

Transport-related Physical Activity, Health Outcomes, and  
Urban Design: Descriptive Evidence

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## List of Abbreviations

<i>Abbreviation</i>	<i>Definition</i>
AFES	Active Friendly Environments Survey
AFES-TPA	Active Friendly Environments Survey-Transport-related Physical Activity
ANOVA	Analysis of variance
AUTEC	Auckland University of Technology Ethics Committee
BMI	Body mass index
BRFSS	Behavioral Risk Factor Surveillance Systems
CATI	Computer assisted telephone interview
CI	Confidence interval
CO <sub>2</sub>	Carbon dioxide
d	Cohen effect size
df	Degrees of freedom
F	Variance ratio
GIS	Geographical information systems
GPS	Global positioning system
ICC	Intraclass correlation coefficient
IPAQ	International Physical Activity Questionnaire
IPAQ-SF	International Physical Activity Questionnaire-Short Form
IPAQ-LF	International Physical Activity Questionnaire-Long Form
IRBC	Infra-red beam counter
Kg	Kilogram
Km	Kilometre
LTPA	Leisure-time physical activity
m	Metre
MET	Metabolic equivalence
n	Sample size
NEWS	Neighborhood Environment Walkability Index
NZ	New Zealand
NZPAQ-SF	New Zealand Physical Activity Questionnaire-Short Form
OR	Odds ratio
OTA	Obstacles to Action
PA	Physical activity

<i>Abbreviation</i>	<i>Definition</i>
PP	Population proportion
RR	Relative risk
SES	Socio-economic status
SMARTRAQ	Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality
SPACES	Systematic Pedestrian and Environmental Scan
SPARC	Sport and Recreation New Zealand
SPSS	Statistical Package for Social Scientists
TPA	Transport-related physical activity
US	United States of America
VO <sub>2max</sub>	Maximum oxygen uptake
WHO	World Health Organization

## List of Publications Arising from Doctoral Thesis

Chapters 2 to 9 represent individual papers that have been drawn from this PhD thesis and submitted for consideration to peer-reviewed academic journals for publication and to scientific committees for conference presentations. Copies of the published journal articles are included in this thesis as appendices. A report to stakeholders outlining the Active Friendly Environments Study key findings has also been published. The citations of the eight papers, six conference proceedings, and one report related to this doctoral thesis are listed below:

### *Peer-reviewed Journal Publications*

1. Badland, H.M. & Schofield, G.M. (2005). Transport, urban design, and physical activity: An evidence-based update. *Transportation Research Part D: Transport and Environment*, 10:177-196.
2. Badland, H.M. & Schofield, G.M. (2005). The built environment and transport-related physical activity: What we do and do not know. *Journal of Physical Activity & Health*, 2:433-442.
3. Badland, H.M. & Schofield, G.M. (2006). Perceptions of replacing car journeys with non-motorized travel: Exploring relationships in a cross-sectional adult population sample. *Preventive Medicine*, 43:222-225.
4. Badland, H.M. & Schofield, G.M. (2006). Test-retest reliability of a survey to measure transport-related physical activity in adults. *Research Quarterly for Exercise and Sport*, 77:386-390.
5. Badland, H.M. & Schofield, G.M. (in press). Health associations with transport-related physical activity and motorized travel to destinations. *International Journal of Sustainable Transportation*.

6. Badland, H.M. & Schofield, G.M. (in press). Understanding the relationships between private automobile availability, and overall and transport-related physical activity in adults. *Transportation*.
7. Badland, H.M., Schofield, G.M., & Schluter, P.J. (2007). Objectively measured commute distance: Associations with actual travel modes and perceptions to place of work or study in Auckland, New Zealand. *Journal of Physical Activity & Health*, 4:80-86.
8. Badland, H.M., Schofield, G.M., & Garrett, N. (in press). Travel behaviour and objectively-measured urban design variables: Associations for adults travelling to work. *Health & Place*.

*Peer-reviewed Conference Presentations and Associated Publications*

1. Badland, H.M. & Schofield, G.M. (2005, 13-15 October). How do physical activity levels, perceptions of the physical environment, and socio-economic variables correlate with replacing car journeys? *Proceedings from the Fifth National Physical Activity Conference, Melbourne; Journal of Science and Medicine in Sport* (abstract), 8:71.
2. Badland, H.M. & Schofield, G.M. (2006, 9-11 February). Differences in body mass index, overall physical activity, and environmental perceptions by active and non-active travel modes. *Proceedings from the Australasian Society of Behavioural Health and Medicine Conference, Auckland* (p. 29).
3. Badland, H.M. & Schofield, G.M. (2006, 16-18 February). Test-retest reliability of a transport-related physical activity survey. *Proceedings from the Active Living Research Conference, San Diego* (p. 47-48).
4. Badland, H.M. & Schofield, G.M. (2006, 29 November-2 December). Associations between personal car accessibility, overall physical activity levels, and transport-related physical activity in adults. *Proceedings from the International Congress of Behavioral Medicine, Bangkok* (p. 347).



5. Badland, H.M., Schofield, G.M., Schluter, P.J., & Garrett, N. (2007, 30 May-2 June). Objectively measured commute distance related to actual and perceived travel modes to place of work/study. *Proceedings from the American College of Sports Medicine 54<sup>th</sup> Annual Meeting, New Orleans* (p. S184).
6. Badland, H.M., Schofield, G.M., & Garrett, N. (2007, 4-6 July). Transport-related physical activity: Evidence to date. *Proceedings from the Public Health Association Conference, Auckland* (p. 125).

#### *Report Publication*

1. Garrett, N., Mackay, L., Badland, H., Svendsen, C., & Schofield, G. (2007). Active Friendly Environments: Physical activity and the built environment. A study of physical activity and the urban environment in North Shore City. Centre for Physical Activity and Nutrition Research, Auckland University of Technology, Auckland. 135 pages.

## **Attestation of Authorship**

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Chapters 2 to 9 inclusive, represent eight separate papers that have been submitted to international journals for peer-review processes and publication consideration. The contributions from different authors for each of these chapters are outlined in the introductory chapter. In all instances, the candidate conceived the study and contributed the majority of work to each manuscript. All co-authors have agreed to the inclusion of these papers as chapter contributions to the present doctoral thesis.

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Undertaking a PhD goes well-beyond existing as an academic experience, and the encouragement I have had from all my family and friends has gone a long way to helping me achieve this goal. I am eternally grateful for their support. Mum and Dad, you have supported me unconditionally and have always encouraged me to do my best. The values you instilled in me have stood me in good stead. Dave, during the last seven years, you have provided amazing support for everything that I do. I only hope I can do the same for you, and look forward to undertaking the next part of the journey with you.

## Thesis Abstract

Environments that support physical activity (PA) engagement are now seen as an important part of the solution for accumulating daily physical activity which confers health benefits, particularly transport-related PA (TPA). Despite this recognition, understanding the determinants of health-related PA has traditionally focused on identifying associations between the social environment and non-specific PA domains. As such, prior to commencing this thesis little was known about the relationships between the built environment and overall PA engagement within the New Zealand context. Little was also known about associations between TPA attitudes and behaviours, and urban design.

This research sought to overcome this paucity of knowledge by investigating associations between overall PA and TPA engagement and perceptions, health outcomes, urban design, and socio-demographic variables from a public health perspective. The body of research was initiated with two literature reviews that formed the context for the following six empirical chapters. Data in the empirical chapters were drawn from three self-report surveys using adult samples. The research commenced by examining associations between urban design and overall PA engagement, and then narrowed towards TPA-specific relationships. TPA relationships were identified through the development and implementation of a reliable survey that captured associated behaviours and attitudes.

Several new findings were drawn from this body of work. Overall, 21% of adults recognised they could replace automobile journeys on at least two days per week, and walking was deemed an acceptable travel alternative. Adult TPA engagement levels were low; 7% commuted to place of work/study and 32% travelled to the convenience shop by TPA modes. Furthermore, when compared with those who commuted to an occupation by TPA, respondents who used motorised travel were less likely to be classified as active (odds ratio (OR)=0.5) and be of normal body mass index (OR=0.5). No significant health relationships existed for convenience shop travel. As well, 4% of adults reported no automobile availability. When this group was compared with those with unrestricted automobile availability, they were less likely to be classified as active (OR=0.3), but were more likely to engage in TPA modes to access

destinations (occupation, OR=6.3; convenience shop, OR=9.8). Occupation-related commute distances also revealed interesting findings. Overall, 50% of respondents perceived they could, and 10% of the sample actually did, commute by TPA modes for distances less than five kilometres, and relationships were strongly mediated by distance. Other urban design variables were objectively assessed with TPA engagement for occupation-related commute distances less than five kilometres. Those who travelled along the most connected street networks were more likely to engage in TPA modes (OR=6.9) when compared with respondents travelling along the least connected networks. No relationships were found with other urban design variables and TPA engagement.

This research substantially contributes to this research area by identifying associations between overall PA and TPA engagement and perceptions with urban design. It is likely that shifting the perceptions of adults who recognise they can employ TPA modes, into actual TPA engagement will result in promising population health gains. Future PA initiatives with adults should consider promoting walking for transport as a sustainable solution. A lack of TPA interventions is evident; however, methodological issues need to be resolved before developing such initiatives. Although strategies aimed towards changing perceptions may be valuable for future TPA interventions, it is likely macro-scale urban design modifications (e.g., improved job-housing balance, highly-grained street networks) and legislation (e.g., automobile restrictions) will have the greatest success for increasing TPA engagement in the adult population.

## Chapter 1: Introduction

### Physical Activity and Health

A substantial and convincing body of evidence exists associating regular physical activity (PA) engagement with the prevention of numerous chronic, non-communicable diseases, such as cardiovascular disease, type II diabetes, certain cancers, and obesity [1, 2]. As such, national [2] and international [1, 3] health agencies currently recommend that adults should accumulate at least thirty minutes a day of moderate intensity PA on all or most days of the week to gain health benefits.

Many people in developed countries, however, are not engaging in sufficient levels of PA to gain health benefits [1, 2]. Recent estimates suggest only 26% of United States (US) adults [4] and 39% of New Zealand (NZ) [5] adults achieve the recommended PA guidelines. Furthermore, during the last few decades, leisure time PA levels (LTPA) have remained consistent, yet overall PA levels have systematically declined [4, 6]. Potential reasons for the decline in overall PA engagement are that many opportunities for incidental PA accumulation are being removed through integration of advanced technology (e.g., labour saving devices) and the urban environment is often designed to promote sedentary behaviours (e.g., private automobile reliance) into daily lifestyles [4].

### *Theoretical Models of Physical Activity*

To date, the majority of PA research has incorporated individual focused approaches to behaviour change that often include educational components. Unfortunately, these approaches have been ineffective for changing health behaviours long-term, largely because the environment in which the behaviour occurs in remains unchanged [7-9]. Current research in the field recognises the potential of ecological models which incorporate the broader environment because of the ability to influence the society, while being cost-effective and sustainable [10].

Within an ecological framework, perceived, physical, and social environments are incorporated, and the broad levels of the model are individual,

organisational, community, and policy [7]. In ecological models, external and internal variables are operationalised as interdependent determinants of health, accounting for the physical and social context in which health behaviour broadly occurs [7, 11]. Although ecological frameworks are commonly used in public health interventions (e.g., smoking cessation), they have been the least applied models to PA research [12]. Despite this, there is substantial opportunity to incorporate these models into overall PA and specifically transport-related physical activity (TPA) research, primarily because of the multi-disciplinary interactions within the field. As such, this thesis is based on a model that posits an individual's behaviour as a product of their environment, inferring that the contextual environment (design properties) is more influential in modifying PA levels (particularly TPA) than the compositional setting (individual behaviours). Using such a model assists with understanding how the built environment, TPA, transport behaviour, and health are inter-related.

## **Urban Design and Transport Trends**

From a global perspective, there is a shift towards urbanisation. It is projected that half of the world's population will live in an urban environment by 2007 and two-thirds of the populace by 2040 [13]. Currently, 87% of the NZ population reside in towns or cities [14]. In order for communities to successfully and sustainably fulfil these urbanisation demands, the built environment needs to be designed with social cohesion, environmental aesthetics, and health promotion in mind. Since private automobile ownership became widespread in the 1950's [15], declines in well-connected street networks [16, 17], reduced mixed land use [18], and decreased population densities [19] have become evident in many developed countries. This in part, likely leads to an increase in commute distances, changing environmental aesthetics, urban sprawl, and autocentric environments [20].

To date, little consideration in urban planning has been given to encouraging and supporting walking and cycling as viable transport modes [15]. As such, it is hypothesised the decline in population-level PA engagement may be partially attributable to the changing urban environment that discourages TPA (i.e., walking and cycling as modes of travel) engagement and promotes private automobile use for travelling short distances [4]. Indeed, almost all

developed countries now rely on private automobiles as their main form of transport [20, 21], and a similar trend is appearing in developing countries [22].

### **Transport-related Physical Activity**

Previous and current public health PA initiatives are generally focused towards promoting LTPA engagement at the population-level [23], and little is known about associations between overall PA, TPA, and the built environment. One potential reason for this dearth of knowledge is that urban and transport planners have historically worked independently to public health agencies, despite these disciplines having many commonalities. Increasingly, these similarities are being recognised, and although in its infancy, support exists for trans-disciplinary approaches for examining the built environment and health outcomes. Prior to this thesis, no TPA prevalence data existed for the NZ adult population and limited evidence was available internationally regarding associations between overall PA, TPA, and the built environment. As such, there was a need to further investigate the built environment and travel behaviours from a health perspective, thereby potentially providing a sustainable and habitual solution to improving population-level PA levels [20].

### **Statement of the Problem**

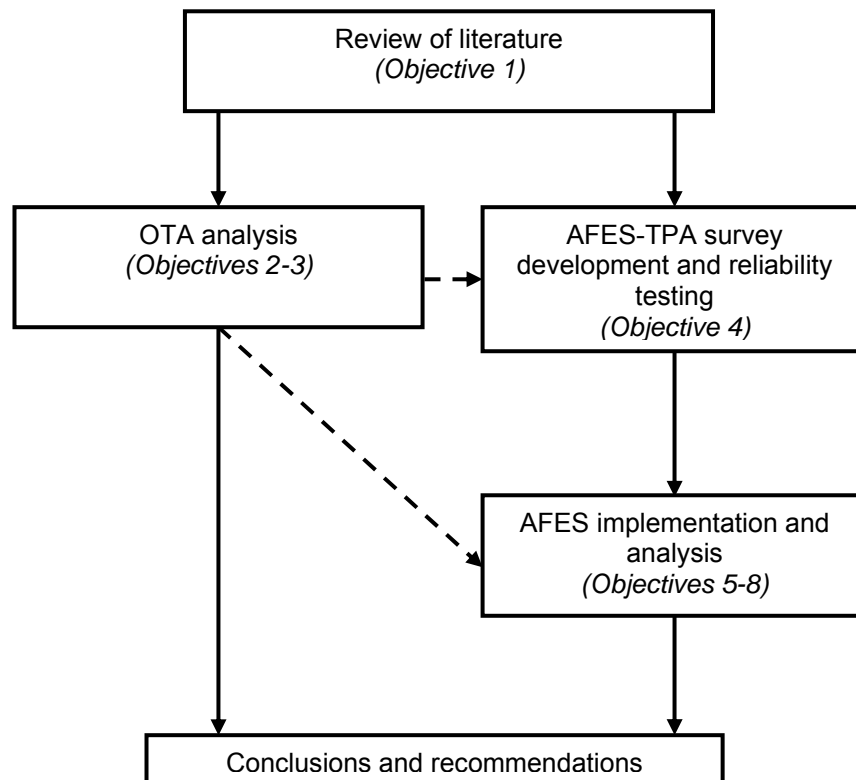
Preliminary findings suggest the urban environment has a substantial impact on overall PA behaviours and subsequent health-related outcomes. A more thorough investigation was warranted, however, as previous population-based PA surveys have not attempted to identify the optimal built environment for overall PA and TPA engagement, or specifically targeted TPA engager characteristics. Furthermore, as TPA engagement has not been a focus for health and transport practitioners, no reliable large-scale TPA survey tool existed. As a consequence, there were limited data available and minimal understandings of the relationships between the built environment and PA behaviours on a local scale, and a lack of understanding of variables associated with TPA behaviours and perceptions on an international scale. Specific areas that required further investigation at a population-level included differences in socio-demographic variables, social and physical environments, and travel patterns between those who do, and do not, engage in TPA.



## **Thesis Structure**

This body of work is presented as a logical progression of studies (presented as a series of chapters) that work together to form a thesis. Two literature reviews are followed by six descriptive, empirical research studies that operate in synergy to construct a comprehensive picture of the associations between overall PA and TPA engagement and perceptions, health outcomes, urban design, travel mode engagement, and socio-demographic variables. The final chapter (Chapter 10) serves to summarise key findings and recommendations that emerged from this body of research and place these within the context of current knowledge in the area. The appendices contain additional information which was excluded from the thesis chapters.

Because of the chosen submission format of the thesis being collated as a series of papers presented in chapter style, this document is repetitive in parts, with the purpose of the Chapter 10 being to summarise and contextualise the series of separate but linked research chapters. The prefaces serve to logically link each research study. This thesis fulfils the Auckland University of Technology Doctor of Philosophy guidelines by existing as a well developed, critical analysis of urban design and TPA research, and exists as an original contribution to this field of study. The thesis structure and related objectives are shown in Figure 1.



**Figure 1:** Overview of thesis structure

### *Data Sources*

This thesis analyses data from primary and secondary sources. The OTA survey was developed by SPARC in 2002 and implemented in 2003. The dataset was provided to the candidate for secondary analysis in 2004. For the AFES, the doctoral candidate played an integral role in the development of the survey, in particular the construction and reliability testing of the TPA component. AC Nielsen collected data for the AFES under contract in 2005 and the raw data was provided to the candidate for analysis later that year.

### *Study Aim*

The overarching aim of this thesis was to investigate the associations between overall PA and TPA engagement and perceptions, health outcomes, urban

design, travel mode engagement, and socio-demographic variables from a public health perspective.

### *Study Objectives*

1. To systematically review existing TPA, LTPA, and overall PA research that has examined urban design variables.
2. To determine how overall PA levels and environmental and travel mode perceptions were associated with recognition of replacing private automobile journeys with TPA modes in the NZ adult population.
3. To develop a reliable TPA survey tool that was suitable for a cross-section of the NZ adult population.
4. To examine the relationship between travel mode engagement to two destinations and overall PA engagement and body mass index (BMI) in North Shore City adults.
5. To understand the associations between private automobile availability, travel mode engagement to two destinations, overall PA, and TPA engagement in North Shore City adults.
6. To investigate the relationship between objectively-measured commute distance and travel mode engagement and perceptions for North Shore City adults who travelled to an occupation.
7. To understand the associations between objectively-measured urban design variables and travel mode engagement for North Shore City adults who travelled to an occupation.

