analysis of Northern California shoppers. Environment and Planning B: Planning and Design (advance online publication)	Shopping channel user segmentation.
Newby, L and L Sloman (1996) Small steps, giant leaps. A review of the Feet First project and the practice and potential of promoting walking. Environ, Leicester (GB); Transport 2000 Trust, London (GB).	Essentially a traffic calming study.
Organisation for Economic Co-operation and Development (OECD) (2008) Household behaviour and the environment. Reviewing the evidence.	
Owen, N, N Humpel, E Leslie, A Bauman and JF Sallis (2004) Understanding environmental influences on walking: Review and research agenda. *American Journal of Preventive Medicine 27*, no.1: 67–76.	Included in Bauman and Bull 2007; Badland and Schofield (2005a); Saelens and Handy (2008).
Pagliara, F, J Preston and J-H Kim (2002) Residential location choice behaviour in Oxfordshire. In *Proceedings from the European Transport Conference,* Cambridge, 2002.	While density is referred to, not about mode choice or effect.
Painter, K (1996) The influence of street lighting improvements on crime, fear and pedestrian street use, after dark. *Landscape and Urban Planning 35:* 193–201.	Before and after studies of pedestrian improvements to BE.
Pinjari, AR, N Eluru, CR Bhat, RM Pendyala and E Spissu (2008) Joint model of choice of residential neighborhood and bicycle ownership: accounting for self-selection and unobserved heterogeneity travel behavior analysis. Pp 17–26.	Bicycle ownership by HH – significant finding: ignoring RSS may not always result in overestimating effects-- ignoring RSS, had underestimate of bicycle ownership.
Powell, KE (2005) Land use, the built environment, and physical activity: a public health mixture; a public health solution. *American Journal of Preventive Medicine 28*, no.2S2: 216–217.	Not an intervention study – commentary.
Redmond, L (2000) Identifying and analyzing travel-related attitudinal, personality, and lifestyle clusters in the San Francisco Bay Area. Institute of Transportation Studies (University of California, Davis) *Paper UCD-ITS-RR-00-08.*	Provides statements from surveys referred to in Schwanen and Mokhtarian (2005).
Rodriguez, DA, AJ Khattak and KR Evenson (2006) Can new urbanism encourage physical activity? Comparing a new urbanist neighborhood with conventional suburbs. *Journal of American Planning Association 72*, no.1: 43–54.	Not an intervention study – cross sectional design.
Saelens, B, J Sallis and L Frank (2003) Environmental correlates of walking and cycling: findings from the transportation, urban design and planning literatures. *Annals of Behavioural Medicine 25*, no.2: 80–91.	Included in Bauman and Bull 2007; Badland and Schofield (2005a); Saelens and Handy (2008).
Sallis, J, L Frank, B Saelens and M Kraft (2004) Active transportation and physical activity: opportunities for collaboration on transportation and public health research. *Transportation Research 38*: 249–268.	Included in Bauman and Bull 2007; Badland and Schofield (2005a).
Sharpin, AB (2006) *Urban development strategy working paper 6: the social and environmental effects of residential infill development in New Zealand. A literature review.* Paper prepared for Wellington City Council.	Discusses possible impacts of infill in a New Zealand context. Traffic problems mentioned.
Sisson, SB (2005) Taking it to the streets: Increasing physical activity through community improvement: Part one. *ACSMs Health & Fitness Journal 6*: 8–11.	Not an intervention study.

Study reference	Reason for exclusion
Soltani, A and F Primerano (2008) The travel effects of community design. *28th Australian Transport Research Forum*.	Uses HTS data, GIS, urban design and network data, etc to general MNL models of how different development patterns affect mode choice.
Space Syntax Ltd (2002) *Millennium bridge and environs: pedestrian impact assessment study*. London: Space Syntax Ltd.	Before and after studies of pedestrian improvements to BE.
Space Syntax Ltd (2004a) Trafalgar Square: comparative study of space use patterns following the re-design of the public space. London: Space Syntax Ltd.	Before and after studies of pedestrian improvements to BE.
Space Syntax Ltd (2004b) Paternoster Square: comparative study of pedestrian flows following the re-design of the public space. London: Space Syntax Ltd.	Before and after studies of pedestrian improvements to BE.
Stanilov, K (2004) Health and community design: the impact of the built environment on physical activity. *J. Planning Ed. & Res* 24, no.1: 107–108.	Outside scope.
Stauffacher, M, R Schlich, KW Axhausen and R Scholz (2005) The diversity of travel behaviour: motives and social interactions in leisure time activities, *Arbeitsberichte Verkehr- und Raumplanung 30x*, IVT, ETH Zürich, Zürich.	Outside scope.
Talen, E (2001) Traditional urbanism meets residential affluence: an analysis of the variability of suburban preference. *Journal of the American Planning Association 67*, no.2: 199–216.	Exploratory study examining residential preferences for suburban living of wealthy Americans.
Taniguchi, M (2003) The new guideline for sustainable urban layout – to reduce the reliance on the automobile. *WCTR–SIG1 Meeting in Sendai - Increasing Roles of Land Use - Transport Instruments for Sustainable Cities and Communities* 26 May 2003.	Analysis of Japan NPTS plus BE info (eg rail station and services) – related to petrol consumption.
Transportation Alternatives (2008) Streets to live by: how livable street design can bring economic, health and quality-of-life benefits to New York City. Available from *www.transalt.org*.	Marketing pitch to extend liveable streets programme in NY – providing 'evidence' of impacts and arguments for doing it.
Transportation Research Board (2002) Transportation environmental research needs statements. *Report of Environmental Research Needs Conference Washington, DC*. 21–23 March 2002	Overview of (future) research needs.
Trost, SG, N Owen, AE Bauman, JF Sallis and W Brown (2002) Correlates of adult's participation in physical activity: review and update. *Med Science Sports and Exercise 34*, no.12: 1996–2001.	Included in Bauman and Bull 2007.
Van Acker, V, B van Wee and F Witlox (2010) When transport geography meets social psychology: toward a conceptual model of travel behaviour. *Transport Reviews 30*, no.2: 219–240.	Develops a conceptual model for future testing.
van Reenen, KM (2007) Residential densification in Dunedin: impacts and acceptability. Masters of Planning thesis, University of Otago, Dunedin.	Poor research design renders results meaningless for current project.
van Wee, B and K Maat (2003) Land-use and transport: a review and discussion of Dutch research. *EJTIR 3*, no.2: 199–218.	Unsystematic review with no clear objective.
Vernez, MA (2005) Active living research and the urban design, planning, and transportation disciplines. *American Journal of Preventive Medicine 28*, no.2S2: 214–215.	Not an intervention study – commentary.
Vojnovic, I (2006) Building communities to promote physical activity: a multi-scale geographical analysis. *Geografiska Annaler Series B-Human Geography 88B*, no.1: 67–90.	Included in Bauman and Bull 2007.
Walton, D, SJ Murray and JA Thomas (2007) Population density and perceived neighbourhood quality. Accessed January 2010 from *www.learningsustainability.org.nz/lspublications.htm*	Not relevant – perceived neighbourhood quality; transport not discussed, also published as a journal article: Walton, D, SJ Murray and JA Thomas (2008) Relationships between population density and the perceived quality of neighbourhood. *Social Indicators Research 89*, no.3: 405–420.
Walton, D and S Sunseri (2007) Impediments to walking as a mode choice. *Land Transport NZ research report 329*. 46pp.	Looks at decisions regarding walking/driving to PT station.
Ward, M, J Dixon, B Sadler and J Wilson (2007) Integrating land use and transport planning. *Land Transport NZ research report 333*. 116pp.	Land use planning guidelines/frameworks.
Webber, C and G Athey (2007) The route to growth: transport, density and productivity. *www.ippr.org/centreforcities* briefing paper no. 4:	Agglomeration benefits.
Wells, N and Y Yang (2008) Neighborhood design and walking: a quasi-experimental longitudinal study. *American Journal of Preventive Medicine 34*, no.4: 313–319.	Exploratory study based on very low-socio economic women.
Wendel-Vos, GC, A Schuit, Jantine, R De Niet, H Boshuizen, W Saris and D Kromhout (2004) Factors of the physical environment associated with walking and bicycling. *Medicine & Science in Sports & Exercise 36*, no.4: 725–730.	Included in Bauman and Bull 2007; Badland and Schofield (2005a).