### **Significance of the Research**

The significance of this research was as follows:

1. The surveys served to provide cross-sectional data to assist with understanding the investigated relationships in national and regional population-level samples of adults. Inferences can be made about these adult populations as the datasets used in the research were representative.
2. The research substantially expanded on the limited international body of existing urban design, transport, and TPA literature. Robust study

designs were utilised and the findings have been widely disseminated to health, transport, and urban design audiences.

3. A reliable TPA survey tool suitable for use with adults was developed as part of the research. Subsequent collaborative use of the survey may help to bridge the gap between urban design, transport, and health behaviours as no TPA-specific tool previously existed. There is also potential to incorporate the AFES-TPA survey into other national and international studies for comparison and tracking purposes.
4. The studies helped to understand and define the optimal environment for overall PA and TPA engagement by identifying real and perceived barriers that impacted on travel mode choices.
5. Public health recommendations could be provided to local government bodies regarding urban design and transport infrastructure. This may result in improving the quality of the built environment to make it more 'activity friendly', as well as increasing the sustainability of TPA engagement, thereby improving population health outcomes.

### **Study Delimitations**

Specific parameters form the boundaries of the studies. These were:

1. Aside from geographical information systems (GIS) measures of the built environment, no other objective measurements were taken, and all survey data were gathered by self-report methods. Relying on self-report measures may have led to some systematic under- or over-reporting.
2. Data were single time point, cross-sectional measures. As such, causality could not be inferred.
3. Environmental audits around respondents' residential addresses were not undertaken. Subsequently, the environmental data (excluding GIS measures) were based solely on the respondents' perceptions.
4. Participants' perceptions of a neighbourhood were self-defined, therefore these classifications likely varied from person to person.
5. Study participants were limited to English speaking, NZ adult respondents. Caution should be used when generalising the findings to other populations.

6. Residents who did not have access to a land-based telephone or had unlisted telephone numbers were excluded from participating in the Active Friendly Environments Survey (AFES).
7. TPA engagement occurrences were delimited to travelling to or from a respondent's occupation (place of work/study) and their local convenience shop.
8. Both literature reviews comprehensively examined published peer-reviewed literature at the time of their submissions to scientific journals. Relevant peer-reviewed evidence after 2004, has not been included in Chapters 2 and 3 (review chapters), as these initial literature reviews formed the basis for the chosen research design and methodology. More recent research has been included in the thesis by being incorporated into the subsequent thesis chapters.

### **Study Limitations**

Study limitations of the present research were:

1. The non-response rates may have caused bias.
2. The contributions of PA from different domains could not be generated from the surveys.
3. Based on the self-report nature of the studies, energy expenditure through objective measures of PA could not be ascertained.
4. The travel mode survey tool has not been validated with a criterion measure.

### **Research Chapter Contributions**

The academic contributions for the research chapters were as follows:

Chapter 2: *Transport, Urban Design, and Physical Activity: An Evidence-based Update.*

Badland, H.M. (75%) & Schofield, G.M. (25%)

Chapter 3: *The Built Environment, Transport-related Physical Activity, and Health: What We Do and Do Not Know.*

Badland, H.M. (80%) & Schofield, G.M. (20%)

Chapter 4: *Perceptions of Replacing Private Automobile Journeys with Transport-related Physical Activity Modes: Exploring Relationships in a Cross-sectional Adult Population Sample.*

Badland, H.M. (80%) & Schofield, G.M. (20%)

Chapter 5: *Test-retest Reliability of a Survey to Measure Transport-related Physical Activity Levels in Adults.*

Badland, H.M. (90%) & Schofield, G.M. (10%)

Chapter 6: *Health Associations with Transport-related Physical Activity and Motorised Travel to Destinations.*

Badland, H.M. (85%) & Schofield, G.M. (15%)

Chapter 7: *Understanding the Relationships Between Private Automobile Availability, and Overall and Transport-related Physical Activity in Adults.*

Badland, H.M. (90%) & Schofield, G.M. (10%)

Chapter 8: *Objectively Measured Commute Distance: Associations with Actual Travel Modes and Perceptions for Adults Travelling to an Occupation.*

Badland, H.M. (80%), Schofield, G.M. (10%), & Schluter, P.J. (10%)

Chapter 9: *Travel Behaviour and Objectively-measured Urban Design Associations for Adults Travelling to an Occupation.*

Badland, H.M. (75%), Schofield, G.M. (15%), & Garrett, N. (10%)

## **Chapter 2: Transport, Urban Design, and Physical Activity: An Evidence-based Update**

### **Preface**

The urban environment is increasingly being linked to PA participation and population health outcomes, yet the associations between the built environment and PA behaviours have largely been reported from either health or urban design paradigms, rather than from collaborative approaches. Previous reviews in this field have generally been constrained to perceptions of the neighbourhood or walking behaviours, and consequently limit the understanding of broader urban design influences on other PA modalities, such as TPA engagement. As such, the purpose of this review is to strengthen and update the existing evidence surrounding various urban design features and PA behaviours. This chapter encompasses a review which systematically addresses physical built environment variables, populations at risk, and assessment tools, relative to PA engagement. Investigating these variables will assist with revealing pertinent relationships that require further examination, and subsequently, help frame the studies within this thesis.

## Introduction

Sedentary lifestyles in industrialised countries are increasingly becoming a major health risk, and it is estimated that insufficient PA causes 1.9 million deaths worldwide per annum [1, 3]. Local streets have been consistently identified as the most common place for engaging in PA [24, 25], with a body of research linking LTPA and TPA behaviours to built environment and transport fundamentals.

During the last few decades, immense urban changes have occurred in many developed countries, including reduced population density in cities and increased sprawl of housing, resulting in the residential migration to suburban developments [26]. In many cases, urban design has caused a population-level reliance on automobiles for daily travel [21], reduced accessibility to facilities [27], and altered community perceptions and cohesion [28]. Concurrently, many countries are reporting low PA levels and increases in obesity prevalence [3]. Although the link between the urban environment and health has been established, understanding the impact of the built environment on PA behaviours has been inadequately addressed by both the health and transport sectors.

Health promotion, transport, and urban design policies all have similar objectives. These are to produce practical, cost-efficient, and successful interventions that apply to a broad cross-section of the population. Urban design principles can easily be aligned with ecological models to increase incidental PA, and therefore total energy expenditure. Examples of these collaborative approaches include restricting city blocks to pedestrian only access, placing car parks away from building entrances, and making stairways more accessible and convenient. The aforementioned design modifications are conducive to PA, providing small individual changes. At the population-level, such changes could bring considerable long-term benefits, including reductions in healthcare expenditure, local traffic congestion, pollution, and infrastructure costs. Despite these advantages, the potential for such changes is based on a limited understanding of travel behaviour influences.

Several general reviews of the built environment and PA relationship exist [29-31]. Humpel, Owen, and Leslie [29] examined 19 studies in diverse settings, detailing consistent associations between PA and perceptions of



accessibility, opportunities, and the aesthetics of the environment. Weaker relationships were demonstrated between weather and safety with PA engagement, possibly due to the subjective nature of these variables. A strength of the paper was the authors attempted to separate out aggregate environmental measures by isolating numerous variables that could potentially impact on PA levels [29]. More recently, McCormack et al., [30] examined 30 PA studies, and evaluated the findings under the broad categories of neighbourhood functionality, safety, aesthetics, and destinations. The review added little to the existing body of knowledge, but reaffirmed previous findings detailed by Humpel, Owen, and Leslie [29]. Another review focused on 18, predominantly cross-sectional, walking environment studies. Three of the four studies that examined TPA engagement detailed positive associations between walking for transport with open space access, higher composite environmental scores, and high neighbourhood walkability [31].

Transport literature has also been evaluated from a public health perspective. One review by Sallis et al., [32] provided the basis for merging urban design, transport, and PA at a policy level, but demonstrated limited exploration of previous evidence. Readers were directed to another paper where a small number of US studies were evaluated [33]. Consistent positive correlations existed between PA levels and mixed land use, density, and street connectivity. Although the previous general PA and TPA reviews were comprehensive in their own right, all were primarily limited to cross-sectional designs, walking behaviour, homogenous groups, and were reliant on small sample sizes, subsequently limiting the amalgamation of knowledge from urban design and PA fields. The reason for this is that the reviews have been based on the evidence available at the time. As such, the aim of the present study is to build upon these reviews, as well as incorporating other relevant academic literature from health, urban design, and transport disciplines. This review systematically draws together evidence surrounding neighbourhood differences and traffic calming effects based on urban design fundamentals, the impact of the localised environment for at risk populations, TPA characteristics, and measurement issues associated with merging PA, urban design, and transport research.

## Neighbourhood Differences

Pre-World War II, cities were highly localised places that subsisted on the premise of low automobile ownership. The infrastructure that existed allowed daily requirements to be achieved within a comfortable walking distance, or with the combination of transit. Post-war economics led to increased disposable income and decentralisation of cities to suburban centres and single land uses [15]. As a result, automobiles are now relied on for travelling the long inter-destination distances associated with suburban sprawl. Traffic congestion, single-occupant automobile travel, increased pollution, rising infrastructure costs, and degeneration of communities are serious concerns for transport sectors in developed countries [15, 34]. Consequently, in many urban environments PA opportunities have shifted from TPA to LTPA.

Subdivision age has been used as a proxy measure of urban form. Older urban environments often show increased walkability because of higher population and building density, grid street design, complete footpaths, and mixed land use diversity associated with pre-World War II necessities [35-37]. At the disaggregate level, living in older homes has been associated with walking. Adjusted findings indicated that residents living in pre-1973 dwellings walked at least one mile more, 20 times per month, when compared with those living in newer residences [35]. The non-specific walking associations existed for residents in urban and suburban neighbourhoods, but not for those in rural areas and for other types of PA engagement. Surprisingly, no discernable differences were shown in walking behaviour between those dwelling in residences built pre-1946 and 1946-1973. Nevertheless, a relationship may have existed if TPA engagement had been specifically examined. In contrast, one study showed that residents living in a newer neighbourhood development demonstrated higher walking levels in comparison to residents living in an older neighbourhood [38]. The anomaly may have been linked to differences in public transport accessibility. Based on the presented evidence, it remains to be determined if localised urban design is more influential than residential age (see Table 1).

The mean age of a developed area (an informal proxy measure of sprawl) has also been associated with household TPA engagement. Residents of older subdivisions tend to make less automobile trips and engage in more TPA than those in newer subdivisions. For example, Friedman, Gordon, and

Peers [17] compared transportation survey data from pre- and post-World War II neighbourhoods in the San Francisco Bay area. Post-war suburban residents engaged in almost two more auto driver trips per day, and walked less than pre-war neighbourhood residents (8% versus 15%, respectively). Comparison groups, however, were not adjusted by potential confounders and all data were self-report. To further support this relationship, three years of self-reported health and localised county sprawl have been investigated, with lower sprawl values indicating greater residential sprawl. Residents in areas one standard deviation above the mean county sprawl walked 14 minutes more for leisure each month compared with residents living in localities one standard deviation below. A reverse trend was shown with BMI, detailing a 0.085 kg/m<sup>2</sup> reduction with each standard deviation increase [39] (see Table 1).

**Table 1:** PA and neighbourhood differences research

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Berrigan & Troiano [35]	n=14,827 Adults M=7,117	Age of residence	Local neighbourhood	Walking LTPA	A, E, I, L, R, S	Residence age was associated with urban walking frequency and all demographic variables apart from gender.
Ewing et al., [39]	n=206,992 Adults M=unreported	Urban sprawl	Census tracts	Walking	A, E, R, S, SP, SS	Risk of increased BMI and hypertension, and decreased walking were associated with increased county sprawl.
Friedman, Gordon, & Peers [17]	n=7,091 Adults M=unreported	Number of trips per household Travel mode per trip	Census tracts	TPA	None	Post-World War II suburbs were associated with residents making more automobile trips. Pre-World War II suburbs were associated with residents using alternative transport modes.
Leslie et al., [38]	n=87 Adults M=23	Residential density Land use mix diversity Land use mix access Street connectivity Walking infrastructure Neighbourhood aesthetics Traffic safety Level of crime	Local neighbourhood	Walking	None	High walkability neighbourhoods were associated with higher residential density, street connectivity, and land use mix.

Table 1 continued overleaf

Table 1 continued

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Saelens et al., [18]	n=107 Adults M=50	Land use diversity Residential density Street connectivity Walking/cycling facilities Neighbourhood aesthetics Traffic safety Level of crime	Local neighbourhood	Walking Cycling	A, E	Those reporting mixed land use diversity, higher density, street connectivity, better aesthetics, and safety were more likely to reside in highly walkable neighbourhoods.

Statistical adjustment key: A=age, BMI=body mass index, E=education, I=income, L=activity limitations, M=male, R=race/ethnicity, S=sex, SES=socio-economic status, SS=smoking status, SP=urban sprawl

Studies repeatedly show that mixed land use diversity is an urban design variable likely to affect the walkability within neighbourhoods, primarily by influencing the accessibility and convenience of locations [18, 36, 38, 40]. An Australian study detailed those who reported better facility access, mixed land use, density, and connectivity resided in more walkable neighbourhoods and were more physically active. On a cautionary note, the low walkability neighbourhood contained hillier topography and the residents reported reduced access to public transport [38]. Nevertheless, residents' neighbourhood walkability differences are estimated to be between 15-30 minutes [32] and 70 minutes [18] per week, with the latter value based on a small pilot study. In practical terms, residents living in high walkability neighbourhoods accumulate current PA recommendations (30 minutes of moderate intensity activity) on at least one additional day per week.

### **Traffic Calming Mechanisms**

Modifying traffic patterns through calming mechanisms may be a logical way to influence PA levels. Traffic calming measures such as speed humps, traffic circles, and pedestrian refuges have merit as self-regulating automotive speed designs, and may provide opportunistic occurrences for TPA engagement such as utilising road closure thoroughfares and pedestrian crossings. Although traffic calming mechanisms may increase PA opportunities, it is unknown what effect the devices have on modifying LTPA and TPA levels. It has been shown that traffic calming devices reduce pedestrian injuries, where the risk of injury or death for child pedestrians were significantly higher for increased traffic volume (Odds ratio (OR)=14.3; 95% Confidence interval (CI)=7.0-29.2) and higher density curb parking (OR=8.1; 95%CI=3.3-19.9) in a case-control study [41]. Increases in child pedestrian injuries were evident in streets that had greater than 10% curb space allocated for parking and 250 automobiles travelling on the road per hour. The curb parking variable requires further investigation, however, as other research suggests that automobiles parked on the road increases the perception of pedestrian safety from street traffic [15].

## **At Risk Populations**

### *Children*

Interaction with the built environment is a key component of LTPA and TPA engagement for children. Not surprisingly, Roberts et al., [42] detailed a positive relationship between the number of streets crossed and chronological age, and a negative association between household vehicle ownership and reduced walking with children. Unfortunately a more comprehensive understanding of children's travel behaviour could not be determined as accompanied and unaccompanied child trips were not ascertained. Timperio et al., [28] also supported the relationship between household automobile ownership and walking behaviour in children. These findings, however, were based on a low response rate (36%) and proxy reporting, resulting in variable test-retest reliability measures (Table 2). Parental socio-economic status (SES) also influences residential location with many parents choosing to move to the suburbs on the premise of providing play areas and safe environments for children. As a consequence, unsupervised child TPA occurrences may be restricted because of inter-destination suburban distances [32] and associated parental traffic concerns [43], as travel modes of children are strongly influenced by parental perceptions [28]. Parents' perceived safety of the environment has also been related to reluctance of allowing children to play freely outside [15], and active childhood outdoor pursuits may be replaced with 'safer' sedentary activities where children can be monitored.

### *Older Adults*

Many older adults face health risks due to inactive lifestyles. Older adults take fewer trips overall by any transport mode, and their travel is largely automobile dependent [21, 44]. High suburban automobile speeds and incomplete footpaths may convey the perception that it is unsafe for older adults to use the local environment for walking [45]. For example, 99% of adult pedestrians aged 72 years or older could not cross electronically controlled street crossings in the allocated time, and 11% of the sample reported general difficulties crossing the road [46]. The findings were based on the time it took participants to walk eight metres (m) down a corridor from a standing start. The test, however, was not environment specific and potentially underestimated walking speeds.

**Table 2:** PA and physical and social environmental research with at risk populations

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Balfour & Kaplan [47]	n=883 Older adults M=383	Traffic safety Loud noise Level of crime Presence of litter Presence of lighting Public transport accessibility	Local neighbourhood	Overall and lower extremity functional loss	A, BRF, E, H, I, R, S	Residents that reported multiple neighbourhood problems were associated with increased risk of overall and lower extremity functional loss. Excessive noise, inadequate street lighting, and heavy traffic were associated with an increased risk of functional loss in residents.
Estabrooks, Lee, & Gyurcsik [27]	n=133,046 Adults M=unreported	Availability of user pays PA facilities Availability of free PA facilities	Census tract	Facility accessibility	None	Availability of free PA facilities was positively associated with SES increases.
Giles-Corti & Donovan [40]	n=1,803 Adults M=532	Spatial access to individual facilities Perceptions of the physical environment Use of facilities	Census tract	Walking LTPA	A, E, I, NC, O, S	Time spent walking for transport was associated with low SES. Sufficient PA, spatial access to facilities, facility use, and vigorous activity were associated with increases in SES.
Langlois et al., [46]	n=1,249 Older adults M=560	Difficulty crossing the street Crossing controlled intersections in designated time	Local neighbourhood	Walking	A, HO, MH, S, V	Low walking speed, required daily assistance, history of strokes, fractures, or diabetes, were associated with increased risk of difficulty in crossing the street.

Table 2 continued overleaf



Table 2 continued

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Roberts et al., [42]	n=13,423 Children M=unreported	Number of streets crossed	Environment between home and school	Walking Cycling	SCE	Increase in number of streets crossed was associated with increased age of child. Increased household private automobile ownership was associated with reduced likelihood of a child walking to school. Number of streets crossed by a child was inversely associated with household private automobile ownership.
Ross [48]	n=2,482 Adults M=1,015	Number of days walked per week Vigorous activity participation	Census tract	Walking LTPA	A, E, I, MS, R, S	Residents of low SES neighbourhoods and neighbourhoods with a high proportion of residents with college degrees were more likely to regularly walk.

Table 2 continued overleaf

Table 2 continued

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Takano, Nakamura, & Watanabe [49]	n=3,001 Older adults M=1,312	Space near residence for a stroll Local park accessibility Tree-lined residential street Automobile and factory noise Level of crime Hours of sunlight Residential garden Public transport accessibility Communication with neighbours Preference to live in the community	Local neighbourhood	Walking	A, L, MS, S, SES	Five year survival was associated with adequate neighbourhood walking space, neighbourhood parks and tree-lined streets, and preference to live in the community.
Timperio et al., [28]	n=291 5-6 year old children M=150 n=919 10-12 year old children M=424	Appropriate distance for child to walk Traffic safety Stranger danger Child and parental (proxy) perceptions of the neighbourhood	Local neighbourhood	Walking Cycling	SCE, SES	Heavy traffic, single private automobile ownership, dog ownership, and adequate public transport were associated with increased walking and cycling. Negative parental perceptions, lack of crossings, and proximal parks were associated with decreased walking and cycling.

Statistical adjustment key: A=age, BRF=behavioural risk factors, E=education, H=health status, HO=housing, I=income, L=activity limitations, MH=mental health status, M=male, MS=marital status, NC=number of children (<18 years old), O=occupation, R=race/ethnicity, S=sex, SCE=school clustering effects, SES=socio-economic status, V=vision

A link has been established between self-defined neighbourhood problems and functional loss in older populations (see Table 2). One cohort study examined self-reported functional deterioration and associated perceived neighbourhood problems during a one year period. Those who reported multiple neighbourhood problems were more at risk of overall physical (OR=2.2; 95%CI=1.0-4.6) and lower extremity (OR=3.1; 95%CI=1.2-8.5) functional losses when compared with older adults who reported no, or one neighbourhood problem [47]. Inadequate street lighting was the greatest single neighbourhood variable associated with functional loss, followed by excessive noise. Interestingly, limited accessibility to public transport was associated with elevated risk of functional deterioration, suggesting that accessibility and localised mobility may be critical to sustaining functional independence in older adults. Regardless of SES and baseline functional capacity, positive associations also exist between longevity and favourable attitudes toward the community, walkable green spaces, and quality of residential streets [49].

#### *Socio-economic Status*

The most pronounced urban design and transport differences exist for SES variations amongst individuals. A GIS-based study compared PA facilities with census tracts, showing SES variances with facility accessibility. Unadjusted group differences existed regarding accessibility to free structured facilities, with low and medium SES tracts having a reduced number of facility sites available ( $4.5 \pm 2.3$  and  $4.9 \pm 2.6$  sites, respectively) in comparison to high SES census tracts ( $8.4 \pm 3.5$  sites). The amount of user pay facilities, however, was similar across all groups ( $3.1 \pm 1.5$  sites) [27]. This is concerning, as low SES groups are least likely to have disposable income and are most at risk to suffer from chronic illnesses associated with physical inactivity [1, 2].

In contrast, Australian researchers detailed residents in low SES census areas had better network access to facilities, including footpaths, but were less likely to use them for LTPA engagement. After adjusting for various confounding factors, significant associations were shown with low SES residents reporting increased walking for transport in comparison to their high SES counterparts, but were more likely to be classified as inactive [40]. Caution should be applied when interpreting these data as the sample consisted predominantly of women and the study was based on SES extremities (Table 2). On the other hand, a

multi-level analysis associated a higher level of leisure time walking engagement in low SES groups with enhanced perceptions of convenience. This was purported as a potential normalisation effect of the local environment, although possible confounders, such as automobile accessibility and public transport variables, were not investigated [48].

### **Transport-related Physical Activity**

Recognised travel mode considerations include commute distance, modal speeds, costs, and convenience, with modal user characteristics warranting further investigation. Inter-destination design features such as residential density, facility accessibility, mixed land use, and street connectivity may also be mitigating factors for TPA engagement. A review of trip-chaining analyses of people in three European countries detailed commuting to place of work/study was the main bicycle travelling motive. As expected, the extent of bicycle network development was positively associated with bicycle use [50]. Other analyses indicated that cycling and walking in Europe were safer than other non-European industrialised countries. Specific urban design fundamentals linked to reduced cycling injury levels in Europe included traffic calming, automobile restrictions, extensive traffic education policies surrounding TPA modes, and pedestrian- and cyclist-sensitive designs. Incorporating these design features and policies into future initiatives may be useful to encourage cycling engagement, particularly in many non-European industrialised countries where cycling levels are low across all age groups [21, 42, 51].

In non-European countries, potential causes of low cycling rates may be because of the lack of cycle corridors leading to practical destinations and residential proximity to cycle trails. To support this finding, Australian inner city residents who used and resided 1.5 kilometres away from a cycle trail were more likely to use a cycle trail approximately one hour extra per person per week ( $p\text{-value} < 0.05$ ) than suburban users who lived 1.5-5.0 kilometres away from the infrastructure [52]. The cohort study also indicated that males and younger adults (18-34 years old) were more likely to have used the trail at least once (see Table 3). Aside from accessibility and connectivity, negative correlates of bicycle use included heavy intersection traffic and the presence of steep hills, and unadjusted significant positive relationships were shown with

light traffic and mixed land use diversity, but were not evident in the adjusted models. These findings, however, may not have been based on sufficient participant variability, as the cross-sectional sample was predominantly white and well educated [53]. Based on the presented information in Table 3, it appears that environmental variables are not strongly related to recreational cycling behaviour.

**Table 3:** TPA and physical environmental research

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Giles-Corti & Donovan [54]	n=1,773 Adults M=564	Presence of footpaths Presence of trees Land use diversity Access to river Access to open space Access to beach Access to golf club Quiet surrounding roads Street lighting Dog ownership	Local neighbourhood	Walking	A, E, I, NC, S	Access to open space was associated with increased walking.
Merom et al., [52]	n=450 Adults M=248	Recall of trail promotional campaign message Bicycle trail use	Suburb	Cycling	A, AR, MS, R	Inner city cyclists, males, trail launch, and recollection of baseline message were associated with increased cycling. Minimum daily temperature and rainy days were negatively associated with cycling.
Rafferty et al., [55]	n=3,808 Adults M=1,512	Distance walked for transport	State-wide	Walking	A, R, S	Men and African-Americans were more likely to walk for transport. Warmer seasons were associated with increases in walking for transport.

Table 3 continued overleaf

Table 3 continued

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Troped et al., [53]	n=413 Adults M=164	Presence of footpaths Topography Level of crime Land use mix diversity Street lights Distance to trails Scenery Traffic safety Unattended dogs	County	Cycling	A, SE, SO	Pleasant scenery, presence of street lights, neighbourhood footpaths, and no hills were associated with increased cycling for transport. Increased distance to trails was negatively associated with cycling for transport.

Statistical adjustment key: A=age, AR=residential area, E=education, I=income, M=male, MS=marital status, NC=number of children (<18 years old), R=race/ethnicity, S=sex, SE=self efficacy, SO=social support, TS=transit service

Walking is the most common and preferred form of PA for the general population, and is likely the principle reason why numerous PA reviews that have focused on the behaviour. Walking popularity likely stems from its accessibility, negligible equipment specialisation, and acceptability as a form of exercise for various sub-populations [56]. Although it may be the most pursued form of PA, the minority of Australians engage in adequate walking for health benefits [54]. Giles-Corti and Donovan [54] detailed one significant relationship between self-reported walking behaviour and access to public open space. This is somewhat of an anomaly as an extensive body of research has reported significant relationships with the other study variables investigated (see Table 3). It is likely, however, that research findings for walking are culturally specific. For example, Indian travellers without vehicles were simulated to regularly engage in walking distances between 1.3 and 2.5 kilometres, with distance discrepancies based on SES [57]. In contrast, a cross-sectional study demonstrated that 8% of US adults did not think it was acceptable to walk any distance for transport. The three most common barriers associated with walking for transport were time inconvenience, poor weather, and substandard health [55]. Conversely, other research has demonstrated trip distances were the most defining barrier when travel mode options were limited [57].

## **Measurement Tools**

Public health researchers have predominantly been concerned with tracking PA changes, instead of measuring the contextual environment, whereas transport and urban design practitioners have spent little time focusing on TPA levels [32]. In order to ensure mutually beneficial research, urban design, transport, and PA objectives need to be integrated into comprehensive studies. In the first instance, measurement strategies need to be incorporated at a cross-sectional level with practitioners seeking to develop cohort studies that track behaviour in differing environments. Table 4 outlines pertinent studies that have incorporated some of these measures in the study designs.

### *Audit Tools*

Audit tools show promise for collaborative approaches as they are relatively easy to use and can incorporate a large number of variables. Sallis et



al., [58] developed a 43-point scale that examined PA engagement in various settings, including in the home and neighbourhood, and on frequently travelled routes. Although adequate test-retest reliability existed ( $r=0.7-0.9$ ) and construct validity was supported, the only significant association once confounders were adjusted for existed between home PA equipment and strength exercises [58]. Environmental characteristics measured by the Neighborhood Environment Walkability Scale (NEWS) have also showed moderate to high test-retest reliabilities ( $ICC=0.6-0.8$ ) in a predominantly Caucasian sample (Table 4). Those who reported higher density, land-use mix, connectivity, safety, and aesthetics accumulated more PA as measured by accelerometers. Residents living in high walkability neighbourhoods also reported more TPA engagement for errands than those in low walkability localities (85% versus 60%, respectively) [18].

NEWS has also been used in two Australian studies. Significant positive relationships were shown for neighbourhood walking with men who held more optimistic neighbourhood perceptions and for women who perceived greater facility accessibility [59]. NEWS also detected differences between residents living in high and low walkable neighbourhoods, showing the greatest neighbourhood variability for mixed land use diversity and least group differences for adequate street connectivity [38]. Pikora et al., [60] has also developed a simple, reliable audit tool to measure the local physical environment. The Systematic Pedestrian and Environmental Scan (SPACES) defined a neighbourhood as a 400m radius from a respondent's residence, and assessed components of functionality, safety, aesthetics, and destinations. Both the intra- and inter-reliability of the items in the SPACES audit were generally high, aside from subjective measures of attractiveness of the streetscape and difficulty in walking [60].

### *Geographical Information Systems*

GIS is an objective spatial mapping tool that analyses layers of the built environment. It is gaining popularity in the health and urban design sectors with several studies incorporating this technology to provide an in depth objective analysis of the local environment. Pikora et al., [60] incorporated GIS into the SPACES assessment to ascertain geographic features of the audited

environment. Similarly, GIS databases have been employed to measure green space around a respondent's residence (300 m-500 m radius) in an attempt to understand PA influences. A study by Wendel-vos et al., [61] demonstrated no significant associations for walking engagement, and cycling behaviours were dependent on the radius around the respondent's home (see Table 4), reiterating the findings from Merom et al., [52] that those who live closer to a cycle trail were more likely to use it. Caveats of the study were that only a limited number of GIS variables were measured and participants resided in exceptionally hilly terrain. Troped et al., [53] also applied GIS measures in a cycling study, showing a negative relationship between bicycle use and environmental variables [53] (Table 3).

GIS has also been used at a simulation level to model neighbourhood pedestrian network connectivity [16, 62]. Modelling neighbourhoods prior to development show promise for conceptualising the urban environment relative to PA behaviours. Although several PA studies (both real and simulated) have used GIS, further attention is still required, including vigilant selection of information overlays to detect determinants of neighbourhood level PA. The objectivity and level of detail acquired from GIS provides high utility for public health and urban planning research and many GIS uses remain untapped. Despite this, the cost and expertise required limits GIS uses to primarily large, collaborative studies.

**Table 4:** PA research that utilised physical environmental measurement tools

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Boarnet & Sarmiento [63]	n=769 Adults M=377	Residential density Land use mix Street connectivity	Local neighbourhood	Trips	None	Women were most likely to engage in non-work trips. Children and elderly were least likely to make non-work trips.
Cervero & Radisch [64]	n=1,460 Adults M=unreported	Mixed land use diversity Travel mode Street network length	Census tracts	TPA	I, TS	Neo-traditional neighbourhood residents were more likely to engage in TPA, non-work trips and make less daily automotive trips than suburban residents. Residents in mixed use, compact areas were more likely to access public transport by walking and cycling than residents in more sprawling areas.
De Bourdeaudhuij, Sallis, & Saelens [65]	n=521 Adults M=270	Side walk quality Activity facilities Home activity equipment Residential density Land use mix diversity Land use mix access Street connectivity Walking/cycling facilities Aesthetics Traffic safety Level of crime Public transport accessibility	Local neighbourhood	Overall PA	None	Increased footpath quality was positively associated with an increased likelihood of minutes walking and moderate intensity PA for men. Enhanced accessibility to shops, public transport, and facilities were associated with increased minutes walking and moderate intensity PA for women. Vigorous activity was positively associated with proximity of activity facilities and home activity equipment.

Table 4 continued overleaf

Table 4 continued

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Humpel et al., [66]	n=800 Adults M=402	Residing in coastal versus non-coastal locations Accessibility Convenience Traffic safety Aesthetics	Local neighbourhood	Walking	A, E	Men residing in a coastal location and held positive perceptions of their neighbourhood were more likely to engage in neighbourhood walking than non-coastal men. Reduced accessibility to services was associated with an increase in neighbourhood walking for women.
King et al., [67]	n=149 Older adults M=0	Proximity to park Proximity to trail Land mix diversity Aesthetics Traffic safety Level of crime	Community	Walking LTPA	None	Those who lived within walking distance of a trail, retail store, or park were more likely to have higher pedometer scores than those not living within walking distance. Neighbourhood walkability scores increased as the number of destinations accessible by walking from home intensified.
Sallis et al., [58]	n=110 Adults M=27	Home PA equipment PA facilities Presence of footpaths Hilly landscape Enjoyable scenery Level of crime	Local neighbourhood	Overall PA levels	A, E, FA, HE, I, S	Presence of home equipment was associated with an increased likelihood of PA.

Table 4 continued overleaf

Table 4 continued

<i>Reference</i>	<i>Number Age Gender</i>	<i>Environmental variable</i>	<i>Setting</i>	<i>PA behaviour</i>	<i>Statistical adjustment</i>	<i>Significant association with main outcome variables</i>
Takano, Nakamura, & Watanabe [49]	n=3,001 Older adults M=1,312	Space near residence for a stroll Local park accessibility Tree-lined residential street Automobile and factory noise Level of crime Hours of sunlight Residential garden Public transport accessibility Communication with neighbours Preference to live in the community	Local neighbourhood	Walking	A, L, MS, S, SES	Five year survival was associated with adequate neighbourhood walking space, neighbourhood parks and tree-lined streets, and preference to live in the community.
Wendel-vos et al., [61]	n=11,541 Adults M=5,353	Neighbourhood green space Neighbourhood recreational space	300-500m radius around respondent's home	Walking Cycling	A, E, S	Size of sports ground was associated with an increased likelihood in general bicycling in the 500m radius. Size of parks was associated with an increased likelihood in bicycling for transport in the 300m radius.

Statistical adjustment key: A=age, E=education, FA=facilities, HE=home equipment, I=income, M=male, S=sex, TS=transit service

### *Self-report Tools*

Numerous generic PA questionnaires exist and have been used extensively in urban design research. The International Physical Activity Questionnaires (IPAQ) have been successfully used in environmental studies [65, 66], and show the most utility for international PA comparisons [68]. The seven day recall IPAQ measure has shown acceptable international psychometric performance, reporting  $r=0.8$  for reliability and  $r=0.3$  for validity (criterion measure accelerometers) in adults [69]. In one study, minutes spent walking were significantly correlated to environmental variables, although walking for transport or recreation could not be differentiated (Table 4). The IPAQ, however, explained only minimal variance between reported PA and environmental correlates [65].

A common criticism of the commonly used IPAQ-short form (IPAQ-SF) is that it is not sensitive enough to detect TPA engagement [65, 66]. The IPAQ-long form (IPAQ-LF) scores higher activity level prevalence than other questionnaires, however, as it accounts for transport, occupational, and recreational PA. Therefore higher recommended PA guidelines may need to be established if the IPAQ-LF is to be used systematically as a surveillance tool. On a cautionary note, the IPAQ-LF is lengthy and repetitive, making it costly for routine surveillance. Two studies have also found the IPAQ-LF telephone survey to over-report PA levels [70, 71].

Travel diaries have been used to form the basis of aggregate trip data. Current methods of self-report travel diary data appear to capture home-based travel better than work-based travel, potentially because work-related trips are under-reported when trip-chaining occurs (i.e., linking several trips within one journey) [72]. Boarnet and Sarmiento [63] used two-day travel diaries to estimate the number of residential non-work trips through regression modelling techniques. A complex non-significant relationship existed between socio-demographic variables and land use characteristics near the person's place of residence for non-work trips, and no relationships were established with work-related travel [63]. Limitations were the sample was biased towards well-educated, white people, and the measured area was too confined to capture many non-work trips. Other research has also utilised travel diaries, with participants recording their three main transport trips from the previous day [64].

Although the response rate was low (18%), a substantial amount of information was gathered, including travel means, origin and destination information, and trip length and duration. Matched-pair non-work travel appeared to be more elastic than work-related travel and it was strongly linked to household vehicle ownership.

### *Motion Sensors*

Motion sensors, such as pedometers and accelerometers are objective PA monitors that record ambulatory activity, and have been successfully implemented in environmental studies. King et al., [67] found a positive association between older women with higher pedometer step counts and living within walking distances of a park, walking trail, or specific shops ( $p$ -value $<0.01$ ). Unadjusted findings demonstrated older women perceived that 20 minutes was an acceptable walking time to access destinations, and were more likely to walk when multiple destinations were present. Other research detailed a relationship between accelerometer-determined minutes of PA engagement, walkability of a neighbourhood, and obesity prevalence. The relationship between residents' weight status and neighbourhood walkability, however, was weakened once other covariates were included [18].

Tudor Locke et al., [73] used accelerometers with children to understand energy expenditure differences between engaging in different modes to travel school. Annual energy expenditure differences between walking and being driven to school equated to 8,840 calories for boys and 6,640 calories for girls. Similar findings for children were reported elsewhere [74]. In both cases [74], urban design variables were not measured, as the objectives were to establish energy expenditure associated with school related travel. Although PA studies often seek to incorporate motion sensors, limitations do exist. These include the lack of measurement sensitivity to certain types of body movements (e.g., cycling), and the cost of both the unit and attaching the sensors to the participants. Nevertheless motion sensors show promise in urban design studies as they are portable, non-invasive, and easy to use.

Infrared sensors are common automated measurement devices used in transport research, but are limited in the field of PA. The sensors are vulnerable to reliability and validity issues regarding TPA travel modes, including only

being able to measure one person at a time, disturbances by environmental conditions, inability to distinguish between modal activity and individuals, and inconsistencies in open spaces [75]. A study comparing infra-red beam counters (IRBC) with direct observation in five parks demonstrated that the IRBC overestimated people using walking paths by 14% to 78% and underestimated pedestrian volume count by approximately 20% [76]. Presently, infrared sensor applications are limited for measuring PA in an urban setting.