Study reference	Reason for exclusion
White, RR (2005) Health and community design: the impact of the built environment on physical activity. *Ecological Economics 52*, no.2: 258–259.	Not an intervention study – book review.
Williams, K (2007) Can urban intensification contribute to sustainable cities? An international perspective. Accessed from: *www.urbanicity.org/ 2*	(Opinion) re: compact cities and densification issues in developed v. developing countries.
Yanagawa, T (2004) We are where we live: creating environments that improve our health. 'Smart growth' challenges us to build 'livable, walkable communities'. *Active Living 13*, no.5: 22–24.	Not an intervention study.
Zegras, C, E Ben-Joseph, F Hebbert and J Coughlin (2007) Everyday life without a car would be impossible. A comparative study of baby boomers' travel behavior and residential preferences in age-restricted and typical suburban neighborhoods. *Paper presented at Transportation Research Board 2008 Annual Meeting*.	Outside scope - focus on 'urban edge neighbourhoods' and 55 to 65 year olds – focus groups.
Zhou, B and KM Kockelman (2008) Self-selection in home choice: use of treatment effects in evaluating the relationship between the built environment and travel behavior. Forthcoming in Transportation Research Record 2008.	Uses HTS data in Austin to compare VMT in CBD/core residential areas and suburban/rural areas; creates latent index model.

Appendix C: Intensification questionnaire (final version)

C.1. Screening questions

S1 Which best describes you? Select 1 response.

A	Working full time (30+ hours per week)
B	Working part time (less than 30 hours per week)
C	Full-time student
D	Part-time student
E	Looking for work/unemployed
F	Looking after home and family
G	Retired
H	Beneficiary
I	Other

S1b Which of these cities do you live in?

If C or D selected in S1 please use 'Which of these cities do you live in term time?'

Auckland	1	Go to S2.1 (max n=300)
Wellington	2	Go to S2.2 (max n=300)
Christchurch	3	Terminate survey
Other location	4	Terminate survey

If one choice is A or B then WORK section

If one choice is C or D then STUDY section

If choice is E through I →*Go to Q26*

S2.1. Looking at the map above, please tell us where your residence is located.

A	In Auckland's central city area (as highlighted by yellow)	
B	Elsewhere in Auckland city	
C	In another Auckland region city (Waitakere, North Shore, Manukau)	
D	Somewhere else (where?) _____	**TERMINATE**

S2.2 Looking at the map above, please tell us where your residence is located.

A	In Wellington's central city area (as highlighted by yellow)	
B	Elsewhere in Wellington city	
C	In another Wellington region city (Lower Hutt; Upper Hutt; Porirua/Tawa)	
D	Somewhere else (where?) _____	**TERMINATE**

Programmer instruction

Need at least N=120 respondents residing in central city areas across both Auckland and Wellington, eg minimum quota N=120 who answer EITHER A at S2.1or A at S2.2

C.2 Commuting to work or study (Auckland and Wellington workers and students)

C.2.1 WORK section

WK2 In the last 4 weeks, how often did you use each of the following travel methods to ***commute to work***?

	5–7 days a week	3–4 days a week	1–2 days a week	Less than one day a week	Not at all
Driving a motor vehicle (car, truck, van, motorcycle)	A	B	C	D	E
Passenger in a motor vehicle	A	B	C	D	E
Walking/jogging	A	B	C	D	E
Bicycle	A	B	C	D	E
Public transport (bus, train, ferry)	A	B	C	D	E

WK4 Please estimate the amount of time it *usually* takes you to commute from your home to your workplace.

_____ minutes

WK5 Indicate your agreement or disagreement with each of the following statements:

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
No matter where I live, I intend to walk, cycle or use public transport to travel to work.	1	2	3	4	5
If I could, I would drive to work every day.	1	2	3	4	5

C.2.2 STUDY section

Please answer the following questions **as if you're living where you lived during your most recent term of study/training**, even though you may have 'gone home' for the summer break.

ST2 In the last 4 weeks of your most recent term, how often did you use each of the following travel methods to **commute to your study/training**?

	5–7 days a week	3–4 days a week	1–2 days a week	Less than one day a week	Not at all
Driving a motor vehicle (car, truck, van, motorcycle)	A	B	C	D	E
Passenger in a motor vehicle	A	B	C	D	E
Walking/jogging	A	B	C	D	E
Bicycle	A	B	C	D	E
Public transport (bus, train, ferry)	A	B	C	D	E

ST4 Please estimate the amount of time it *usually* takes you to commute from your home to your study/training.

_____ minutes

ST5 Indicate your agreement or disagreement with each of the following statements:

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
No matter where I live, I intend to walk, cycle or use public transport to travel to study/training.	1	2	3	4	5
If I could, I would drive to my study/training course every day.	1	2	3	4	5

C.3 Characteristics of current residence (all)

(Show this message to respondents answering C or D to Q1):

Please answer the following questions **as if you're living where you lived during your most recent term of study/training**, even though you may have 'gone home' for the summer break.

26 Which best describes your current household? PLEASE TICK ONE BOX ONLY

A	Couple living alone
B	Couple or extended family living with children, **some** aged 0–17 years.
C	Couple or extended family living with children, **all** aged 18 years or older.
D	Single adult living with children, **some** aged 0–17 years.

E	Single adult living with children, **all** aged 18 years or older.
F	Adult living alone
G	Adult living with other adults
H	Living with my parents/guardians
I	Other (please specify……..)

27 Including yourself, how many people in your household are aged 18 or older?

Please do NOT include anyone who usually lives somewhere else or is just visiting, such as a college student away at school.

0	1	2	3	4	5 or more people

28 **In the last 4 weeks**, how often did you use each of the following travel methods to get from place to place?

	5-7 days a week	3-4 days a week	1-2 days a week	Less than 1 day a week	Not at all
Driving a motor vehicle (car, van, truck, motorcycle)	A	B	C	D	E
Passenger in a motor vehicle	A	B	C	D	E
Walking/jogging	A	B	C	D	E
Bicycle	A	B	C	D	E
Public transport (bus, train, ferry)	A	B	C	D	E

29 How many motor vehicles (including motorcycles/motor scooters) are normally available for use by people in your ***current*** residence?