## **Limitations**

Understanding the association between the built environment and PA behaviour is a challenging task, but one that is gaining momentum. Australian [30, 66, 77-79] and US [32, 39, 80-83] researchers are leading the way in built environment and PA research, however, more detailed international perspectives are needed. The 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. Another problem facing researchers in the area of urban design, transport, and PA is sampling and measurement inconsistencies between studies, making inter-study comparisons often impossible. This is evident in the presented tables where contradicting information is shown. Furthermore, the present review is confined to existing academic publications, and a paucity of research has been highlighted around trip-chaining, traffic calming, and a comprehensive understanding of how the built environment impacts on travel mode choices.

## **Implications**

An opportunity exists to combine and develop ecological models that may increase the understanding of transport and PA behaviours. Further investigation is needed first, however, to understand perceived and real environmental barriers for different user groups, particularly low SES groups and those with limited vehicular accessibility. Urban and health planners need to prioritise settings that are most specific for these user-groups. Facility site selection and traffic calming mechanisms also need careful consideration to maximise population health outcomes. Parental environmental and safety concerns need to be targeted to encourage the sustainability of child TPA



engagement, and prospective research needs to investigate if travel modes utilised as a child track into adulthood.

This review supports different urban design features are conducive to discrete PA behaviours. It now remains to be understood which urban investments will maximise PA engagement. Based on the presented evidence it appears that TPA engagement may show promise for activity sustainability, but limited information is available regarding this behaviour and much work remains in this field. Future prospective designs need to determine if individuals select their neighbourhood based on travel modality opportunities, or if neighbourhood choice is based on individual, social, economic, and logistical restrictions external to travel considerations. This is a comment echoed by nearly all published urban design and PA research to date. Despite this, the present review goes some way to drawing together existing transport, built environment, and PA literature, however, the complexity of the relationships need further systematic attention.

## **Chapter 3: The Built Environment, Transport-related Physical Activity, and Health: What We Do and Do Not Know**

### **Preface**

Based on the evidence presented in the preceding chapter, fostering suitable built environments are critical to sustaining overall PA engagement, and specific urban design variables are linked to TPA participation. Key urban design features identified from the literature and presented in Chapter 2 that were attributable to TPA engagement were density, subdivision age, street connectivity, and mixed land use. The evidence presented in this chapter extends on these findings by focusing on and reviewing international TPA-specific research in relation to current trends, measurement issues, and health outcomes associations, and further explores related urban design variables. This review substantially contributes to TPA research by combining and evaluating relevant studies from multiple disciplines in order to identify future research opportunities in this field.

## **The Case for Transport-related Physical Activity**

Vehicle congestion, traffic accidents, and pedestrian fatalities have been the primary concerns for urban designers and transport researchers for many decades [84], whereas public health agencies have examined the relationship between the built environment and health status, namely: respiratory health [85], cardiovascular disease [86, 87], and social capital [88]. Although these problems are worthy of attention, the burden of disease and subsequent mortality rate from physical inactivity is alarmingly high [1, 89], and public health agencies are becoming increasingly concerned at the low PA engagement levels evident within developed and developing countries, and resulting co-morbidities [1]. It is estimated that non-communicable diseases account for 60% of all deaths, and 47% of the global burden of disease. These figures are expected to respectively rise to 73% and 60% by 2020 [3], in part, because of the changing environment that supports sedentary lifestyles [90].

Increasingly, evidence is linking the built environment with PA engagement. Several recent comprehensive reviews [29-31, 91] have identified aspects of urban design associated with activity behaviours. Following on from these, two inclusive reviews have specifically documented correlates of TPA engagement, both from health [32] and urban design [33] perspectives. The latter reviews pointedly demonstrate that promoting TPA engagement should become a public health priority, with the Task Force on Community Preventive Services [92] and the World Health Organization (WHO) [20] further recommending environmental and policy approaches to increase PA levels. Accordingly, the US national health surveillance survey (Behavioural Risk Factor Surveillance Systems (BRFSS)) has been incorporating travel-related questions from 2001 onwards [55]. Although this is a worthy initiative, the current BRFSS survey cannot specifically track TPA engagement as the frequency and duration are not recorded independent to LTPA engagement. Despite this, the present review strengthens the case for focusing on TPA behaviours by addressing pertinent urban design variables, travel behaviour, and associated health outcomes.

## Current Transport Trends

Industrialised countries are becoming increasingly autocentric. As cities become more sprawling and have less street connections, few realistic alternatives other than private automobile use are available [84, 93]. Motorised travel now replaces many TPA journeys, existing as the main form of transport in many developed countries [21], and automobile ownership is increasing rapidly in developing nations, such as China [22]. Despite this trend, preliminary findings from the Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality (SMARTRAQ) survey detailed 40% of all current motorised trips in the area could reasonably be substituted with TPA travel. The survey reasoned replaceable journeys were for food, school transport, shopping, and entertainment [94]. Furthermore, the WHO suggests that transport policies should focus on promoting walking and cycling for commute distances less than five kilometres [20].

Although TPA occurrences are reducing [15], TPA promotion may be a realistic approach for PA accumulation, largely because of the combined and vested interest from transport and health sectors. Government organisations in developed countries are now beginning to understand the economic, social, and health impacts of automotive dependency [95]. TPA engagement offers promise as a sustainable option, as it fulfils the dual purpose of PA and travel, while becoming a habitual transportation mode. Aside from being readily accessible for the majority of the population, cycling and walking are multifunctional modes of TPA, incorporating substantial health and transport benefits while causing minimal pollution. TPA modes are cost efficient, both from an energy and infrastructure viewpoint when compared with relative automobile costs [20], and they are complimentary to other travel modes. This is evident in transit, where a review using data sourced from the Netherlands, Germany, and the United Kingdom, indicated people would cycle up to five kilometres to access transit facilities [50].

The acceptance of TPA engagement as a travel mode varies by country, and this is evident when comparing cycling levels between non-European and northern European industrialised nations [15, 50, 96]. Travel differences also exist between developed and developing countries. In China 94% of adults regularly commuted to work via TPA modes [97], whereas 8% of US adults perceived that it was unreasonable to walk for transport at all, and 45% would

walk between 0.25 mile and 1 mile for TPA purposes [55]. Similarly, only 7% of Australians walked regularly for transport [54]. Those that had irregular or no access to an automobile were significantly more likely to walk for TPA purposes [40]. Despite these findings, no comparative PA data were taken between TPA and LTPA engagers, and to date, no research has investigated overall PA and TPA behaviour relationships in adults.

Aside from a paucity of comparative data, TPA research has not been a focus for public health or transport researchers. There are several reasons for this. Firstly, TPA modes are viewed as low-technical investments, which make up only a modest share in total traffic [84]. Secondly, as with any PA intervention, the individual exertion required may deter participants. Although this may be the case, the potentially shorter distances associated with commuting and participating in purposive activity, in conjunction with self-selected intensity, could act as incentives to engage in the behaviour. Thirdly, measurement issues are associated with assessing TPA engagement. Journeys may be hard to measure, partly because they can comprise of a trip-chain. Lastly, TPA behaviour is dependent on existing localised built environment infrastructure and destination access. Although only limited TPA studies exist [32], urban planners are acknowledging the importance of TPA engagement as a means to reduce traffic congestion and pollution when travelling short distances [37, 95], while public health agencies view the behaviour as a mechanism to increase habitual activity and improve population health outcomes.

### **Transport-related Physical Activity and Health**

Aside from improving the cost:benefit ratio of travel, TPA engagement may provide comparable health benefits when weighed against LTPA occurrences. Potential reasons include accumulation of small, regular doses of PA with individuals using TPA engagement as a form of transport for travelling to and from destinations, doubling the PA exposure. Documented health outcomes associated with TPA engagement include reduced BMI [98], improved blood lipid profile [99, 100], lowered hypertension [97, 101], and reduced all-cause mortality [102] in a variety of different populations.

Indeed, those who partake in TPA often report little or no LTPA engagement, but often convey superior health statuses when compared with LTPA engagers. For example, men who actively commuted to work showed a weight reduction ( $r=-0.0075$ ,  $p\text{-value}=0.07$ ), whereas those who only engaged in moderate intensity LTPA detailed no significant body mass diminutions ( $r=-0.0564$ ,  $p\text{-value}=0.70$ ). On a cautionary note, no incremental correlations were presented regarding TPA intensity and duration with body mass [98]. A more recent study detailed Chinese men who recorded the lowest blood pressure, engaged daily in 31-60 minutes of TPA, or TPA combined with LTPA, and men who completed 1-30 minutes of TPA engagement daily were less likely to be overweight ( $OR=0.7$ ;  $95\%CI=0.5-0.99$ ) than those who engaged in the same duration of LTPA ( $OR=0.9$ ;  $95\%CI=0.7-1.1$ ) [97]. Another study ( $n=3,708$ ) reported significant inverse associations with serum lipids and TPA engagement, but not with LTPA participation [100]. A prospective study has also demonstrated reduced all-cause mortality risk for those who cycled to work ( $RR=0.7$ ;  $95\%CI=0.6-0.9$ ), even after controlling for LTPA, BMI, blood lipid profile, smoking, and blood pressure [102]. A caveat of these findings, however, is that some potential confounders, such as activity frequency and duration, and total energy expenditure, were not controlled for in the aforementioned studies.

### *Correlational Studies*

Walking has been associated with health benefits [1]. A Japanese study tracked men ( $n=6,017$ ) in sedentary occupations for 59,784 person-years. Those who walked for 11-20 minutes ( $RR=0.9$ ;  $95\%CI=0.8-1.0$ ) and  $\geq 21$  minutes ( $RR=0.7$ ;  $95\%CI=0.5-1.0$ ) to work daily had a reduced relative risk ( $RR$ ) of developing hypertension ( $>160/95\text{mm Hg}$ ). In practical terms, one case of hypertension was prevented for every 26.3 men who walked more than 20 minutes to work. No significant relationship was evident between LTPA and TPA engagement [101]. This relationship, however, may be different for children. Using accelerometers as a criterion measure, those who walked to school accumulated significantly more step counts/minute ( $712\pm 207$  step counts/minute) than children who were driven to school ( $630\pm 207$  step counts/minute). Boys who engaged in TPA were also more active after school

and in the evening than boys who commuted by private automobile. This relationship was not evident in girls [74].

As well as showing associations with chronic diseases and overall activity accumulation, an inverse relationship has been demonstrated between TPA engagement and weight status. Adults who habitually expended at least 10 metabolic equivalence (MET) hour/week actively commuting to work, but did not necessarily report vigorous intensity exercise engagement, demonstrated a reduction in body mass [98]. Consequently, researchers are now trying to ascertain a relationship between PA, obesity, and the built environment. This association is being addressed in the SMARTRAQ study. The multi-disciplinary study is the first to establish BMI and PA patterns within a household travel survey. Preliminary data show significant relationships with lower obesity rates associated with more compact, dense, mixed use, and transit accessible neighbourhoods and decreased time spent in an automobile and kilometres walked [94]. Other research documented Chinese people who own automobiles were 80% ( $p\text{-value}<0.05$ ) more likely to be obese than individuals who did not. Men who acquired an automobile during an eight year time period, on average, were also 1.8 kilograms heavier ( $p\text{-value}<0.05$ ) than those who only had access to non-motorised transport modes. Chinese women reported a 0.4 kg increase with automobile acquisition also, but the relationship was non-significant once potential confounders were adjusted for [22].

### *Intervention Studies*

TPA interventions have proved difficult to implement, largely because the success of the study is dependent on local urban infrastructure and individual adherence [32]. To date, there appears to be no published interventions to increase local shopping by TPA modes, and only two TPA worksite commuting interventions have been identified in the literature [99, 103]. A 10-week Finnish intervention to increase TPA levels ( $n=68$ ) for inactive employees yielded encouraging findings. Post mean walking and cycling trip distances were 3.4 kilometres and 9.7 kilometres, respectively, and approximately 85% of participants commuted to and from the worksite via TPA daily. No post-intervention adherence data were obtained. Positive physiological changes included improved blood lipid profiles,  $VO_{2\text{max}}$ , heart rate, and blood lactate [99].

Mutrie et al., [103] conducted a randomised controlled trial framed within the transtheoretical model of behaviour change to encourage walking to and from work (n=295). At the conclusion, the intervention group increased walking to work more than the control group (OR=1.9; 95%CI=1.1-3.5). A promising finding was that 25% of the initial inactive intervention group remained physically active one year post-intervention [103].

To summarise, despite the lack of intervention data, existing evidence clearly demonstrates TPA engagement is a viable tool to improve population health outcomes. Numerous cross-sectional studies show the importance of TPA engagement as a valuable way to accumulate PA and the limited intervention studies show promise. Despite these benefits, it is imperative that travel behaviours are understood before developing TPA interventions.

### **Travel Behaviour**

In order to promote TPA engagement, it is necessary to understand why and how individuals choose travel modes. TPA modes may not be primarily engaged in for health benefits, but instead reflect convenience, time, and other urban design factors relative to other travel choices. Based on this premise, individuals may tend to engage in whichever transport mode will be the most convenient to access destinations, and it is likely that time constraints and expediency may be influential in this contemporaneous environment. As such, urban designers rather than public health practitioners may have the greatest influence on TPA engagement. Practically, to increase TPA levels in the built environment, urban design convenience factors, such as street design, residential and employment density, and mixed land use, need to be maximised to enhance the utility of TPA options, making them a realistic alternative to other travel modes.

### **Transport, Urban Design, and Physical Activity**

Evidence supports that built environment modifications are a logical way to influence population-level behaviour. For individuals to realistically engage in TPA, the environment needs to support convenient and efficient travel through appropriate urban design fundamentals. The association between the built environment and PA has long been recognised [104], however, the



collaboration of transport, urban planning, and health professionals is a relatively new phenomenon [32, 33]. Pertinent urban design variables likely related to TPA engagement are discussed in greater detail below.

### *Street Design*

Post-World War II, suburbanisation commenced resulting in incorporation of unconnected street networks (i.e., culs-de-sac) and reduced number of intersections, thereby replacing the finer grained traditional grid design [15]. Cul-de-sac street designs serve to increase the network distance to destinations and often make TPA engagement unrealistic. Accordingly, almost three times as much TPA engagement occurs within urban settings, largely because of reduced connectivity within suburban neighbourhoods [105]. For example, in the San Francisco Bay area, twice as many TPA trips were taken in the urban settings when compared with the suburban neighbourhoods (19% versus 10%, respectively), and automobile use was 32% higher in suburban areas [17]. This reinforces the underlying assumption that finer neighbourhood grains will likely increase TPA engagement [26].

Street design extends to cycle paths. Well-connected bicycle networks exist in many northern European countries, providing practical links to destinations [106]. The high ratio of separate scenic cycle corridors in non-European industrialised countries, however, indicates the behaviour has not become integrated with the transport system [51]. This has been reiterated at an international conference where cycling was viewed as a recreational activity, and its acceptance as a commuter vehicle in daily use was missing in many developed countries [107]. Despite this, a positive relationship exists between miles of bicycle pathways and percentage of cycle commuters [108]. In the US, higher cycle commuting levels were reported as more miles of cycle pathways led to specific destinations.

### *Density*

The critical mass of population density may influence transport in various ways. Higher density areas have greater concentrations of trip-ends, thereby potentially lessening trip length and distances by minimising travel outside the localised area [19]. Substantial population density also ensures transit is

financially feasible [26]. US cities typically have low population densities (14 people/hectare) and residents use buses and trains for 8% of travel, whereas Asian cities have 168 residents per hectare and the population utilises public transport for 30% of all trips [109]. Moreover, higher densities increase traffic congestion and make car parking prohibitive by increasing the cost of parking and restricting accessibility [110]. Density also shows an exponential association with TPA and public transport engagement [111, 112], and an inverse relationship with vehicle ownership [113], and commuting by automobile [64]. Specifically, employees with one automobile per household were more likely to use it for commuting purposes if they lived in a low density neighbourhood ( $r=0.8$ ) versus an area with medium to high residential densification ( $r=0.3$ ) [64].

### *Mixed Land Use*

Mixing residential and commercial settings within a localised area reduces distances to facilities, thereby increasing the perception of convenience [64]. Residents in high mixed land use areas reported more time walking for errands than those residing in neighbourhoods with limited mixed land use [18, 38], and living within walking distances of shops ( $p\text{-value}<0.01$ ) has also been positively associated with higher pedometer step counts [67]. Handy and Clifton [36] examined mixed land use and TPA engagement in six neighbourhoods. Traditional neighbourhoods (pre-1950) averaged 215 stores within a 0.5 mile radius compared with 48 shops for the late modern areas (post-1970). Typically, 50% of trips to the shops in the traditional localities were walked, in comparison to 3% in the late modern neighbourhoods [36].

As well as engaging in more TPA, those who live in neighbourhoods with increased land use mix show reduced risk of being overweight or obese [94]. Frank, Andresen, and Schmid [94] detailed for each quartile increase in land mix, there was a 12% reduced likelihood of residents being classified as obese. The study did not show a significant relationship between weight status and residential density. Cervero [114] also detailed that the presence of local shops may operate as a better predictor of TPA engagement than population density.

### *Modal Choice*

Travel mode selection appears to be based on a complex relationship of socio-demographic variables and localised urban design. Transit use is primarily a product of trip destination density, mixed land use, and population density. Specifically, previous research has shown residents in traditional neighbourhoods were more likely to carpool (9% versus 7%, respectively), engage in public transport and TPA modes (19% versus 10%, respectively), and were less likely to travel to work from home by an automobile (69% versus 83%, respectively) when compared with residents of suburban neighbourhoods [17]. Another study also reported a similar relationship with use of public transport. After controlling for confounders, those living in neighbourhoods with higher residential density and increased mixed land use reported increased use of rail stations for work purposes. A positive relationship was also evident with transit use and size of employment centre [64].

### **Implications**

Although substantial health benefits from TPA engagement exist, there are many areas that require further research. Presently, much of the research is angled towards understanding how urban design variables influence overall PA engagement. Future TPA research should aim to identify differences in locality, socio-demographics, perceptions, environmental barriers, and commute route information between those who do and do not engage in TPA. Comparisons of those who do and do not engage in TPA may also help to understand TPA engagement by revealing key components of the behaviour. Valid and reliable TPA measurement and surveillance tools, such as questionnaires, accelerometers, and GIS, need to be developed and/or incorporated into existing regular assessments to ascertain population-level TPA engagement and health outcomes. Further work also needs to separate TPA participation from overall PA engagement before prospective study designs can be implemented. As such, much work remains to be conducted before TPA behaviours can be understood comprehensively.

## **Chapter 4: Perceptions of Replacing Private Automobile Journeys with TPA Modes: Exploring Relationships in a Cross-sectional Adult Population Sample**

### **Preface**

Based on the previous chapters' findings, there is compelling evidence that urban design features are strongly associated with PA behaviours and attitudes. The research presented in this chapter builds upon these reviews by analysing several urban design variables that were identified in the preceding chapters, while also incorporating a population-representative NZ adult sample. The focus of the research is towards TPA-specific behaviours and perceptions, of which the rest of the thesis follows. The objective of this chapter is to establish preliminary population-level attitudes towards TPA engagement by examining perceptions of replacing automobile journeys with TPA modes relative to socio-demographic variables, attitudes to walking and cycling, and physical and social environmental barriers. Unfortunately, these findings can only contribute to the country-specific, cross-sectional TPA literature, however, the population-representative sample builds upon earlier research with small sample sizes. To date, little is known internationally about how these attitudes may vary at the population-level.

## Introduction

Physical inactivity is now recognised as a major contributor to many chronic illnesses [1], and it is estimated that non-communicable diseases currently account for 60% of all deaths and 47% of the global burden of disease [3]. Despite the increasing importance of promoting a physically active lifestyle, overall PA levels are declining in many Western countries [4]. In part, these decreases can be attributed to dramatic changes within the urban environment resulting in dependency on private automobiles for travelling short distances [94]. Private automobiles are now used for nearly 90% of mean distance travelled in the US, and the average trip length is approximately ten miles. This distance, however, is the sum of large and short trips [115], and potential exists for different journey lengths to be matched with diverse travel modes. An association has also been shown with time spent in private automobiles and obesity [94]. As such, it is likely there is considerable capacity and justification at the population-level to increase PA through substituting shorter distance private automobile journeys with TPA engagement [3].

TPA engagement primarily operates by integrating small, habitual doses of activity to access destinations. Cycling and walking for transport are cost efficient, both from an energy and infrastructure viewpoint when compared with relative automobile costs [20], and also show substantial health benefits that minimise risk factors for many chronic communicable diseases, including hypertension [97], cholesterol [100], and colon cancer [116], as well as reduced BMI [98] and all-cause mortality [102]. Evidence also suggests that TPA engagement has utility for increasing and sustaining activity levels for low active populations [103], and adolescent populations [117]. For these reasons, TPA engagement has now been identified as a target area for PA research in an effort to enhance population health outcomes [4].

Currently, three reviews have focused specifically on TPA behaviour, from both health [32, 118] and urban design [33] perspectives, with all acknowledging further research is required. As well as these overviews, an emerging body of research has sought to investigate the relationship between environmental perceptions and TPA engagement. Environmental correlates identified from the literature that show positive associations with TPA-specific behaviours include proximity to destinations [67, 119] and to trails [120],

streetlight presence [120], cycle lane availability [119], heavy traffic [120], availability of green spaces [61], and seeing others being physically active [54, 119]. Presence of hills [53] and poor footpath quality [119] have been negatively associated, and environmental aesthetics [119-121] remain inconclusive, when TPA engagement is assessed independent to other PA domains. These findings, however, may be confounded by the non-representative samples employed.

Despite the growing literature centred on environmental perceptions and TPA engagement, little is known about the target audience for TPA-based interventions. Preceding any intervention, it is necessary to identify the characteristics of the population who perceive they have the capacity to engage in TPA modes. Once this population profile has been identified, future TPA initiatives can be constructed towards this audience, thereby maximising success. Consequently, the aim of the present study is to establish the relationship between socio-demographic variables, overall PA levels, consideration of TPA modes, and physical and social environmental barriers, with the perception of replacing private automobile journeys with TPA engagement in a population-representative sample of adults.

## **Methods**

### *Questionnaire Design and Implementation*

The survey instrument used (OTA) was adapted from an American Cancer Society questionnaire. Advisors from SPARC and the NZ Cancer Society modified the survey for the NZ context, and after a pilot trial with adults, implemented it with a population-representative sample in June-July 2003. All relevant analyses were conducted in December 2004-May 2005. Amongst other variables, the survey required participants to self-report: current PA levels for all purposes, perceptions of the localised environment, considerations of walking and cycling short distances, perceived ability to replace private automobile journeys with TPA engagement, and socio-demographic variables. A full copy of the OTA questionnaire is shown in Appendix A.

The questionnaire was conducted as a population-level survey with case weights applied to reduce potential non-response bias based on household size (Appendix B). After rim weighting adjustment for age, gender, ethnicity, and

region, a sample of 14,000 households was randomly drawn from the NZ electoral roll. Each of these households was posted the 26-page survey. After subtracting ineligible addresses, 13,574 households qualified for participation. The adult ( $\geq 16$  years of age) with the first birthday after 1 June in each household was invited to complete and return the questionnaire. Incomplete surveys, wrong person completion, or questionnaires received after cut-off date were excluded from all analyses. After incorporating a three stage follow up system (Appendix C), 7,894 surveys were eligible for the present analysis (58% response rate). All participants provided informed consent and the AUTECH approved the study retrospectively (Appendix D).

### *Physical Activity Measures*

The New Zealand Physical Activity Questionnaire-Short Form (NZPAQ-SF) was included as part of the OTA survey to ascertain self-report PA levels. The NZPAQ-SF has recently been validated with accelerometers [122]. In the NZPAQ-SF, participants recorded frequency of, and minutes spent engaged in, moderate intensity (including walking) and vigorous intensity PA for all purposes during the seven days preceding the survey. Minutes spent engaged in vigorous activity had a weighting factor of two to take into account the greater intensity of the activity.

After equating vigorous intensity activity, respondents were classified into PA groups. Those classified as: 'sedentary' reported no time engaging in any PA during the last seven days; 'insufficiently active for health benefits' respondents did not reach the threshold of five episodes of activity (either moderate or vigorous intensity) totalling 150 minutes during the previous week; 'sufficiently active for health benefits' respondents recorded at least five sessions of PA equalling 150 minutes during the last week; and for respondents to be classified as 'sufficiently active including moderate and vigorous PA', participants had to fulfil 'sufficiently active for health benefits' requirements, as well as reporting both moderate and vigorous intensity PA sessions during the seven days prior. Such definitions are in line with current national [5, 122] and international [1, 123] PA classifications.

### *Transport-related Physical Activity Measures*

Respondents reported on a pre-defined question relating to replacing private automobile journeys: 'Most weeks I could replace car trips by walking or cycling on at least two days (without too much difficulty)'. The responses used in the final analyses were taken from a five-point Likert-type scale (ranging from 1 being strongly disagree to 5 equalling strongly agree) with the 'strongly disagree (1)' and 'strongly agree (5)' classes used for statistical comparisons. The middle scores for this question (agree, neutral, disagree (2-4)) were excluded from all statistical operations. This is primarily because respondents who strongly agreed with replacing private automobile journeys hold the most chance for at least intending to substitute private automobile journeys with TPA engagement, and then actually changing travel behaviour. In other words, it is probable that only a portion of those within the 'strongly agree' with replacing private automobile journeys category, will progress from identifying they have the initial capacity for engaging in TPA, to intention, and finally to behaviour change. Therefore, in the first instance, it is important to identify pertinent relationships within this sub-group that are conducive to recognising replacing private automobile journeys with TPA modes.

Respondents also recorded their perceptions of utilising cycling and walking for travel modes: 'For a short journey when the weather was fine and I had nothing to carry, I would...' (referring to cycling) or 'For a journey of 1.5 kilometres, when the weather was fine and I had nothing heavy to carry, I would ...' (relative to walking). The six-point Likert-type scales (1=not even consider cycling/walking to 6=almost always cycle/walk) were collapsed into: 'never consider cycling/walking' (1-2), 'occasionally consider cycling/walking' (3-4), and 'frequently consider cycling/walking' (5-6) categories. A similar reclassification occurred for current cycling levels.

### *Physical and Social Environmental Barriers*

The proposed physical environmental barriers that potentially prohibited PA engagement were asked as dichotomous responses, therefore were not recoded. Social environmental barriers were reclassified from a seven-point Likert-type scale (1=does not influence me at all to 7=influences me a lot), to a



dichotomous classification of: 'no influence on PA levels' (1-2) and 'substantial influence on PA levels' (6-7). Scores of 3-5 were removed for the analysis.

### *Body Mass Index Classification*

BMI classifications were derived from respondents' self-reported height (m) and body mass (kg) data. The standard BMI calculation was used ( $\text{weight (kg)}/\text{height (m)}^2$ ), with mutually exclusive cut-off points applied to determine classifications for underweight, normal weight, overweight, and obese for those of differing ethnic descents: Asian, <18.5, 18.5-22.9, 23.0-24.9, and  $\geq 25.0$ , respectively; Caucasian, <18.5, 18.5-24.9, 25.0-29.9, and  $\geq 30.0$ , respectively; and Maori/Polynesian, <18.5, 18.5-25.9, 26.0-31.9,  $\geq 32.0$ , respectively [124].

### *Chronic Conditions Classification*

Participants were asked to self-report the number and type of chronic conditions they have been diagnosed with by a medical professional. Respondents could choose between zero and more than three chronic conditions.

## **Statistical Analyses**

Binary logistic regression analyses and weighted population percentage statistical procedures were generated using SPSS Version 11.5 (SPSS Inc., 2003). Binary logistic regression modelling (OR) was employed to understand the likelihood of the relationships between the independent socio-demographic variables with the dichotomous dependent variable, replacing private automobile journeys with walking or cycling on at least two days per week. The dependent variable had two levels for the unadjusted and mutually adjusted models: 'strongly agree', and 'strongly disagree with replacing private automobile journeys with TPA modes'. A significance level of  $\alpha=0.05$  was implemented. Population percentages were rim-weighted for the individual probability of being sampled according to 2001 census statistics [125]. Cohen effect sizes ( $d$ ) for differences in perceptions of environmental and attitudinal barriers were calculated by dividing the difference in means between the two groups for each potential barrier by the combined standard deviation.

## Results

For the sample of 7,894 adults, 21% strongly agreed that they could replace private automobile journeys with TPA modes on at least two days per week (Table 5). In contrast, approximately 40% of the respondents within the sample perceived they could not utilise TPA modes to substitute private automobile journeys for at least two days a week.

**Table 5:** Perceptions of replacing private automobile journeys with TPA modes in the OTA sample

<i>Classification of replacing private automobile journeys with TPA modes</i>	<i>(%)<sup>^</sup></i>
Strongly disagree	25
Disagree	17
Neutral	17
Agree	17
Strongly agree	21

<sup>^</sup>Weighted according to 2001 census [125]

### *Sample Characteristics*

In Table 6, the crude and mutually adjusted binary logistic regression models revealed significant negative relationships of perceptions of private automobile journey replacement with SES indicators (i.e., education, income). At each level, respondents who earned more, or were more educated, were less likely to identify they could replace private automobile journeys with TPA modes compared with those earning  $\leq$ \$20,000 per annum, or no high school qualification, respectively. PA classification predicted perceptions of private automobile journey replacement, with consistent positive trends shown between replacing private automobile journeys with TPA modes and PA levels. Respondents who were sufficiently active for health benefits were nearly one and a half times more likely to perceive they could replace private automobile journeys with TPA modes (OR=1.4; 95%CI=1.2-1.7) when compared with sedentary respondents. Non-significant relationships were shown throughout for the number of chronic conditions and BMI classifications with automobile journey replacement.

**Table 6:** Socio-demographic profile for replacing private automobile journeys with TPA modes, and logistic regression models for strongly agreeing with replacing private automobile journeys with TPA modes in the OTA sample

<i>Variable</i>	<i>Strongly disagree with replacing private automobile journeys with TPA modes (%)<sup>a</sup></i>	<i>Strongly agree with replacing private automobile journeys with TPA modes (%)<sup>a</sup></i>	<i>Categorisation within strongly agree with replacing private automobile journeys with TPA modes (%)<sup>a1</sup></i>	<i>Crude OR</i>	<i>95%CI</i>	<i>Adjusted OR<sup>a</sup></i>	<i>95%CI</i>
<i>Gender</i>							
Male	25	19	45	1.0	<i>referent</i>	1.0	<i>referent</i>
Female	26	22	55	1.2*	1.1-1.4	1.2	1.0-1.4
<i>Age (years)</i>							
16-24	20	24	19	1.0	<i>referent</i>	1.0	<i>referent</i>
25-39	29	20	28	0.7*	0.5-0.8	0.9	0.7-1.2
40-54	27	18	25	0.7*	0.5-0.8	0.8	0.7-1.1
55-70	22	19	16	0.6*	0.5-0.8	0.8	0.7-1.1
>70	23	23	13	0.6*	0.5-0.7	0.8	0.6-1.0
<i>Ethnicity</i>							
NZ European	26	20	71	1.0	<i>referent</i>	1.0	<i>referent</i>
Maori & Pacific Island	19	29	20	0.8	0.7-1.0	1.0	0.8-1.2
Asian	18	14	4	1.4*	1.2-1.6	1.4*	1.2-1.7
Other	28	16	5	1.8*	1.5-2.2	1.8*	1.5-2.2
<i>Annual personal income (NZ\$)</i>							
≤20,000	20	24	46	1.0	<i>referent</i>	1.0	<i>referent</i>
20,001-40,000	28	19	26	0.6*	0.5-0.7	0.6*	0.5-0.8
40,001-70,000	31	16	14	0.7*	0.6-0.8	0.7*	0.6-0.8
70,001-100,000	35	13	2	0.6*	0.6-0.7	0.7*	0.6-0.8
>100,000	24	21	13	0.6*	0.5-0.7	0.6*	0.5-0.8

Table 6 continued overleaf

<sup>1</sup> This column shows the break down of socio-demographic variables within the strongly agree with replacing private automobile journeys with TPA modes category.

Table 6 continued

<i>Variable</i>	<i>Strongly disagree with replacing private automobile journeys with TPA modes (%)<sup>a</sup></i>	<i>Strongly agree with replacing private automobile journeys with TPA modes (%)<sup>a</sup></i>	<i>Categorisation within strongly agree with replacing private automobile journeys with TPA modes (%)<sup>a</sup></i>	<i>Crude OR</i>	<i>95%CI</i>	<i>Adjusted OR<sup>a</sup></i>	<i>95%CI</i>
<i>Highest education qualification</i>							
No high school	22	28	25	1.0	<i>referent</i>	1.0	<i>referent</i>
High school	23	21	32	0.5*	0.4-0.6	0.7*	0.5-0.8
Trade, diploma, certificate	27	20	30	0.6*	0.5-0.7	0.6*	0.5-0.8
University degree	29	13	12	0.7*	0.6-0.8	0.7*	0.6-0.9
<i>Town size (# residents)</i>							
<1,000	38	15	9	0.9	0.8-1.1	1.0	0.8-1.2
1,000-29,999	21	25	26	0.7*	0.6-0.9	0.7*	0.6-0.9
30,000-100,000	26	22	21	1.0	<i>referent</i>	1.0	<i>referent</i>
>100,000	24	19	44	0.9	0.7-1.0	0.8*	0.7-1.0
<i>Number of chronic conditions</i>							
0	26	22	12	1.0	<i>referent</i>	1.0	<i>referent</i>
1	24	21	65	1.0	0.8-1.2	0.9	0.7-1.2
2	25	24	15	1.0	0.8-1.2	1.0	0.8-1.3
3	28	17	5	1.0	0.8-1.3	1.0	0.8-1.3
>3	6	2	2	1.1	0.9-1.3	1.1	0.8-1.3
<i>BMI<sup>c</sup></i>							
Underweight	30	16	2	1.0	0.8-1.1	1.0	0.9-1.2
Normal weight	24	21	43	1.0	<i>referent</i>	1.0	<i>referent</i>
Overweight	26	20	31	1.0	0.8-1.1	1.0	0.8-1.2
Obese	26	20	16	0.9	0.8-1.1	0.9	0.8-1.1

Table 6 continued overleaf

Table 6 continued

<i>Variable</i>	<i>Strongly disagree with replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>Strongly agree with replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>Categorisation within strongly agree with replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>Crude OR</i>	<i>95%CI</i>	<i>Adjusted OR<sup>a</sup></i>	<i>95%CI</i>
<i>Overall PA</i>							
Sedentary	33	12	7	1.0	<i>referent</i>	1.0	<i>referent</i>
Insufficient activity	26	17	24	1.3*	1.1-1.4	1.4*	1.2-1.7
Sufficient activity	27	23	17	1.4*	1.2-1.5	1.4*	1.2-1.7
Sufficient activity including moderate and vigorous PA	22	25	50	1.2*	1.1-1.3	1.3*	1.1-1.5

<sup>^</sup> Weighted according to 2001 census [125]

<sup>a</sup> Mutually adjusted by other socio-demographic variables in the model

<sup>c</sup> BMI ethnically adjusted according to the WHO criteria [124]

\* Significant relationship exists as 95%CI do not cross 1.0

### *Automobile Journey Replacement and Physical Activity*

Data presented in Table 7 provides a summary of the relationships between PA attitudes and perceptions of replacing private automobile journeys with TPA engagement. These associations were in the expected direction. Respondents who strongly agreed with replacing private automobile journeys, when compared with those who strongly disagreed with replacing private automobile journeys, were more likely to report currently cycling and recognise walking and cycling as alternative transport modes for travelling short distances. The majority of respondents, regardless of group, never cycled, or never considered cycling.

**Table 7:** PA correlates for respondents who strongly disagreed or strongly agreed with replacing private automobile journeys with TPA modes in the OTA sample

<i>Variable</i>	<i>Within strongly disagreed replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>Within strongly agreed replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>p-value</i>
<i>Bicycle available for use</i>			<i>0.24</i>
No	60	56	
Yes	41	44	
<i>Cycling level</i>			
Never	77	66	
Infrequent	16	14	
Often	7	21	
<i>Consider cycling for short distances</i>			<i>&lt;0.01</i>
Never	66	52	
Sometimes	22	25	
Often	12	24	
<i>Consider walking 1.5 km</i>			<i>&lt;0.001</i>
Never	20	7	
Sometimes	36	25	
Often	44	68	

<sup>^</sup>Weighted according to 2001 census [125]

**Table 8:** Environmental barrier differences for respondents who strongly disagreed or strongly agreed with replacing private automobile journeys with TPA modes in the OTA sample

<i>Variable</i>	<i>Within strongly disagreed replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>Within strongly agreed replacing private automobile journeys with TPA modes (%)<sup>^</sup></i>	<i>d</i>
<i>Physical environmental barriers</i>			
Limited number of footpaths	17	10	0.25
Poor footpath maintenance	16	17	-0.02
Heavy traffic	21	20	0.05
Steep hills	13	11	0.10
Inadequate street lighting	20	20	0.07
Inadequate cycle lanes	3	5	-0.09
Too many stop signs	7	11	-0.06
Unpleasant scenery	7	9	-0.08
Rarely see others being active	9	15	-0.11
Crime prevalence	16	22	-0.10
Dog nuisance	22	20	0.09
<i>Social environmental barriers</i>			
Lack time due to work responsibilities	57	49	0.44
Lack time due to family responsibilities	62	43	0.22
Too many household chores	40	32	0.23
Preference for other activities in spare time	34	31	0.26
Lack energy	35	26	0.13
Hard to stick to a routine	19	15	0.05

<sup>^</sup>Weighted according to 2001 census [125]

### *Automobile Journey Replacement and Environmental Barriers*

Physical and social environmental barriers for recognising replacing private automobile journeys with TPA modes are presented in Table 8. In all cases, those who strongly agreed reported less time barriers, than those who strongly disagreed with replacing private automobile journeys by means of TPA engagement. Aside from not being able to stick to a routine, all effect sizes were either small (4), or moderate (1) for the social environmental barriers. Seven physical environmental effect sizes were trivial, indicating that in the majority of cases, respondents in both automobile replacement categories had similar perceptions of their surroundings.