DON'T count vehicles that belong to visitors; or vehicles that this household borrowed occasionally from another household.

0	None→ *Go to Q31*
1	1
2	2
3	3 or more

30 Please complete the following statement: I might be able to live in a household without a motor vehicle if…

A	I moved to a different area
B	I changed jobs or course of study
C	I retired
D	Public transport services improved
E	I don't believe it is possible for me to live without a motor vehicle
F	Other (please specify) → *Go to Q30a*

30a You selected 'other' in the previous question. Please tell us what other changes would be necessary for you to live without a motor vehicle.

→ *Go to Q32*

31 What are the primary reasons that your household does not have any motor vehicles? Select up to 3 reasons.

A	No one in household is able to drive
B	Cost of vehicle/driving
C	No need for a motor vehicle – other transport options available
D	Health/physical difficulties
E	Lack of parking spaces
F	Don't like driving or prefer other means of transport
G	Environmental reasons
H	Temporarily without a motor vehicle but will acquire another one shortly
I	Other (please specify) → *Go to Q31a*

31a You selected 'other' in the previous question. What are the other reasons that your household does not have any motor vehicles?

32 In your ***current*** residence, how do you or others in your household usually travel to…

	Drive a motor vehicle	Passenger in a motor vehicle	Walk/ jog/ cycle	Public transport (bus, train, ferry)	Other method	I/we don't go to this place
Supermarket	A	B	C	D	E	F
Primary school or college	A	B	C	D	E	F
ANOTHER ADULT IN MY HOUSEHOLD'S work/education	A	B	C	D	E	F
YOUR usual place to exercise or play sport	A	B	C	D	E	F

C.4 Car sharing (Auckland residents only)

A33 Self-service car share companies have cars available for hire by the hour, day or week. In Auckland, 'Cityhop' has cars parked in various places around the Auckland CBD which may be hired for $15 or less per hour. Booking is done electronically and cars are available 24 hours a day.

A34 Before today, were you aware car sharing was available in Auckland?

1	Yes
0	No → *Go to QA38*

A35 Are you, or have you been, a member of the Cityhop car sharing scheme?

1	Yes
0	No → *Go to QA38*

A36 How frequently have you hired a Cityhop car in Auckland?

A	Never→ *Go to QA38*
B	Once or twice
C	About once or twice a month
D	About once a week
E	More than once a week

A37 Which statement most accurately describes your household? Since being a member of Cityhop, my household has…

A	Acquired a car
B	Decided not to acquire a car
C	Postponed acquiring a car
D	Got rid of a car
E	None of the above

C.5 Length of time in current residence (Auckland respondents)

A39 When you do the following activities, where do you usually do them?

	Central city area	Another area	Don't usually do this
Your work	A	B	C
Your education	A	B	C
Supermarket shopping	A	B	C
Eating out/having coffee	A	B	C
Exercise or play sport	A	B	C

A40 What year did you shift to your current residence?

A	2010
B	2009
C	2008
D	Before 2008 → *Go to Q49*

A41 Where did you live before moving to your current residence?

A	In Auckland's central city area (as highlighted by yellow)
B	Elsewhere in Auckland city
C	In another Auckland region city (Waitakere, North Shore, Manukau)
D	Somewhere else in New Zealand (where?) _____
E	Overseas

→ *Go to Q42C.6*

C.6 Length of time in current residence (Wellington respondents)

W39 When you do the following activities, where do you usually do them?

	Central city area	Another area	Don't usually do this
Your work	A	B	C
Your education	A	B	C
Supermarket shopping	A	B	C
Eating out/having coffee	A	B	C
Exercise or play sport	A	B	C

W40 What year did you shift to your current residence?

A	2010
B	2009
C	2008
D	Before 2008→ *Go to Q49*

W41 Where did you live before moving to your current residence?

A	In Wellington's central city area (as highlighted by yellow)
B	Elsewhere in Wellington city
C	In another Wellington region city (Lower Hutt, Upper Hutt, Porirua/Tawa)
D	Somewhere else in New Zealand (where?) _____
E	Overseas

C.7 Characteristics of previous residence (Auckland and Wellington respondents who shifted since 2008)

42 What was the main reason you moved from your previous residence to your current one?

43 Which best describes your ***previous*** household (just before you shifted to your current residence)? PLEASE SELECT ONE BOX ONLY

A	Couple living alone
B	Couple or extended family living with children, some aged 0–17 years.
C	Couple or extended family living with children, all aged 18 years or older.
D	Single adult living with children, some aged 0–17 years.
E	Single adult living with children, all aged 18 years or older.
F	Adult living alone
G	Adult living with other adults
H	Living with my parents/guardians
I	Other (please specify……)

44 How many people aged 18 or older lived in your ***previous*** residence at the time you moved?

0	1	2	3	4	5 or more people

45 How many motor vehicles (including motorbikes/motor scooters) were normally available for use by people in your ***previous*** residence at the time you moved?

DON'T count vehicles that belong to visitors or vehicles that this household borrowed occasionally from another household.

0	None
1	1
2	2
3	3 or more

46 In your **previous** residence, how did you or others in your household usually travel to…

	Driver in a motor vehicle	Passenger in a motor vehicle	Walk/ jog/cycle	Public transport (bus, train, ferry)	Other method	I/we didn't go to this place
Supermarket	A	B	C	D	E	F
Primary school or college	A	B	C	D	E	F
YOUR work	A	B	C	D	E	F
YOUR education	A	B	C	D	E	F
ANOTHER ADULT IN MY HOUSEHOLD'S	A	B	C	D	E	F

	Driver in a motor vehicle	Passenger in a motor vehicle	Walk/ jog/cycle	Public transport (bus, train, ferry)	Other method	I/we didn't go to this place
work/education						
YOUR usual place to exercise or play sport	A	B	C	D	E	F

47 **In your *previous* residence**, would you have used these travel methods more or less often than you have in the past 4 weeks?

	Didn't use this method previously	A **lot more** often than I did in the past 4 weeks	A **little more** often than I did in the past 4 weeks	About the **same** as I did in the past 4 weeks	A **little less** often than I did in the past 4 weeks	A **lot less** often than I did in the past 4 weeks
Driving a motor vehicle (car, van, truck, motorcycle)	A	B	C	D	E	F
Passenger in a motor vehicle	A	B	C	D	E	F
Walking/jogging	A	B	C	D	E	F
Bicycle	A	B	C	D	E	F
Public transport (bus, train, ferry)	A	B	C	D	E	F

For those who selected 'little more/lot more often' for 'Driving a motor vehicle'→ *Go to Q48a*

For those who selected 'little less/lot less often' for 'Driving a motor vehicle'→ *Go to Q48c*

All other responses → *Go to Q49*

48a What are the reasons you drive more often now than you did in your previous residence? Select all that apply

A	Changed jobs/started working
B	Stopped working
C	Live further away from places I want to go to now
D	Had children
E	Children started school
F	Health problems

G	Bought a car
H	To avoid congestion
I	Changes to public transport provision
J	Other (please specify) → *Go to Q48b*

48b You selected 'other' in the previous question. Please tell us what other reasons you said you drive more often now than when you lived in your previous residence.