## Discussion

The major finding identified in this study is that 21% of the population strongly agreed they could replace private automobile journeys with TPA modes. Before behaviour change based TPA interventions can be developed, much work needs to occur within this preceding stage to shift population-level perceptions of TPA modes as a viable means of transport. The present research focuses on recognising the capacity to replace private automobile journeys with TPA modes, although in reality, the number of people who will progress to actual behaviour change will most likely be much lower. For example, 3,223 respondents in this sample reported they would consider cycling for short distances. A much smaller number of participants ( $n=2,246$ ), however, recorded any level of cycling engagement for the preceding three months. In addition to only a small percentage of respondents identifying they could replace private automobile journeys, the relationship appeared to be associated with current PA levels. Those who engaged in any form of PA were at least 20% more likely to recognise they could replace private automobile journeys with TPA modes than sedentary respondents. Clearly any PA health promotion intervention needs to engage the inactive, rather than the active population. Future work will need to focus on developing health promotion strategies that will result in perception and behaviour changes related to TPA engagement for sedentary or insufficiently active groups.

Similar to previous research [56], walking was widely accepted as a mode of transport. It was observed that the majority of respondents, regardless of their classification for replacing automobile journeys with TPA modes, identified walking as an appropriate mode for travelling short distances. Indeed, 93% of those who strongly agree with replacing private automobile journeys with TPA modes recognised walking as an appropriate form of transport for travelling short distances. Cycling, however, appeared to be a less accessible and acceptable form of transport. Even when those who identified they could replace private automobile journeys with TPA modes were examined independently, over half did not report access to a bicycle (56%), never engaged in cycling (66%), or would consider cycling to proximal destinations (52%). These figures increased for those individuals who perceived they could not replace private automobile journeys with TPA modes. Because of this,



promoting walking rather than cycling, will likely have greater efficacy as an alternative travel mode to a private automobile for travelling short distances.

The construction of the OTA survey did not allow for separate analysis of those who already engage in TPA to be compared with the remainder of the sample. Consequently, respondents who engaged in substantial amounts of TPA may be less likely to agree with incorporating additional replacements of private automobile journeys with TPA modes. The reason being, these respondents are potentially faced with limited opportunities to further incorporate TPA engagement into their lifestyles. The implication of this is that different profiles may exist for those who actually engage in TPA compared with respondents who identified they could replace private automobile journeys with TPA engagement. This relationship can only be addressed in future if overall PA engagement is separated into domains.

The association between current PA levels and perceptions of replacing private automobile journeys with TPA engagement is important. SES variables, however, may also have a substantial influence on TPA perceptions. In the present research, inverse relationships existed with SES predictors (i.e., education attainment, personal income) and perceiving replacing private automobile journeys with TPA engagement. In other words, those who were classified as being more disadvantaged were more likely to acknowledge the potential to replace private automobile trips with walking or cycling. A study by Giles-Corti and Donovan [40] identified that low SES residents were more likely to report walking for transport when compared with high SES respondents (OR=1.3) [40]. In both the present research and the study by Giles-Corti and Donovan [40], the relationships may have been mediated by SES and automobile accessibility. Low SES households generally have lower automobile ownership [126], and an inverse relationship exists between number of private automobiles available per household and TPA engagement [115]. Reduced automobile accessibility possibly necessitates more frequent TPA engagement for low SES groups [40], thereby potentially increasing the efficacy towards perceptions of the behaviour. Although it is unrealistic to expect automobiles to disappear from our society, a multi-faceted strategy that seeks to incorporate social marketing, promote public transport, and reduce household private automobile ownership may encourage more people to consider TPA modes as alternatives to private automobile use.

Thus far, no study has examined physical and social environmental variables with perceptions of replacing private automobile journeys with TPA modes. These data identified respondents who strongly agreed, reported less time barriers than those who strongly disagreed with replacing private automobile journeys with TPA modes. As this is the first indication of this relationship, further work is now needed to examine the associations between perceptions and objectively measured differences of time and distance to destinations with transport choices. Examination of perceived environmental barriers further adds to the inconsistencies that currently exist. Aside from footpath quality, the observed findings concur with Hoehner et al., [119], who found that in a sample of US adults, those who reported adequate number of cycle lanes (OR=1.7; 95%CI=1.1-2.8) and seeing others being active (OR=2.1; 95%CI=1.4-3.2) were more likely to engage in TPA. Despite these similarities, the differences between the two groups in the present research were not as substantial. Another study (n=413) reported positive relationships with street lighting, heavy traffic, and cycling for transport [120]. These associations were not observed in this study, but may be masked by the low representation of those who would consider cycling for short distances, or actually engaged in cycling. Some counterintuitive findings were also presented with respondents who strongly agreed with replacing private automobile journeys with walking or cycling, being more likely to report problems with crime and rarely see others being active. Potentially, this may be because these individuals were already active in their neighbourhood, and therefore, were more aware of the localised environment.

Our findings suggest manipulating some aspects of the physical and social environment (e.g., increasing the number of footpaths, addressing time constraints) will result in encouraging more individuals to consider TPA engagement as viable travel modes. Although the magnitude of the presented effect sizes are not large (-0.02 to 0.44), these modest changes spread over the population may translate into a sustainable shift in TPA engagement, with far-reaching health and transport implications. For many of these changes to be implemented, however, interventions must occur at the local government level in order to result in sufficient infrastructural changes.

The strength of this research is the large population-representative sample that was utilised to understand the differences regarding replacing

private automobile journeys with walking or cycling. The main limitation of the study, however, was actual TPA engagement was not assessed; instead the intention of replacing private automobile journeys with TPA modes was measured. The discrepancy between action and intention may be the reason that no BMI differences were observed in the study, despite previous research detailing reduced BMI scores for those who engaged in TPA [98, 117]. Other limitations included: all data were self-report, non-response bias potentially existed, and PA behaviour was not classified into domains. Separating TPA from overall PA engagement may provide a more accurate depiction of the relationship between current TPA engagement and the perceptions surrounding walking and cycling as transport modes.

### *Conclusions*

Despite the increasing focus of TPA behaviours, the relative infancy of the area leaves much to be understood. This exploratory study, however, served to identify relationships that require further attention. Future research should seek to: understand the association between overall PA with TPA levels, examine the relationships with socio-demographic variables, private automobile accessibility, and TPA engagement, and determine the associations with time, distance, and travel mode choices. More work is also needed to further explore and understand the influence of the built environment and time constraints on TPA behaviour. By understanding these relationships more explicitly, appropriate policy and infrastructural approaches can be implemented to encourage TPA engagement as a sustainable approach for positively shifting the population distribution of PA. Indeed, walking appears to be an acceptable mode of travel for a large portion of the adult population. The ultimate challenge, however, as ascertained in this study, is to make the considerable transfer from the minority of individuals recognising they can replace private automobile journeys, to having the majority of the population incorporating walking and cycling as daily modes of travel.

## **Chapter 5: Test-retest Reliability of a Survey to Measure Transport-related Physical Activity Levels in Adults**

### **Preface**

The previous empirical chapter confirmed that increasing PA levels in NZ adults would likely result in population health gains, and approximately 20% of the NZ adult population recognised they could replace automobile journeys with TPA modes for at least two days a week. Based on these findings, it was apparent more specific detail was needed to understand TPA behaviours and perceptions. TPA engagement could not be directly assessed in Chapter 4 because the behaviour could not be isolated from other PA domains in the OTA survey. It is likely that interesting differences will be revealed if overall PA and TPA engagement were separated. Furthermore, it appears no published existing travel surveys can reliably capture TPA behaviours, perceptions, and barriers to common destinations. Therefore, the objective of this chapter is to develop a reliable survey tool that measures TPA engagement, attitudes, and barriers in order to adequately answer some of the research priorities raised in the previous chapters.

## Introduction

Physical inactivity has been undisputedly recognised as a primary contributor to numerous chronic lifestyle diseases [1]. Despite the importance and benefits associated with regular PA engagement, overall levels are declining in many developed countries, primarily through decreasing levels of occupational, transportation, and home environment PA [4]. The emerging understanding of the influence of the built environment on PA levels has drawn attention to TPA engagement as a possible means to improve population activity levels [33]. Amongst adults, preliminary TPA engagement findings appear promising with regard to health improvements, such as reduced BMI [98], improved blood lipid profile [99, 100], lowered hypertension [97, 101], and decreased risk of all-cause mortality [102]. As such, it is important to be able to effectively assess TPA engagement within this population. The purpose of this study therefore, is to develop and examine a survey that measures TPA behaviours, perceptions, and barriers to two common destinations (i.e., place of work/study, convenience shop) in an adult population.

Increasing TPA engagement has now been recognised as a public health priority, with the Task Force on Community Preventive Services [92] and the WHO [3] recommending policy approaches to increase TPA engagement for short commute distances. Despite recognition of the benefits from TPA engagement, no TPA-specific survey instruments presently exist. The IPAQ provides a composite score that accounts for transport, occupational, and leisure time activity [69]. Despite this, the IPAQ has been criticised as not being sensitive enough to adequately detect TPA engagement [65, 66]. The US national health surveillance tool (BRFSS) has also been used to examine TPA trends by incorporating TPA-related questions since 2001 [55]. The current BRFSS survey cannot track TPA engagement, however, as the frequency and duration are not recorded independent of LTPA occurrences. The present research details test-retest reliability of a newly developed, structured telephone-administered TPA survey for adults (Active Friendly Environments Survey – Transport Related Physical Activity (AFES-TPA)). The AFES-TPA examines barriers, perceptions, and current travel behaviours to place of work/study and the convenience shop. Demonstrated test-retest reliability of the

AFES-TPA is essential for researchers to ensure confidence in reliability of scores from the instrument's findings.

## **Methods**

### *Participants*

Data for this study were collected from an adult sample ( $\geq 16$  years of age) of academic and allied employees ( $n=30$ ) at a NZ university. Every fifth staff member as listed in the employee database was identified and telephone contact was attempted by a trained interviewer. Prior to providing consent, it was explained that the survey would be conducted with the participant again within the following seven days. All respondents completed the surveys at both time points. Before the sample of 30 participants was fulfilled, 75 employees were contacted and invited to participate in the study (overall response rate 40%). The primary reason for not partaking in the study was because the survey was conducted during work hours and involved a time commitment from the participant. Utilising a sample of 30 adults ensured that appropriate test-retest CI could be generated ( $ICC=0.90$ ;  $95\%CI=0.82-0.94$ ) by fulfilling the minimal acceptable criteria of intraclass correlation coefficient (ICC) values above 0.7 [127]. AUTECH approved the study (AUTECH 04/220) (Appendix E) and all participants provided informed consent. Feedback was provided by e-mail to the study participants at the conclusion of data collection (Appendix F).

### *AFES-TPA Survey Development and Implementation*

The purpose of the 19-question AFES-TPA telephone-based instrument was to assess perceptions, barriers, and behaviours related to TPA engagement. The survey schedule was informed by the extensive review of urban design and PA literature presented in Chapters 2 and 3. These reviews, in conjunction with the studies presented in Chapters 4 and 5, identified pertinent variables for further analysis. Content validity of the tool was ascertained through consultation and several reiterations of the AFES-TPA with three PA experts within the host university. Survey comprehension was informally established with the survey being conducted on colleagues prior to the pilot testing. Except from determining the total time acceptable for generic

travelling by TPA modes, the AFES-TPA survey was separated by travelling to usual place of work/study and the usual convenience shop. Relative to each destination, respondents reported on typical travel modes, approximate time taken to access the destination, barriers to TPA engagement, and perceptions of TPA accessibility. Aside from distances and times, all responses were selected from a pre-determined nominal scale schedule. No other PA measures were taken. A copy of the AFES-TPA is shown in Appendix G.

### *Data Collection*

Telephone calls were made to participants in January-February 2005 by two trained interviewers. Two calls were made to each participant within normal work hours (8.30am-5.00pm) on weekdays (Monday-Friday) during a period of three weeks. Test-retest periods varied between three and seven days. The reason for the variation between the testing phases was that it was often inconvenient to conduct the survey with the participant at the pre-specified time. Utilising different retest periods may also have strengthened the robustness of the reliability findings.

### **Statistical Analyses**

After determining adequate variation within the data, a one-way ICC model was chosen as all question differences from time 1 ( $t1$ ) to time 2 ( $t2$ ) were assumed random between the testing sessions [128]. The ICC value cut-off ranges used were: 0.0-0.2 (weak agreement), 0.21-0.4 (poor agreement), 0.41-0.6 (moderate agreement), 0.61-0.8 (substantial agreement), and 0.81-1.0 (almost perfect agreement) [129]. Overall, an ICC above 0.7 was considered an acceptable measure of test-retest reliability [127]. One-way analysis of variance (ANOVA) and Levene statistics were incorporated to further determine if systematic differences existed between the testing occasions based on statistical significance [128]. All reliability analyses were conducted with SPSS 11.5 software (SPSS Inc., 2003) and a significance level of  $\alpha=0.05$  was implemented.

## Results

### *Test-retest Reliability*

The reliability scores for each item as per the survey schedule are presented in Table 12. Across all items, the AFES-TPA yielded acceptable correlations, aside from two questions that focused on the social environment (Table 9). The items: 'Knowing others who walk or cycle to access the convenience shop' and 'Knowing others who walk or cycle to access your place of work/study' were below the 0.7 threshold for acceptable reliability. Aside from these, the ICC values ranged from 0.79-1.0, representing substantial to almost perfect agreement, with the majority of ICC values above 0.9. These latter data indicate that respondents reported similar answers for both testing sessions.

The non-significant ANOVA findings ( $p\text{-value} > 0.05$ ) for all items provided evidence that there were no systematic differences between the testing occasions. The Levene statistic was used to test for homogeneity of variance. Apart from two items: 'What is the approximate distance to your convenience shop' and 'You know people who walk or cycle to the convenience shop', all responses were non-significant ( $p\text{-value} > 0.05$ ). Therefore, the responses were normally distributed. The standard deviations between  $t1$  and  $t2$  were also very similar (data not presented). Data presented in Table 9 show no differences in statistical trends between place of work/study and the convenience shop. The study sample, however, was non-representative of the NZ adult population. Participants earned a higher household income, were more educated, and represented higher Asian and Indian ethnicities in comparison to national prevalence data [125] (Table 10).



**Table 9:** Test-retest reliability values of the AFES-TPA

<i>Variable</i>	<i>n</i>	<i>ICC</i>	<i>95%CI</i>	<i>F</i>	<i>p-value</i>	<i>Levene statistic</i>	<i>p-value</i>
<i>General travel</i>							
How many minutes is it reasonable for you to engage in walking or cycling for transport?	30	0.88	0.7-0.9	0.36	0.55	0.8	0.37
<i>Convenience shop travel</i>							
What type of store is your convenience shop?	30	1.00	1.0-1.0	0.00	1.00	0.0	1.00
What is the approximate distance from home to your convenience shop?	30	0.96	0.9-1.0	1.37	0.25	4.5	0.04
How do you usually get to and from your convenience shop?	30	0.97	0.9-1.0	0.07	0.80	0.2	0.63
How long does it take you to get to your convenience shop?	30	0.87	0.7-0.9	0.00	0.97	0.2	0.70
What is the main reason that you do not walk or cycle to or from the convenience shop?	30	0.97	0.9-1.0	0.07	0.80	0.2	0.63
Do you think your convenience shop is within walking or cycling distance?	30	0.93	0.9-1.0	0.26	0.61	0.5	0.47
How often do you walk or cycle to get to or from the convenience shop?	30	0.88	0.8-0.9	0.21	0.65	0.9	0.36
You know people who walk or cycle to the convenience shop	30	0.67	0.3-0.8	1.35	0.25	5.5	0.02
You can always access car parking at or near the convenience shop	30	1.00	1.0-1.0	0.00	1.00	0.0	1.00
Items purchased at the convenience shop are too heavy to carry home	30	0.89	0.8-1.0	0.07	0.80	0.3	0.62
<i>Work/study travel</i>							
How do you usually get to and from your place of work/study?	30	0.98	1.0-1.0	0.04	0.84	0.1	0.73
How long does it take to get to your place of work/study?	30	0.97	0.9-1.0	0.04	0.85	0.1	0.81
Do you need to travel across the Auckland harbour to get to your place of work/study?	30	0.88	0.8-0.9	0.21	0.65	0.9	0.36
What is the main reason that you do not walk or cycle to or from your place of work/study?	30	1.00	1.0-1.0	0.00	1.00	0.0	1.00
Do you think your place of work/study is within walking distance?	30	0.86	0.7-0.9	0.72	0.40	2.9	0.10
How often do you walk, run, or cycle to get to or from your place of work/study?	30	0.97	0.9-1.0	0.07	0.80	0.3	0.62
You know people who walk or cycle to or from your place of work/study	30	0.69	0.3-0.9	0.10	0.76	0.4	0.54
You can always access car parking at or near your place of work/study	30	0.79	0.6-0.9	0.34	0.56	1.4	0.24

**Table 10:** Socio-demographic profile of AFES-TPA respondents

<i>Variable</i>	<i>n</i>	<i>(%)</i>
<i>Gender</i>		
Male	11	(37)
Female	19	(63)
<i>Ethnicity</i>		
NZ European	18	(60)
Maori	6	(20)
Asian	6	(20)
<i>Age (years)</i>		
≤30	9	(30)
31-50	12	(40)
51-70	9	(30)
<i>Annual household income (NZ\$)</i>		
≤40,000	4	(14)
40,001-70,000	7	(24)
70,001-100,000	10	(34)
>100,000	8	(28)
<i>Highest academic qualification</i>		
No high school	1	(3)
High school	3	(10)
Trade, diploma, certificate	4	(13)
Bachelor degree	9	(30)
Postgraduate degree	13	(43)

## Discussion

The present study is a preliminary investigation to determine reliability of a survey that measures TPA engagement. In most cases, the AFES-TPA reported high test-retest reliability. Indeed, in three cases, exact agreement was shown. Apart from two instances, the high ICC values indicated the tool had appropriate stability over time within this population [127]. The lower ICC values and wide CI shown for the two social environment items were consistent with previous literature [54, [80], and may be caused by the subjectivity surrounding the measure. The non-significant ANOVA findings suggest no recurring differences between  $t1$  and  $t2$  for any of the items [128], and are a further indication of the tool's utility. Two questions, however, were not normally distributed and caution should be applied when interpreting the respective findings.