→ *Go to Q49*

48c What are the reasons you drive less often now than you did in your previous residence? Select all that apply:

A	Changed jobs/started working
B	Started education/training course
C	Stopped working
D	Live closer to places I want to go to now
E	Had children
F	Children started school
G	The cost of driving
H	Health problems
I	To improve health
J	Sold a car
K	To avoid congestion
L	Better public transport where I live now
M	Concerns about the environment
N	Other (please specify) → *Go to Q48d*

48d You selected 'other' in the previous question. Please tell us what other reasons you said you drive less often now than when you lived in your previous residence.

C.8 Intentions to shift in next two years and attitudes (all)

49 Which of the following best describe your intentions?

A	I intend to leave NZ in the next two years → *Go to Q54*
B	I do not intend to shift in the next two years → *Go to Q54*
C	I am intending to shift within NZ in the next 2 years
D	I might shift in the next 2 years

The following questions are all related to the place you might move to in the next 2 years:

50 If you shifted, which of the following best describes your intention?

A	Live in the central city
B	Live somewhere else in the same city as I live in now
C	Live in the central area of another city
D	Move to another town or city in NZ
E	Move somewhere else – eg rural NZ or overseas

51 If you shifted, would the number of people living in your household likely…?

A	increase
B	Decrease
C	stay the same
D	Don't know

52 If you shifted, would the number of vehicles available to your household likely…?

A	increase
B	Decrease
C	stay the same
D	Don't know

53 If you shifted residence, what would be your first choice of travel method for going to…

	Driving a motor vehicle	Passenger in a motor vehicle	Walk/ jog/ cycle	Public transport (bus, train, ferry)	Other method	I/we wouldn't go to this place
Supermarket	A	B	C	D	E	F
Primary school or college	A	B	C	D	E	F
YOUR work	A	B	C	D	E	F
YOUR education	A	B	C	D	E	F
ANOTHER ADULT IN MY HOUSEHOLD'S work/education	A	B	C	D	E	F
YOUR usual place to exercise or play sport	A	B	C	D	E	F

54 Indicate your agreement or disagreement with each of the following statements:

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I prefer living in the inner city to living in a suburb.	1	2	3	4	5
I often use the telephone or the internet to avoid having to travel somewhere.	1	2	3	4	5
I'd rather live in a suburban neighbourhood, even if it meant I had to drive to shops, schools and services.	1	2	3	4	5
Being environmentally responsible is important to me as a person.	1	2	3	4	5
I'd rather live in a neighbourhood where I can walk to some shops, schools, and services.	1	2	3	4	5
In the next 10 years, I intend to live in a house with a section in the suburbs.	1	2	3	4	5
It's important to me to use environmentally-friendly travel methods (walking, cycling and public transport).	1	2	3	4	5

C.9 Background demographics (all)

55 Counting only those occasions where you did **at least 10 minutes** at one time, on how many days *in the past 7 days* did you…

	Number of days							
WALK for recreation, sport, exercise, or leisure (including walking the dog)	0	1	2	3	4	5	6	7
WALK for transport (to get from place to place)	0	1	2	3	4	5	6	7
CYCLE for recreation, sport, exercise, or leisure	0	1	2	3	4	5	6	7
CYCLE for transport (to get from place to place)	0	1	2	3	4	5	6	7

Here are a few questions to help us describe the groups of people who have responded to this questionnaire. All this information remains confidential. Each person's answers will be put together with those of others to show the results.

56 Gender	Male Female
57 Age (in years)	5-year bands

58 Is your current driver's licence a…

A	Learner's licence
B	Full or restricted licence
C	I don't hold any driver's licence

59 Which best describes your current residence?

A	House or townhouse (NOT joined to any other) →Go to End
B	House, townhouse or unit joined to one or more other houses, townhouses, or units (less than 10 dwellings in total) →Go to Q60
C	Apartment in a building with 10 or more other apartments→Go to Q60
D	Other (please describe) →Go to Q59a

59a You selected 'other' in the previous question. Please describe your current residence.

→*Go to end*

60 What type of outdoor space does your current residence have?

A	Balcony/ courtyard/ patio
B	Garden/ yard/ section
C	Shared/ communal outdoor space
D	Other type of private outdoor space
E	No private or shared outdoor space

Thank you for taking the time to complete this survey. We really value your input!

Appendix D: Walkability reports from Walk Score for selected Auckland and Wellington suburbs

D.1 Inner city Auckland (200 Queen St)

Understanding Your Score

Street Smart Walk Score is calculated using walking distances to the following amenities.

Category	Points	Name	Distance
Groceries	**20** out of 20	Midtown Food Centre/Groceteria	.3 km
Restaurants and Bars	**20** out of 20	A Little Italy	.1 km
		Faro Korean Traditional Grill Restaurant	.2 km
		Mai Thai	.2 km
		Vivace Restaurant	.2 km
		Renkon Japanese Restaurant	.2 km
		Munster Inn	.3 km
		Taller Park	.3 km
		The Playhouse Pub & Brassier	.3 km
		SKYCITY Hotel Auckland	.4 km
		The Vulcan Pub	.4 km
Shopping	**15** out of 15	Radius Care Pharmacy	.1 km
		Munns - The Man's Store	.1 km
		Recycle Boutique	.1 km
		Scotties Boutique	.2 km
		Country Road Clothing NZ	.2 km
Coffee	**15** out of 15	Starbucks Coffee	.0 km
		Mexican Cafe	.2 km
Schools	**6** out of 6	Freelance Animation School	.1 km
Parks	**6** out of 6	Albert Park	.4 km
Books	**6** out of 6	Whitcoulls	.0 km
Entertainment	**6** out of 6	Val Morgan Cinema Network	.3 km
Banking	**6** out of 6	ANZ Banking Group (New Zealand) Limited	.0 km
Total Walk Score	**100** out of 100		Agree Disagree

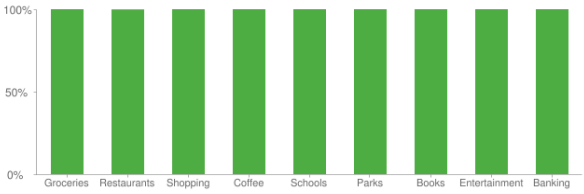
Pedestrian Friendliness

Short blocks and lots of intersections are better for walkers.

Average Block Length: 71 meters
Good

Number of Intersections: 471 per sq mi
Good

Walkability by Category



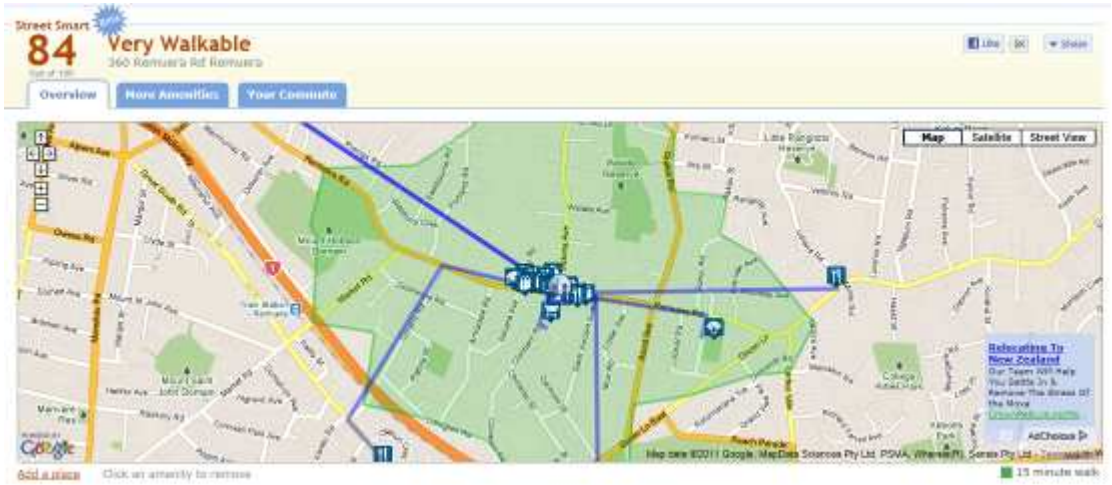
Walk Score home report for 200 Queen St Auckland. See the amenities and walking routes that contribute to your Walk Score. Walk Score also calculates block length and intersection density to measure the pedestrian friendliness of your area. See more nearby amenities.

Public Transportation

Transit Score™ 97 Rider's Paradise
641 nearby routes: 598 bus, 31 rail, 12 other

- .01 km - 200 Woodward Rd To Midtown Limitec
- .01 km - 210 Avondale To Midtown
- .01 km - 210 Woodward Ave To Midtown
- .01 km - 211 Rosebank Road To Midtown
- .01 km - 211X Rosebank Rd To Midtown Expres
- .01 km - 212 Patiki Road To Midtown

D.2 Remuera Auckland (Remuera Road)



Understanding Your Score

Street Smart Walk Score is calculated using walking distances to the following amenities.

Category	Points	Name	Distance
Groceries	**20** out of 20	New World Supermarket Remuera	.2 km
Restaurants and Bars	**15** out of 20	Milky Way Japanese Restaurant	.1 km
		Sichuan in Remuera Restaurant	.1 km
		Thai Hut Restaurant	.1 km
		Thai Village Restaurant	.1 km
		Curry Village Indian Restaurant	.2 km
		Sabai Sabai Thai Restaurant	.2 km
		Soi Japanese Cuisine	1.3 km
		Ritz Greenlane Motor Inn	1.6 km
		Cock & Bull English Pub & Brewery	2.7 km
		The Post House	3 km
Shopping	**15** out of 15	Meg & Molly's Clothing Alteration Specialists	.1 km
		AlexandraApple	.1 km
		Wylies Pharmacy	.2 km
		Mortimers Recycled Clothing	.2 km
		Sweetie fashion Recovery	.3 km
Coffee	**15** out of 15	Le P'tite Pyrenees	.0 km
		Sierra Cafe	.0 km
Schools	**6** out of 6	Bramly Art and Creative School	.2 km
Parks	**5.9** out of 6	Wairua Reserve	.8 km
Books	**6** out of 6	Wheelers Books Remuera	.1 km
Entertainment	**0** out of 6	Rialto Cinemas	2.4 km
Banking	**6** out of 6	ASB Bank Limited	.1 km
Pedestrian Friendliness	**-5.4**	(see below)	
Total Walk Score	**84** out of 100		Agree Disagree

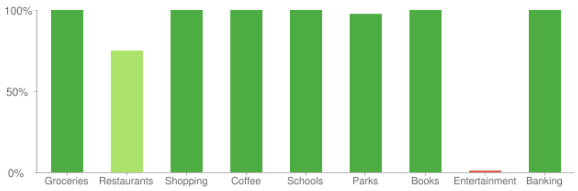
Pedestrian Friendliness

Short blocks and lots of intersections are better for walkers.

Average Block Length: 178 meters
Poor: -3% penalty

Number of Intersections: 69 per sq mi
Poor: -3% penalty

Walkability by Category



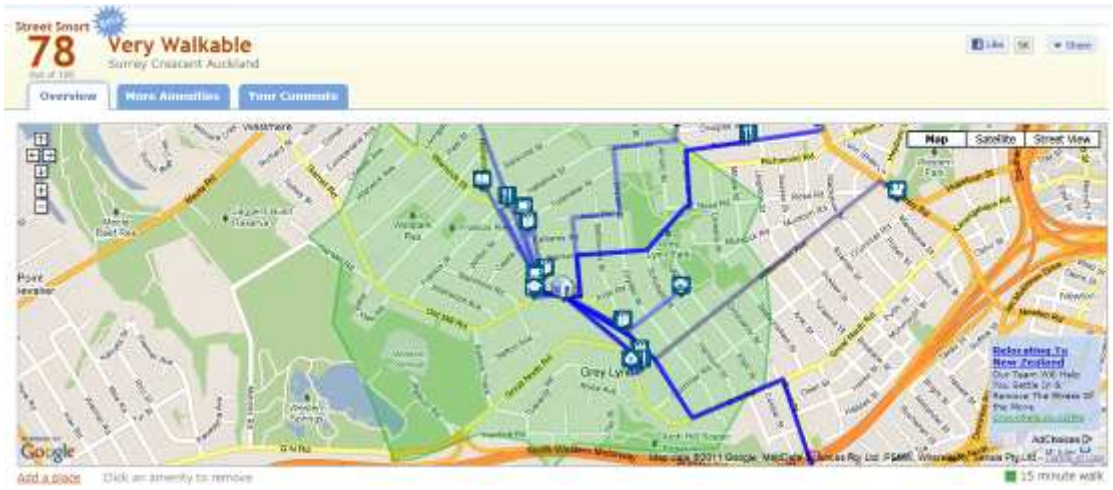
Walk Score home report for 360 Remuera Rd Remuera. See the amenities and walking routes that contribute to your Walk Score. Walk Score also calculates block length and intersection density to measure the pedestrian friendliness of your area. See more nearby amenities.

Public Transportation

Transit Score™ **54** Good Transit
168 nearby routes: 158 bus, 10 rail, 0 other

- 1.02 km - ONE Britomart To Onehunga
- 1.02 km - ONE Onehunga To Britomart
- 1.02 km - STH Britomart To Otahuhu Via Newn
- .07 km - 603 Victoria Ave To Civic Centre
- .07 km - 605 Benson Road To Civic Centre
- .07 km - 606 Benson Road To Civic Centre

D.3 Grey Lynn Auckland (Surrey Crescent and Great North Road)



Understanding Your Score

Street Smart Walk Score is calculated using walking distances to the following amenities.