Despite establishing test-retest reliability and content validity of the tool, criterion validity has not been ascertained. This is primarily because accurately separating TPA engagement from other PA behaviours (i.e., leisure time, occupation, household) is problematic. To compound this, engagement in TPA is often sporadic in nature and may exist as travelling short distances that

cannot be detected in this survey. Although objective PA measures (e.g., accelerometers, pedometers) may overcome problems associated with accumulated activity, it is nearly impossible to isolate what domain the activity occurred in. Subsequently, small bouts of TPA engagement may remain undetected in this survey. Nevertheless, the present AFES-TPA assists with providing an insight to travel behaviours. Travel diaries, however, may show promise for determining convergent validity of the AFES-TPA. Boarnet and Sarmiento [63] modelled travel modes using a two-day travel diary (n=769). Findings showed that the diary method was more effective for measuring non-work trips than commuting behaviour. Conversely, other travel diary research has shown that detailed work-related travel information can be gathered, despite recording only the three main trips within each day [64]. Regardless of the potential for travel diaries to assess convergent validity, the measures may prompt recall bias and a high rate of non-compliance has been noted [64]. Furthermore, the present survey also assessed a series of attitudinal items that may not translate into travel behaviour, therefore would not be appropriate for convergent or criterion validity testing. For these instances, test-retest reliability may be a better measure of the instrument's utility.

When developing a survey to be used for population surveillance, aside from having acceptable stability reliability, it is important to incorporate key variables that have been associated with the behaviour, while not becoming burdensome to the participants. With this in mind, the AFES-TPA has been developed by identifying potential TPA associations, while being able to be administered within a five-minute time frame. After making minor adjustments identified in the pilot study (reducing the cumbersome nature of one question and combining two questions), the AFES-TPA is ready for use in future population studies. The intended application of the AFES-TPA is to incorporate it into an existing telephone-based PA surveillance system to appropriately assess TPA engagement and perceptions, thereby providing utility for transport planners and public health agencies. Collaborative approaches have been highly recommended to enhance public health outcomes [130], and the AFES-TPA is integral to developing sustainable alliances with multiple sectors. There is also scope for developing the AFES-TPA into a self-administered questionnaire that can be used with different population sub-groups. This is

because the AFES-TPA is easy to comprehend, transport and PA jargon use is limited, and it does not require long recall periods.

Extensions of the AFES-TPA include adapting the survey from telephone-administered to mail-based, and developing a similar tool to determine causality of the behaviour. To date, this survey can only be used within a cross-sectional context to understand correlates of TPA. Limitations of the AFES-TPA include that it has not undergone convergent or criterion validity testing, and may be subject to self-report and non-response bias. The present study was also conducted on a small and relatively homogenous sample, and as such, generalisability of the AFES-TPA is currently limited. Other limitations were that for some study participants'  $t2$  questionnaires were administered three days apart from the  $t1$  questionnaire. Typically  $t1$  and  $t2$  questionnaires are administered at least seven and often ten days apart. Future studies should also seek to examine the associations with other potentially pertinent measures of the built environment (e.g., street connectivity, mixed land use, residential density) with TPA engagement to provide a more comprehensive assessment of the behaviour.

### *Conclusions*

This study contributes to the field of PA by providing the first reliable survey to measure TPA behaviours. The AFES-TPA assists with understanding perceptions, barriers, and current transport modes in adults. As such, there is scope to incorporate the AFES-TPA into existing PA measures to assess and track TPA engagement.

## **Chapter 6: Health Associations with Transport-related Physical Activity and Motorised Travel to Destinations**

### **Preface**

After demonstrating appropriate test-retest reliability of the AFES-TPA, the instrument was able to be incorporated into a larger survey instrument (AFES) and applied to a regionally-representative sample of adults to further understand other relationships with TPA engagement, such as health associations. Caveats of the instrument were that the test-retest reliability of the tool was only established in a small, non-representative sample of university employees, and that two of the subjective questions did not show appropriate stability over time. Despite these limitations, incorporating the AFES-TPA into the larger AFES is critical for understanding if increased TPA engagement will likely lead to improved health outcomes in the first instance before commencing community-wide TPA initiatives. It presently remains unknown whether engaging in TPA modes to different destinations confers the same health benefits. Therefore, this chapter seeks to understand the relationships between health risk indicators (i.e., overall PA engagement, BMI) with TPA and motorised travel engagement to place of work/study and the convenience shop in adults (as established by the AFES-TPA).

## Introduction

Despite the known benefits resulting from adequate PA engagement, the majority of adults in most developed countries are not sufficiently active for health benefits [1]. To date, much of the previous efforts to promote PA have focused on the leisure time context [23], with little success. Data presented in Chapter 4, as well as other international literature [1, 6], estimates that approximately 50% of adults in developed nations are not sufficiently active for health benefits. Promoting domains other than leisure-time to accumulate activity, such as transportation, may assist with overcoming the present low PA prevalence rate. TPA engagement is viewed as a potentially viable means for improving and sustaining PA, through providing a structured routine for habitual activity accumulation [20] and imparting accessible transport modes (i.e., walking, cycling) for the majority of the population. During the last few years there has been increased interest by transport planners to develop infrastructure that supports TPA modes. The three main motivators for this focus are to: firstly, reduce the number of automobiles on the road, thereby limiting auto-associated problems (e.g., pollution, traffic congestion); secondly, develop more sustainable urban spaces which support job-housing balances and public transport; and thirdly, minimise equity issues that are inherently associated with private automobile availability [131]. Providing evidence regarding PA and health aspects of TPA engagement will likely provide further support for transport planners to prioritise TPA modes in transport and urban planning.

From the available evidence, private automobile use has been positively correlated with obesity levels [94], and those who lived in more sprawling environments have demonstrated increased prevalence of hypertension, heavier BMI, and walked less during leisure time [39]. Several non-representative studies have also identified enhanced health outcomes in those who commute to place of work/study using TPA modes. These health benefits include improved blood lipid profile [99, 100], lowered hypertension [97, 101], and reduced all-cause mortality [102] in adults. Specific to the variables of interest examined in this study, BMI status has been negatively associated with TPA engagement [98, 116, 117], and overall PA levels have been positively associated with TPA engagement [74, 132, 133]. Noteworthy, however, is the

relationship between TPA and overall PA engagement has only been established with school-based travel using accelerometry in non-representative samples of youth. In addition, research has not examined BMI classification or overall PA level differences based on accessing different destinations compared by travel modes. The present study, through examining travel to place of work/study and the convenience shop (i.e., corner store, local supermarket, proximal petrol station) within a single study, can identify valuable opportunities for TPA engagement and the current body of knowledge can be expanded upon.

To summarise the existing TPA research, health risk indicators have only been compared by commuting to place of work/study and have not been contrasted with travel to other locations, such as the convenience shop. Examining travel to common destinations (e.g., place of work/study, convenience shop) will provide information regarding travel behaviours and will strengthen the applicability of any health-risk associations. Furthermore, the majority of TPA engagement studies have been conducted with non-representative samples and the relationship between overall PA levels and TPA participation has not been examined in an adult population. The present study uses regional population-representative data that may assist in building the evidence base regarding TPA engagement and health outcomes. As well, determining whether TPA engagement to two different localities results in similar health risk associations for adults, can be ascertained. As such, this study is important for both public health and transport disciplines. The purpose of this study is to examine the associations between travel modality (TPA versus motorised transport) with socio-demographic variables, overall PA levels, and BMI classification. These associations are compared by accessing place of work/study and the convenience shop with a regional population-representative adult sample residing within a mainly urban context (North Shore City, Auckland, NZ).

## **Methods**

### *Study Sample*

The AFES was implemented in a regionally-representative adult sample of North Shore City (Auckland, NZ) residents in April 2005 (autumn). Potential

participants were drawn randomly without replacement from the North Shore City electronic telephone white pages and contacted through CATI procedures. Telephone calls were made 10:00am-8:30pm during a one-month period, and a five time call-back system was implemented. Within each household contacted, the English-speaking adult ( $\geq 16$  years of age) with the next birthday was asked to partake in the survey and sampling continued until 2,000 respondents were recruited (31% response rate) (Appendix H). Case weights were applied retrospectively to align the sample with 2001 census data based on gender and age distributions for the region [125]. Participants provided informed consent prior to participating in the AFES and the AUTC approved the study (AUTC 05/40) (Appendix I).

### *Population Profile*

Aside from the north-western perimeter, North Shore City is surrounded by coast, and is connected to Auckland City by a bridge that is accessible only by motorised transport. Approximately 45% of survey respondents worked within Auckland City, and the remainder of employment was based within North Shore City. Respective to the overall North Shore City population, this sample showed similar education (34% (sample mean) versus 38% (North Shore City mean) held a tertiary qualification) and household income (\$25,600 per annum versus \$23,300 per annum, respectively) levels, but were less likely to be of Asian (9% versus 13%, respectively) or NZ European (68% versus 82%, respectively) descent [125].

### *Questionnaire Design*

All measures in the 88-item AFES were self-report and the questionnaire was telephone-administered. Apart from the chronic condition section [134] and the TPA component [135], the AFES was based on the OTA survey [136] (Appendix A). Amongst other things, the AFES assessed socio-demographic variables, overall PA levels, BMI, and travel mode engagement when accessing place of work/study and the convenience shop. Excluding the travel mode engagement section [135] and general PA [135] components, no reliability or



validity testing have been conducted on the AFES. A copy of the AFES is in Appendix J.

### *Physical Activity Measures*

The NZPAQ-SF was included as part of the AFES to ascertain self-reported PA levels. The NZPAQ-SF was based on the IPAQ-SF telephone survey [137]. In the NZPAQ-SF, participants recorded frequency and minutes spent engaged in moderate intensity (including walking) and vigorous intensity activities for all purposes during the seven days preceding the survey. Minutes engaged in vigorous intensity activity were approximately equated with moderate intensity activity by doubling the respondent's reported time spent participating in these higher intensity activities. After equating vigorous intensity activity, respondents were classified into dichotomous PA groups based on the international best practice recommendation of adults accumulating 30 minutes of moderate intensity PA on at least five days per week [1]. 'Insufficiently active for health benefits' participants did not report a threshold of five episodes of PA engagement, totalling 150 minutes during the previous week. 'Sufficiently active for health benefits' respondents recorded at least five sessions of PA engagement equalling 150 minutes or more during the last week.

### *Travel Behaviour Measures*

The travel behaviour component of this study was drawn from the section of the survey that reported typical travel modes for commuting to place of work/study and the convenience shop. For the purposes of the AFES, the convenience shop was defined as the corner store, local supermarket, or proximal petrol station. Respondents were asked: 'How do you usually get to and from your place of work/study?' and 'How do you usually get to and from your convenience shop?' These answers were collapsed into dichotomous travel mode categories (TPA versus motorised) for each destination. The transit/combined travel group was excluded for the purpose of this study as prevalence rates were low, and remained constant when travel to either destination was assessed (5% for both travelling to place of work/study and the convenience shop). The categories used for the regression models were 'TPA'

(i.e., walking and cycling for entire journeys) and 'motorised' travel (i.e., automobile travel only for passages). As identified in Chapter 6, adequate test-retest reliability of the AFES-TPA was previously established in a sample of 30 adults with ICC values for travel to the convenience shop (ICC=0.97) and place of work/study (ICC=0.98) above the 0.7 reliability threshold [135].

### *Body Mass Index and Risk Classification*

BMI classifications were derived from respondents' self-reported height (m) and body mass (kg) data. Several studies have documented high reliability and correlations ( $r > 0.9$ ) between self-reported height and weight in adult populations [138-140]. According to international best practice recommendations, the standard BMI calculation was used (weight (kg)/height (m)<sup>2</sup>), with mutually exclusive cut-off points applied to determine BMI classifications for underweight, normal weight, overweight, and obese for those of differing ethnic descents: Asian,  $<18.5$ , 18.5-22.9, 23.0-24.9, and  $\geq 25.0$ , respectively; Caucasian,  $<18.5$ , 18.5-24.9, 25.0-29.9, and  $\geq 30.0$ , respectively; and Maori/Polynesian,  $<18.5$ , 18.5-25.9, 26.0-31.9,  $\geq 32.0$ , respectively [124]. The underweight and normal BMI classifications for all ethnicities were combined to provide a 'normal BMI' classification and the overweight and obese BMI categories were grouped together to form an 'overweight BMI' category.

### **Statistical Analysis**

Population frequencies were calculated and binary logistic regression models were generated using SPSS Version 11.5 (SPSS Inc., 2003). Prevalence levels were weighted according to 2001 census [125] by adjusting the sample for selection probability at the individual level based on age and gender distributions for the region. Binary logistic regression modelling (OR) was employed to understand the likelihood of the relationships between the independent and dependent variables. TPA engagement operated as the dependent variable for the socio-demographic profile, and then became the independent variable when compared with overall PA and BMI classifications. The dependent variables had two levels of comparison for each model: 'TPA' versus 'motorised' travel; 'insufficiently active for health benefits' versus 'sufficiently active for health benefits'; and, 'normal BMI' versus 'overweight

BMI', respectively. The socio-demographic model was mutually adjusted by the other variables in the analysis, and overall PA and BMI classification models were adjusted by the variables examined in Table 14 (i.e., gender, age, household income, education). Adjusting for potential confounders assisted with isolating the independent influence of TPA engagement with health indicators. A significance level of  $\alpha=0.05$  was implemented.

## **Results**

### *Sample Characteristics*

Data presented in Table 14 outlines the socio-demographic profile of AFES participants. Survey participants were more likely to be physically active when compared with national averages (19% sedentary, 42% insufficiently active for health benefits, and 39% sufficiently active for health benefits (national mean)) [5]. AFES respondents were also more likely to be classed as normal or underweight, and less likely to be classified as overweight or obese when compared with NZ BMI prevalence rates (44% normal and underweight, 35% overweight, and 21% obese (national mean)) [141] (Table 11). In this study the overall prevalence for travelling to place of work/study by TPA modes was 7% and by private automobile was 89%. The percentage of respondents travelling to the convenience shop by TPA modes and private automobile were 32% and 64%, respectively. The remainder was made up of combined (i.e., both TPA and motorised) travel modes. The travel modality differences and low measure of association (phi coefficient=0.14, p-value<0.001) shown when accessing the destinations by TPA modes and motorised transport suggest the journeys to each destination are largely independent of one another.

**Table 11:** Socio-demographic profile of AFES respondents

<i>Variable</i>	<i>(%)<sup>a</sup></i>
<i>Gender</i>	
Male	48
Female	53
<i>Age (years)</i>	
16-30	31
31-50	23
51-70	26
>70	20
<i>Ethnicity</i>	
NZ European	68
Maori	4
Pacific Island	1
Asian	9
Other	18
<i>Annual household income (NZ\$)</i>	
<20,000	11
20,000-40,000	16
40,001-80,000	34
80,001-120,000	23
>120,000	16
<i>Highest education qualification</i>	
No high school	10
High school	24
Trade, diploma, certificate	27
Bachelor degree	25
Postgraduate degree	10
<i>Overall PA level</i>	
Sedentary	6
Insufficient activity	27
Sufficient activity	30
Sufficient activity including moderate and vigorous PA	37
<i>BMI<sup>c</sup></i>	
Underweight	3
Normal weight	50
Overweight	30
Obese	12

<sup>a</sup> Weighted according to 2001 census [125]

<sup>c</sup> Ethnically adjusted BMI classifications according to the WHO criteria [124]

### *Travel Behaviour*

Data presented in Table 12 show the distribution of TPA modes and motorised travel modes for selected socio-demographic variables and the strength of socio-demographic associations (using binary logistic regression) with TPA engagement to both destinations. Significant OR relationships existed within the age categories. In comparison to respondents aged 31-50 years, those who were 16-30 years of age were approximately twice as likely to use TPA modes to travel to their place of work/study and the convenience shop.

This relationship remained significant once other variables in the model (i.e., gender, education, household income) were mutually adjusted for.

Relationships were also shown between household income and travel to the convenience shop. The trend for income was those whose household income was less than the referent category (\$40,001-\$80,000) were more likely to use TPA modes to access the convenience shop, and those who earned more than the reference group were more likely to use motorised modes. After adjusting for gender, age, and education (refer mutually adjusted model, Table 12), the only significant income relationship existed between the reference category and respondents who earned \$20,000-\$40,000.