Category	Points	Name	Distance
Groceries	**20** out of 20	Ooooby	.1 km
Restaurants and Bars	**8.4** out of 20	Malt Bar & Restaurant	.5 km
		Soul Thai	.7 km
		Covo Restaurant Cafe and Bar Grey Lynn	1.3 km
		Cocoro	1.5 km
		SPQR Cafe Restaurant and Bar	1.8 km
		Prego Restaurant	2.2 km
		Taiko Restaurant	2.3 km
		Little India	2.3 km
		The Kingslander	2.3 km
Shopping	**13.4** out of 15	The Coat Company	.2 km
		Dressing Dolls Boutique	.4 km
		Pharmacy 26	.4 km
		Gopal's Pharmacy	.6 km
		CW2000 Limited	1.1 km
Coffee	**14.8** out of 15	Jafa Cafe	.2 km
		Savour & Devour	.4 km
Schools	**6** out of 6	Pre School Centre Irene	.1 km
Parks	**6** out of 6	Grey Lynn Park	.7 km
Books	**5.1** out of 6	Auckland Buddhist Centre	.7 km
Entertainment	**0.3** out of 6	Openair Cinema - Western Park	1.9 km
Banking	**5.2** out of 6	ASB Bank Limited	.6 km
Pedestrian Friendliness	**-0.8**	(see below)	
Total Walk Score	**78** out of 100		Agree Disagree

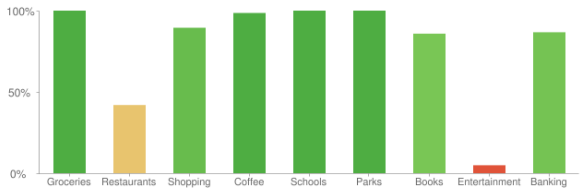
Pedestrian Friendliness

Short blocks and lots of intersections are better for walkers.

Average Block Length: 125 meters
Good

Number of Intersections: 138 per sq mi
Fair: -1% penalty

Walkability by Category



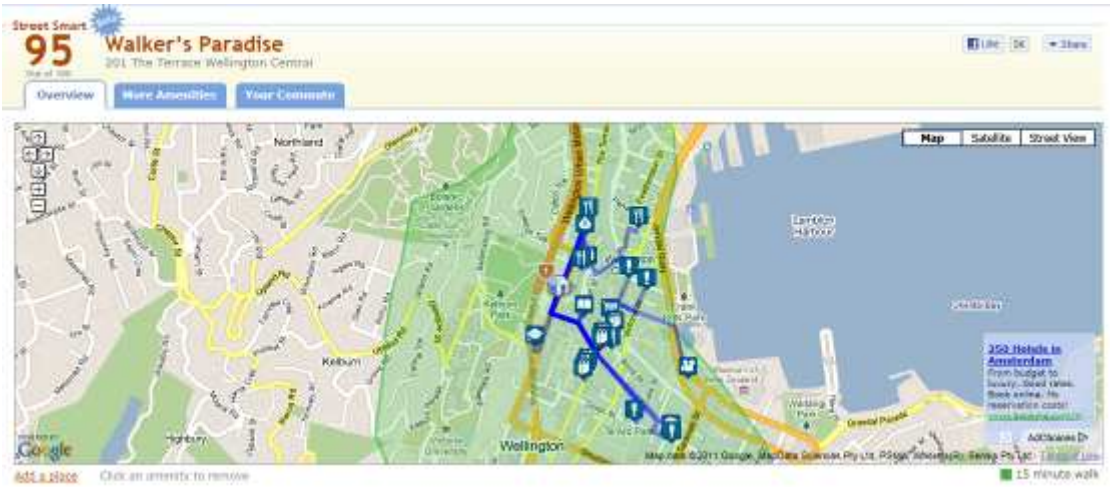
Walk Score home report for Surrey Crescent Auckland. See the amenities and walking routes that contribute to your Walk Score. Walk Score also calculates block length and intersection density to measure the pedestrian friendliness of your area. See more nearby amenities.

Public Transportation

Transit Score™ 55 Good Transit
143 nearby routes: 143 bus, 0 rail, 0 other

- .05 km - 025 Surrey Cres And Richmond Road
- .05 km - 028X Britomart To Westmere Express
- .05 km - 035 Britomart To Westmere And Hern
- .05 km - 035 K''Rd To Westmere
- .05 km - S062 Ponsonby To Western Springs C
- .09 km - 027 Westmere To Britomart Via Richm

D.4 Inner City Wellington (The Terrace)



Understanding Your Score

Street Smart Walk Score is calculated using walking distances to the following amenities.

Category	Points	Name	Distance
Groceries	**19.3** out of 20	New World Metro on Willis Street Supermarket Wellington	.4 km
Restaurants and Bars	**18.5** out of 20	Miyabi Sushi Japanese Cafe	.4 km
		Taste of Korea	.4 km
		James Cook Hotel Grand Chancellor	.4 km
		Dahra Korean Bistro	.4 km
		Boulcott Street Bistro	.4 km
		Pub Charity Inc	.6 km
		The Green Man Pub	.7 km
		The Big Kumara	.7 km
		InterContinental Wellington	.8 km
		Garden Club	.8 km
Shopping	**14.7** out of 15	Alison Blain	.3 km
		Robyn Mathieson	.3 km
		Yourstyle Tailoring	.4 km
		Ascent Technology	.4 km
		Bivouac Outdoor	.4 km
Coffee	**15** out of 15	The Front Page Cafe	.2 km
		Butlers Chocolate Cafe	.3 km
Schools	**6** out of 6	Institute of Travel and Tourism Studies	.2 km
Parks	**5.9** out of 6	Te Aro Park	.8 km
Books	**6** out of 6	Evening Post Library	.2 km
Entertainment	**3.6** out of 6	Rialto Cinema - David Boyes Roadshow	1 km
Banking	**5.8** out of 6	Kiwibank	.5 km
Total Walk Score	**95** out of 100		Agree Disagree

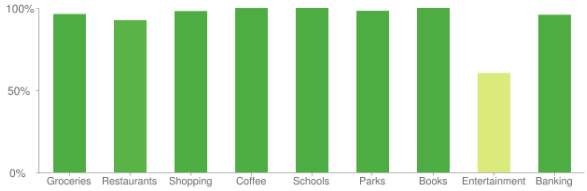
Pedestrian Friendliness

Short blocks and lots of intersections are better for walkers.

Average Block Length: 98 meters
Good

Number of Intersections: 239 per sq mi
Good

Walkability by Category



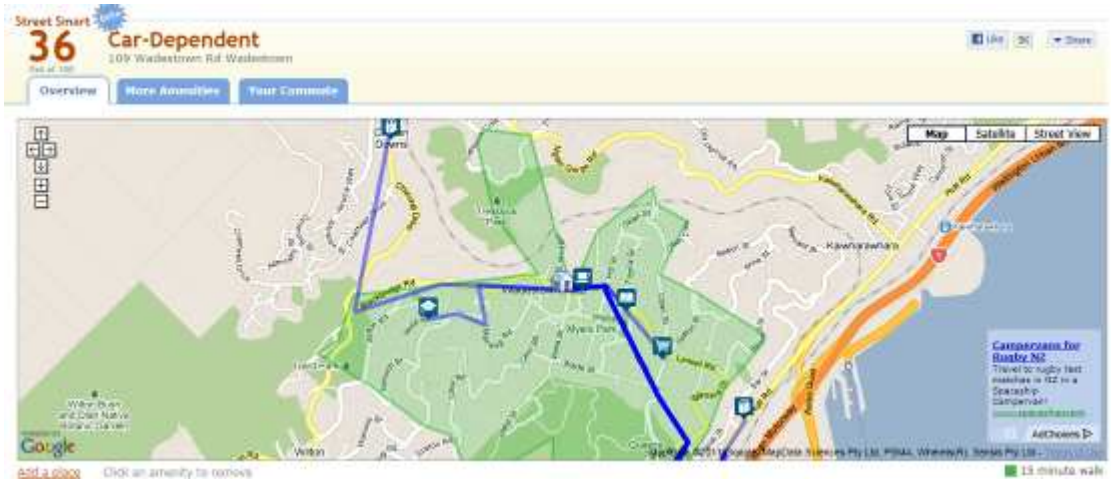
Walk Score home report for 201 The Terrace Wellington Central. See the amenities and walking routes that contribute to your Walk Score. Walk Score also calculates block length and intersection density to measure the pedestrian friendliness of your area. See more nearby amenities.

Public Transportation

Transit Score™ 79 Excellent Transit
127 nearby routes: 109 bus, 16 rail, 2 other

- 1.15 km - HVL Hutt Valley Line (Upper Hutt - W
- 1.15 km - HVL Hutt Valley Line (Wellington - U
- 1.15 km - JVL Johnsonville Line (Johnsonville -
- .07 km - 17 Karori - Wellington
- .07 km - 20 Highbury - Wellington - Mt Victoria
- .07 km - 22 Mairangi - Wellington - Houghton E

D.5 Wadestown Wellington (Wadestown Road)



Understanding Your Score

Street Smart Walk Score is calculated using walking distances to the following amenities.

Category	Points	Name	Distance
Groceries	**18.3** out of 20	Highland Park Store	.6 km
Restaurants and Bars	**0.6** out of 20	Wholly Bagels	1.9 km
		Le Canard	2.1 km
		Maria Pia's Trattoria	2.2 km
		Kingsgate Hotel Wellington	2.2 km
		Backbencher Pub & Cafe	2.3 km
		Charlie Bill - Fine Food Bistro	2.3 km
		La Scala Restaurant	2.6 km
		Arbitrageur Wine Room and Restaurant	2.9 km
Shopping	**1.2** out of 15	Designer Clothing Gallery	1.7 km
		H'a' Fele	1.7 km
		Redstripe IT Systems	1.7 km
		Crofton Downs Pharmacy	1.9 km
		Major Tomms Suit HIre	2 km
Coffee	**9** out of 15	The Wadestown Kitchen	.1 km
		Le Marche Francais	1.7 km
Schools	**4.5** out of 6	Wadestown School	.8 km
Parks	**0** out of 6	Midland Park	3 km
Books	**6** out of 6	Wadestown Library - Wadestown Road	.3 km
Entertainment	**0** out of 6	None	
Banking	**0** out of 6	Reserve Bank of New Zealand	2.8 km
Pedestrian Friendliness	**-3.2**	(see below)	
Total Walk Score	**36** out of 100		Agree Disagree

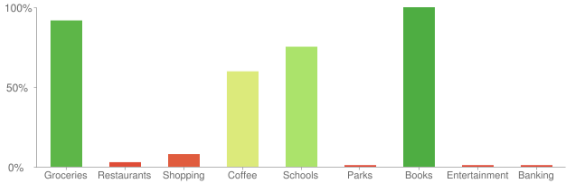
Pedestrian Friendliness

Short blocks and lots of intersections are better for walkers.

Average Block Length: 197 meters
Poor: -5% penalty

Number of Intersections: 64 per sq mi
Poor: -3% penalty

Walkability by Category



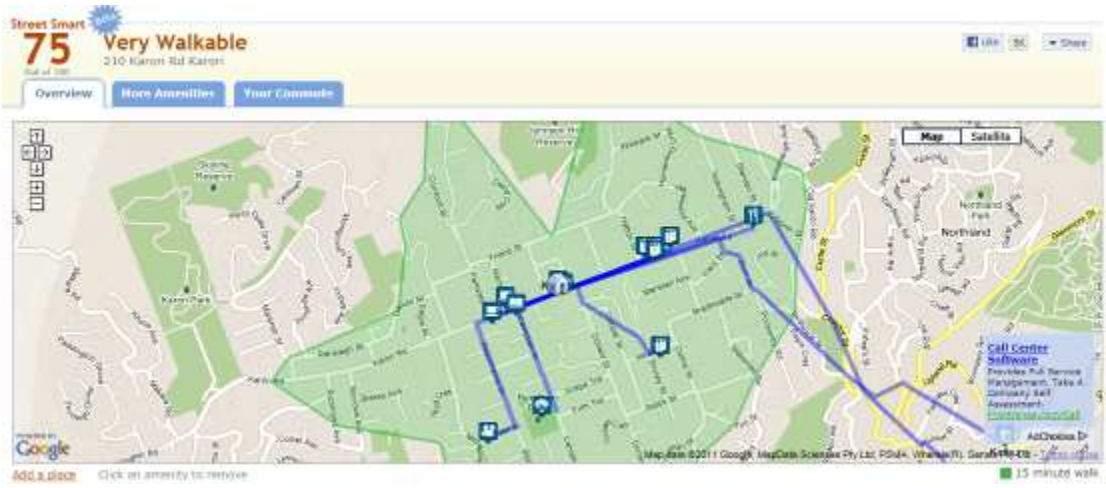
Walk Score home report for 109 Wadestown Rd Wadestown. See the amenities and walking routes that contribute to your Walk Score. Walk Score also calculates block length and intersection density to measure the pedestrian friendliness of your area. See more nearby amenities.

Public Transportation

Transit Score™ **53** Good Transit
80 nearby routes: 70 bus, 10 rail, 0 other

.96 km - JVL Johnsonville Line (Johnsonville - V
.96 km - JVL Johnsonville Line (Wellington - Jol
1.52 km - HVL Hutt Valley Line (Upper Hutt - W
.01 km - 14 The Silver Route (Kilbirnie - Wilton
.01 km - N4 After Midnight (Wadestown/Khand
.05 km - 14 The Silver Route (Wilton - Kilbirnie

D.6 Karori Wellington (Karori Road)



Understanding Your Score

Street Smart Walk Score is calculated using walking distances to the following amenities.

Category	Points	Name	Distance
Groceries	**20** out of 20	New World Supermarket Wellington	.3 km
Restaurants and Bars	**6.6** out of 20	Flavours Indian Cuisine Restaurant	.5 km
		Coucou French Cafe and Restaurant	.9 km
		Kelburn Taven Village Pub	2.6 km
		Hotel Mercure Wellington	3.8 km
Shopping	**13.9** out of 15	Wardrobe Flair	.1 km
		Amcal Pharmacies	.5 km
		Toi Design	.5 km
		Watts Hardware	.6 km
		Compkarori	.7 km
Coffee	**14.9** out of 15	Rosina's Cafe	.3 km
		Cafe on The Square	.4 km
Schools	**6** out of 6	Karori Normal School	.1 km
Parks	**6** out of 6	Ben Burn Park	.7 km
Books	**6** out of 6	Karori Public Library	.3 km
Entertainment	**3.1** out of 6	Heavans Door	1.1 km
Banking	**0** out of 6	None	
Pedestrian Friendliness	-1.5	(see below)	
Total Walk Score	**75** out of 100		Agree Disagree

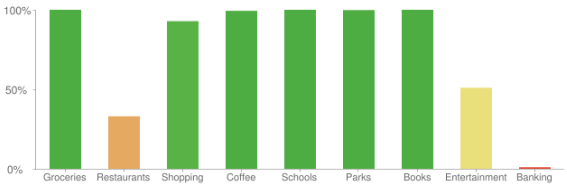
Pedestrian Friendliness

Short blocks and lots of intersections are better for walkers.

Average Block Length: 139 meters
Good

Number of Intersections: 118 per sq mi
Poor: -2% penalty

Walkability by Category



Walk Score home report for 210 Karori Rd Karori. See the amenities and walking routes that contribute to your Walk Score. Walk Score also calculates block length and intersection density to measure the pedestrian friendliness of your area. See more nearby amenities.

Public Transportation

Transit Score™ 45 Some Transit
19 nearby routes: 19 bus, 0 rail, 0 other

- .08 km - 17 Wellington - Karori
- .1 km - 17 Karori - Wellington
- .08 km - 3 The Green Route (Lyall Bay - Wellin
- .1 km - 3 The Green Route (Karori - Wellington
- .08 km - N3 After Midnight (Karori/Northland)
- .11 km - 18 Campus Connection (Karori - Mirar

Appendix E: Glossary

A/W cities	The cities as denoted by the boundaries of Wellington City Council (as at 2011) and the boundaries of the now disestablished Auckland City Council, which has been split into six boards (Whau, Albert-Eden, Waitemata, Orakei, Maungakiekie-Tamaki and Puketapapa) as part of the Auckland Council.
A/W metropolitan (metro) area	Refers to the four cities of Wellington region (Wellington, Porirua, Lower Hutt, Upper Hutt) and what were formerly the four cities of Auckland region (Auckland, Manukau, Waitakere and North Shore). In the new 'supercity' structure, the metropolitan area includes 11 of the 13 wards, excluding the Rodney and Franklin boards.
Built environment	Refers to the structures and infrastructure that are created by people. It includes all structures (from a single building to entire cities) and the supporting infrastructure like streets, footpaths, electricity, water and other utilities, bus shelters and cycle lanes. The built environment can also include outdoor spaces where these have been manipulated or constructed by people (eg community parks, playgrounds and sports grounds).
Census area unit	Non-administrative areas intermediate between meshblocks and territorial authorities, consisting of aggregations of meshblocks. As created by Statistics NZ, census area units must either define or aggregate to define urban areas, rural centres, statistical areas, territorial authorities and regional councils. Area units within urban areas normally contain 3000–5000 population.
Committed Driver	A population segment which is less concerned about using environmentally friendly travel modes (ie they agree/strongly agree with the statement 'If I could, I would drive to work (my study/training course) every day' and disagree/strongly disagree with 'No matter where I live, I intend to walk, cycle or use public transport to travel to work (to study/training)').
Density	Population density refers to the number of people inhabiting (residing in) a particular area, generally a hectare, square kilometre or square mile. Household density refers to the number of residences or households per measured area. In this report, a high (population) density is considered to be 40+ people per hectare or 4000 people per km^2. Low density areas usually refer to those areas with fewer than 10 people per hectare (<1000 people per km^2).
Dissonant Suburbanite	A population segment which would prefer to live in the inner city but currently lives in the metropolitan area (suburban neighbourhood).
Dissonant Urbanite	A population segment which would prefer to live in the metropolitan area (suburban neighbourhood) but currently lives in the inner city.
Family household	Comprises one or more adults living in a household with one or more children aged <18 years.

Inner city A/W	Refers to the 'central business district' areas of Auckland and Wellington, ie the core business districts of the two cities. The boundaries for the inner city areas were defined by Statistics NZ (2010). The boundary streets for Auckland's CBD were Mechanics Bay, The Strand, Stanley Street, Grafton Road, Symonds Street, Khyber Pass Road, Upper Queen Street and the western edges of the Southern Motorway to Freemans Bay. Wellington's CBD boundary streets were Oriental Parade, Majoribanks Street, Brougham Street, Pirie Street, Kent Terrace, Buckle Street, The Terrace, Bowen Street and Bunny Street.
Likert scale	Denotes a type of psychometric scale developed by organisational psychologist Rensis Likert and now frequently used in questionnaires to measure attitudes, preferences and subjective reactions. Likert scales usually have five potential choices (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree) where the average score represents the overall attitude toward the subject of the question.
Meshblock	The smallest geographic unit for which statistical data is collected and processed by Statistics NZ. A meshblock is a defined geographic area, varying in size from part of a city block to large areas of rural land. Each meshblock abuts against another to form a network covering all of New Zealand including coasts and inlets, and extending out to the 200 mile economic zone. Meshblocks are added together to 'build up' larger geographic areas such as area units and urban areas.
Neighbourhood Destination Accessibility Index	An index derived to measure access to specific neighbourhood amenities or destinations within a reasonable walking distance (800m) along the local road network from the population centre of each meshblock.
Pro-Green Traveller	Describes a population segment which is concerned about using environmentally friendly travel modes (ie they agree or strongly agree with the statements 'Being environmentally responsible is important to me as a person'; 'It's important to me to use environmentally friendly travel methods (walking, cycling and public transport)' and 'No matter where I live, I intend to walk, cycle or use public transport to travel to work (to study/training)' and they disagree or strongly disagree with the statement 'If I could, I would drive to work (my study/training course) every day').
Related adults	Couples or families where everyone in the household is aged 18 years or older.
Residential self-selection	Refers to the preferences for particular characteristics in a residential area (eg inner city vs suburban neighbourhoods; living within walking distance to shops and/or schools vs living within driving distance). Such preferences may be shaped by individual attitudes or beliefs, as well as personal characteristics (eg family vs single adult or couple, worker or student, age).
Reverse commuting	Refers to a commuter who lives in the (inner) city and commutes to work or study in the suburbs.

Reverse travel	This is a similar concept to reverse commuting, addressing travel for other trip purposes (eg shopping, doctor's appointment or eating out) where an inner city resident travels to a suburban area to participate in the activity.
True Suburbanite	Describes a population segment which would prefer to live in the metropolitan area (suburban neighbourhood) and currently lives in the metropolitan area.
True Urbanite	Describes a population segment which would prefer to live in the inner city and currently lives in the inner city.
Unrelated adults or unrelated households	Consist of either one adult living alone or two or more adults living together, none of whom are related, whether by birth, marriage, civil union or other long-term intimate relationship.
Walkability Index	An indicator or measure of the walkability condition of a neighbourhood or area based on street connectivity, dwelling density, mixed land use, retail floor area ratio.
Walk Score	A free-to-use website (www.walkscore.com) which measures the walkability of residential addresses located in many cities around the globe. Walkability is based on the distances from a residence to selected amenities. A recent 'beta' version also takes into account the average block length, the intersection density and the link/node ratio (how many roads go into each intersection).