**Table 12:** Socio-demographic profile and logistic regression models defined by TPA engagement to two destinations in the AFES sample

Variable	Work/study travel						Convenience shop travel					
	Motorised mode (%) <sup>a</sup>	TPA mode (%) <sup>a</sup>	Crude OR	95%CI	Adjusted OR <sup>a</sup>	95%CI	Motorised mode (%) <sup>a</sup>	TPA mode (%) <sup>a</sup>	Crude OR	95%CI	Adjusted OR <sup>a</sup>	95%CI
<i>Gender</i>												
Male	51	46	1.0	referent	1.0	referent	47	48	1.0	referent	1.0	referent
Female	49	54	1.3	0.8-2.0	1.2	0.7-2.0	52	53	1.0	0.8-1.2	0.9	0.7-1.1
<i>Age (years)</i>												
16-30	31	45	2.0*	1.1-3.6	2.0*	1.1-3.7	26	40	2.0*	1.6-2.6	1.9*	1.5-2.6
31-50	22	23	1.0	referent	1.0	referent	24	23	1.0	referent	1.0	referent
51-70	28	17	0.6	0.3-1.1	0.6	0.3-1.1	29	22	0.6*	0.5-0.8	0.7*	0.5-0.9
>70	19	15	0.8	0.4-1.6	0.9	0.4-1.8	21	16	0.7	0.6-1.0	0.8	0.6-1.0
<i>Annual household income (NZ\$)</i>												
<20,000	7	5	0.7	0.2-2.4	0.7	0.2-2.2	10	13	1.4	1.0-1.9	1.4	0.9-2.2
20,000-40,000	12	10	0.8	0.3-1.8	0.9	0.4-2.1	15	17	1.1	0.9-1.5	1.6*	1.1-2.3
40,001-80,000	37	37	1.0	referent	1.0	referent	35	33	1.0	referent	1.0	referent
80,001-120,000	26	24	0.9	0.5-1.7	0.9	0.4-1.7	23	22	0.9	0.7-1.2	0.8	0.6-1.1
>120,000	18	25	1.6	0.8-3.1	1.5	0.8-2.9	17	15	0.8	0.6-1.1	0.7	0.5-1.0
<i>Highest education qualification</i>												
No high school	8	7	0.7	0.3-1.9	1.0	0.4-2.5	10	13	1.3	1.0-1.8	1.2	0.8-1.8
High school	22	24	0.8	0.5-1.5	0.8	0.4-1.5	24	25	1.0	0.8-1.3	1.2	0.9-1.6
Trade, diploma, certificate	27	14	1.0	referent	1.0	referent	28	24	1.0	referent	1.0	referent
Bachelor degree	27	37	1.4	0.8-2.4	1.2	0.7-2.1	24	24	0.9	0.7-1.2	0.9	0.7-1.2
Postgraduate degree	11	12	1.0	0.5-2.0	1.1	0.5-2.3	10	8	0.8	0.6-1.2	0.8	0.5-1.2

<sup>a</sup> Weighted according to 2001 census [125]

<sup>a</sup> Mutually adjusted by other socio-demographic variables in the model

\* Significant relationship exists as 95%CI do not cross 1.0

### *Travel Mode and Health Outcomes*

Table 13 shows the strength of associations between TPA engagement and self-reported overall PA levels for accessing both destinations. Those who travelled to place of work/study utilising motorised transport were half as likely to be classed as sufficiently active for health benefits when compared with those who engaged in TPA modes (Table 13). This relationship remained in the negative direction (adjusted OR=0.5) once socio-demographic variables were adjusted for. No differences existed for respondents' overall PA levels when travelling by private automobile or TPA modes to the convenience shop was compared.

**Table 13:** Classification and logistic regression models of being classified as sufficiently active for health benefits defined by travel modes to two destinations in the AFES sample

Travel mode	Work/study travel						Convenience shop travel					
	Insufficient activity (%) <sup>a</sup>	Sufficient activity (%) <sup>a</sup>	Crude OR	95%CI	Adjusted OR <sup>a</sup>	95%CI	Insufficient activity (%) <sup>a</sup>	Sufficient activity (%) <sup>a</sup>	Crude OR	95%CI	Adjusted OR <sup>a</sup>	95%CI
TPA	3	6	1.0	referent	1.0	referent	29	36	1.0	referent	1.0	referent
Motorised	97	94	0.5*	0.3-0.9	0.5*	0.2-0.9	71	64	1.0	0.6-1.5	0.9	0.5-1.5

<sup>a</sup> Weighted according to 2001 census [125]

<sup>a</sup> Logistic regression model adjusted by gender, age, household income, and education

\* Significant relationship exists as 95%CI do not cross 1.0

**Table 14:** Classification and logistic regression models of being classified as normal BMI defined by travel modes to two destinations in the AFES sample

Travel mode	Work/study travel						Convenience shop travel					
	Overweight BMI (%) <sup>a c</sup>	Normal BMI (%) <sup>a c</sup>	Crude OR	95%CI	Adjusted OR <sup>a</sup>	95%CI	Overweight BMI (%) <sup>a c</sup>	Normal BMI (%) <sup>a c</sup>	Crude OR	95%CI	Adjusted OR <sup>a</sup>	95%CI
TPA	4	7	1.0	referent	1.0	referent	31	36	1.0	referent	1.0	referent
Motorised	96	93	0.6*	0.3-0.9	0.5*	0.3-0.9	69	64	0.9	0.5-1.3	1.0	0.6-1.6

<sup>a</sup> Weighted according to 2001 census [125]

<sup>a</sup> Logistic regression model adjusted by gender, age, household income, and education

<sup>c</sup> BMI classifications are ethnically adjusted according to the WHO criteria [124]

\* Significant relationship exists as 95%CI do not cross 1.0



Table 14 reports the relationship between BMI classification and TPA engagement compared with travelling to place of work/study and the convenience shop. Respondents who engaged in motorised travel modes were significantly less likely to be classed as normal BMI (unadjusted OR=0.6, adjusted OR=0.5) when compared with those who used TPA modes to commute to place of work/study. No significant BMI classification differences existed when TPA engagement and motorised travel to the convenience shop were compared.

## **Discussion**

Not surprisingly, motorised transport was the dominant form of travel for this adult population for accessing both destinations. These findings are consistent with US data for adults travelling to work [115] and the local shopping centre [36]. The variations shown in this study for engaging in TPA to access place of work/study (7%) and the convenience shop (32%) may be because of associated distances and logistical constraints. Previous research suggests work and education facilities are often located further away from the home when compared with the convenience shop [112], and distance is cited as a prohibitive barrier to TPA engagement [36]. Furthermore, because of restrictions (e.g., shift work, travel within the workday) it is often unfeasible to commute to place of work/study by TPA modes. Despite this study documenting similar TPA engagement prevalence rates to previous studies [36, 115], this is the first study that has examined the interaction of transport modalities with overall PA levels and BMI classification for commuting to different destinations within the same body of research.

TPA engagement has been advocated as a sustainable approach to improve population-level PA levels [1, 20]. Empirical evidence for a positive relationship between overall PA levels and TPA engagement, however, is based on three studies conducted with youth [74, 132, 133]. Although the former studies incorporated objective measures (accelerometers), only school-based travel was examined, and prior to this research, no studies have examined this relationship in the adult population. While the present study did not separate overall PA into domains, thereby could not isolate the contribution of TPA modes to overall PA accumulation, these findings build on previous

research and strengthen the positive relationship between TPA engagement to place of work/study and higher PA levels overall in adults. Although only a small portion of respondents walked or cycled to their place of work/study when compared with respondents who usually commuted there by motorised means, they were twice as likely to be classified as sufficiently active for health benefits. Despite this relationship, the unknown error of the measurement instrument and small sample engaging in TPA may have confounded these findings. No relationship was identified with accessing the convenience shop.

There are several possible reasons for the overall PA level discrepancy when the two destinations were compared. Firstly, the NZPAQ-SF may not have been sensitive enough to detect the PA contribution with the potentially shorter travel distances or times associated with accessing the convenience shop. A recent study compared two surveys that measured walking duration and frequency (leisure time versus total). When total walking time was specifically addressed as occupational and leisure time occurrences, walking prevalence almost doubled [23]. Secondly, travelling to the convenience shop may be less purposive than work/study-related travel, therefore less well remembered. Thirdly, utilising TPA modes to access work/study may actually confer more PA benefits, through travelling longer distances and/or travelling more frequently. Indeed, Handy and Clifton [36] concluded walking to the local shops was an ineffective strategy to decrease overall automobile use. As such, future TPA work should seek to incorporate objective PA measures to further investigate the relationship between TPA and overall PA engagement to confirm these findings.

BMI classification was also used as a measure of health risk. The findings regarding travel to place of work/study and TPA engagement associations showed agreement with previous research [98, 116, 117]. Similar to the overall PA model, no significant relationships existed between BMI classifications and commuting to the convenience shop. Based on the BMI and overall PA findings, it is likely more health benefits are gained from commuting to place of work/study utilising TPA modes in comparison to walking or cycling to the convenience shop. Although this may be the case, TPA modal engagement for travelling to place of work/study is relatively low in this population. Historically, transport planners have been advocating TPA engagement to place of work/study for a variety of reasons primarily linked to

environmental and social concerns. This research, however, identifies there is substantial scope within the public health and transport planning domains to develop combined strategies that promote walking and cycling to these destinations. Potential initiatives include: advocating for supportive urban environments, providing incentives for TPA travel, social marketing campaigns, and developing appropriate infrastructure to facilitate TPA engagement.

Despite enhancing the knowledge base surrounding TPA behaviour and health-risk associations, particularly regarding travel behaviours to different destinations, potential limitations existed within the present study. The self-report nature of the survey may have limited the efficacy to fully and accurately detect PA levels and BMI classifications. Furthermore, the IPAQ measure, of which the NZPAQ-SF is based on, has previously reported only a weak correlation with accelerometer counts ( $r=0.3$ ) in adults [69]. Some overlap would have also occurred between TPA and overall PA levels in the NZPAQ-SF and it could not be determined whether TPA engagement was a substitute for other forms of PA. The extent of these associations remains unknown, however, because the overall PA and TPA measures were derived from separate components within the AFES. Conclusions regarding causality also cannot be drawn from this study as all data were cross-sectional. Other possible study weaknesses included: only assessing travel to two destinations, the frequency of commuting to the destinations was not established, and although the socio-demographic profile of the respondents were similar to the national average, this sample reported higher PA levels and lower BMI values. To counteract these potential limitations and extend upon this study, future TPA research should seek to employ objective measures to determine health outcomes, and longitudinal research designs should be utilised wherever possible.

### *Conclusions*

This is the first time travel to the convenience shop and place of work/study has been assessed with health risk indicators (i.e., overall PA, BMI classification) in the same study using an adult population sample. TPA engagement remains low, particularly for travel to place of work/study, despite increasing advocacy of TPA modes. Travel to place of work/study findings presented in this study concur with previous youth research; those who utilise

TPA to commute to this destination are more likely to be classified as sufficiently active for health benefits and be of normal BMI classification when compared with those who use motorised modes to access place of work/study. No significant relationships were established when travel to the convenience shop was isolated. Based on these findings, public health promotion strategies should seek to encourage TPA engagement to place of work/study as it is likely that health benefits will be conferred. Objective tools also need to be incorporated wherever possible, especially regarding measuring PA measurement.

## **Chapter 7: Understanding the Relationships Between Private Automobile Availability, and Overall and Transport-related Physical Activity in Adults**

### **Preface**

As identified in the preceding chapters, automobiles are the dominant form of travel in most developed countries and within NZ. The findings presented in Chapter 6 demonstrated those who engaged in motorised travel to place of work/study were less likely to accumulate sufficient levels of PA and be classed as normal BMI when compared with respondents who engaged in TPA to access their place of work/study. No relationships existed between health outcomes and travel to the convenience shop, but the self-report nature of the survey, coupled with the inability to ascertain the contribution of TPA engagement to overall PA, potentially may be why no relationships were shown. Despite the limitations of the survey tool, it remains unknown how private automobile availability is associated with overall PA and TPA engagement. As such, it is pertinent to examine these associations. Using the same sample as Chapter 6 (AFES), the research presented in this chapter builds on the previous study's findings by exploring the relationships between socio-demographic variables, overall PA levels, and TPA engagement to place of work/study and the convenience shop, relative to private automobile availability.

## Introduction

Within most developed countries car ownership is normalized and private automobiles are the dominant travel mode for both long and short journeys. For example, two-thirds of British and 92% of US households have at least one private automobile available [142], and the National Household Travel Survey identified 87% of all trips in the US were made by private automobiles in 2001 [115]. Recent research suggests that up to 40% of automobile trips could feasibly be replaced with TPA [143]. Private automobile ownership and use are also rapidly increasing in developing countries like China, and are likely to be accompanied with severe health implications because of the corresponding increase in sedentary behaviour [22]. It has been purported that automobile reliance has reduced daily PA accumulation as a result of utilizing private automobiles to travel short distances, thereby negatively affecting health outcomes [20]. Evidence suggests that TPA affords some of the well-documented health benefits conferred from regular PA participation [1, 3, 118]. As such, the WHO [20] is endeavoring to promote trips less than five kilometres as being acceptable for TPA modes, such as walking or cycling.

Three reviews have examined the relationships between TPA, health outcomes, and built environment constructs [32, 33, 118], concluding that TPA is worthy of promotion. There is interest from both the transport and health sectors as TPA simultaneously provides travel and health benefits and engagement in TPA may serve to habitually accumulate PA. Indeed, recent research using the same dataset as the present study revealed that adults who walked or cycled to their place of employment were twice as likely to be classified as active for health benefits when compared with those who commuted by motorized modes (Badland & Schofield, in press). Furthermore several studies incorporating accelerometry as the PA measure, have identified positive associations between overall PA levels and walking to/from school in youth [132, 133, 144]. Despite the known benefits of TPA, only a limited amount of information is available regarding TPA engagement for the adult population [118].

Previous research with adults has noted associations between increased walking for transport and reduced automobile ownership [40], and despite high automobile availability within most developed countries, some population sub-

group variability has been shown [131]. Plaut [131] identified those who either earned more, were female, were older, or resided in rural areas, were more likely to engage in motorised travel. The study also demonstrated that individuals who walked or cycled to work were approximately 30% less likely to have a private automobile available, with a strong positive association existing between private household automobile ownership and motorised travel mode engagement.

Although research regarding automobile ownership and travel behaviour exists, little is known about the associations between PA levels, especially for adults, when compared by private automobile availability. This study seeks to overcome this paucity of data by examining the relationships between socio-demographics, automobile availability, overall PA levels, and travel behaviours to different destinations with a sample of adults residing in NZ. An enhanced understanding of these relationships will likely result in greater awareness of the interaction between travel behaviour and public health outcomes.

## **Methods**

### *Sample Size*

Respondents were from North Shore City, Auckland region, NZ. Participants were drawn randomly from the North Shore City electronic white pages and contacted through CATI procedures. Within each household contacted, the English-speaking adult ( $\geq 16$  years of age) with the next birthday was asked to partake in the survey. Before the sample of 2,000 respondents (1,050 females, 950 males) was fulfilled for the AFES, 6,476 eligible respondents were contacted and invited to participate (overall response rate 31%). Case weights were applied retrospectively to align the sample with census data based on gender and age distributions for the region. Participants provided informed consent prior to participating in the AFES and the host institution ethics committee approved the study.

### *Questionnaire Design*

The AFES was implemented in April 2005. All measures in the 88-question AFES were self-report and the questionnaire was telephone

administered. As well as other variables, the AFES assessed private automobile availability, current PA levels, TPA engagement, and socio-demographics. Excluding the TPA [135] and general PA [145] components, no reliability or validity testing has been conducted on the AFES. A copy of the questionnaire is provided in Appendix J.

#### *Automobile Availability*

Respondents reported on their level of private automobile availability in the AFES. Private automobile availability classifications available for participants to choose from were: unrestricted, frequent, limited, and no (none).

#### *Physical Activity Measures*

The NZPAQ-SF was included as part of the AFES to ascertain self-report PA levels. In the NZPAQ-SF, participants recorded frequency and minutes spent engaged in moderate and vigorous intensity activities for all purposes over the seven days preceding the survey. Minutes engaged in vigorous intensity activities were approximately equated with moderate intensity activities by doubling the respondent's self-reported time spent participating in these higher intensity activities. After equating vigorous intensity activity, respondents were classified into dichotomous PA categories. 'Insufficiently active for health benefits' respondents did not reach a threshold of five episodes of activity, totaling at least 150 minutes over the previous week. 'Sufficiently active for health benefits' participants recorded at least five sessions of PA equaling at least 150 minutes over the last seven days. These classifications are aligned with international best practice PA guidelines [1].

#### *Transport-related Measures*

The AFES incorporated a TPA-specific element. Within the TPA aspect of the survey, typical travel modes to travel to common destinations were reported. Respondents were asked: 'How do you usually get to and from your usual place of work/study?', and 'how do you usually get to and from your local convenience shop?' These answers were collapsed into travel mode categories. The TPA (walking and cycling for entire journeys) and motorised



(automobile travel for whole passages) classifications were compared by travelling to place of work/study and the convenience shop.

## **Statistical Analyses**

Population frequencies and were calculated and binary logistic regression models were generated using SPSS Version 11.5. Population proportions were weighted according to New Zealand census 2001 statistics [125] by adjusting the sample for selection probability at the individual level based on age and gender distributions for the region. Binary logistic regression modelling (OR) was employed to understand the likelihood of the relationships between the independent and dependent variables. OR were the most appropriate type of modelling for these data as the analysis did not assume a linear relationship between the independent and dependent variables and it did not require normally distributed variables. Private automobile availability operated as the dependent variable for the socio-demographic profile model, and then became the independent variable when compared with overall PA and TPA. The dependent variables had two levels of comparison for each model; unrestricted versus no (none) private automobile availability; sufficiently versus insufficiently active for health benefits; and TPA versus motorised travel. All CI were set at 95%.

## **Results**

Overall, 1,600 respondents reported unrestricted automobile availability, 240 respondents reported frequent automobile availability, 60 respondents reported limited automobile availability, and 80 respondents had no automobile available to them. Table 15 shows the socio-demographic profile for the different classifications of private automobile availability, overall PA levels, and travel behaviour. Indeed, 92% of respondents reported high private automobile availability, 64% were sufficiently active for health benefits, 7% of the sample walked or cycled to their occupation, and 30% used TPA modes to access the convenience shop. Significant differences existed for all socio-demographic classifications when private automobile availability was examined and overall PA levels were significantly associated with gender and annual household income. Those who were younger were significantly more likely to use TPA

modes to access their place of employment and the convenience shop when compared with other age categories. Further analysis revealed that overall PA classification differences existed by automobile availability (67%, 71%, 73%, and 49% classed as physically active for health benefits for unrestricted, frequent, limited, and no automobile availability, respectively), and frequency distributions of the duration of overall PA by automobile availability and travel mode are reported in Figures 2 and 3. The mean total minutes engaged in PA was 731 minutes/week, and the median time was 380 minutes/week. In comparison to the other automobile categories, a higher percent of respondents with no private automobile available reported less than 15 minutes of PA engagement per week (Fig 2). Those who commuted to the convenience shop by motorised modes were reported a higher percent than the other groups of participating in less than 15 minutes of PA engagement per week (Fig 3).

**Table 15:** Descriptive profile of an adult sample by private automobile availability, overall PA levels, and travel behaviours

	<i>Private automobile availability</i>				<i>p-value</i>	<i>Overall physical activity levels</i>		<i>p-value</i>
	<i>Unrestricted (%)^</i>	<i>Frequent (%)^</i>	<i>Limited (%)^</i>	<i>None (%)^</i>		<i>Sufficient activity (%)</i>	<i>Insufficient activity (%)</i>	
<i>Overall</i>	80	12	3	4		64	31	
<i>Gender</i>					$\leq 0.001$			$\leq 0.001$
Male	82	12	3	3		70	30	
Female	78	13	4	6		64	36	
<i>Age (years)</i>					$\leq 0.001$			0.59
16-30	63	23	7	7		71	29	
31-50	85	11	2	1		66	34	
51-70	89	6	2	3		67	33	
>70	87	8	2	4		70	31	
<i>Education</i>					$\leq 0.01$			0.68
No high school	65	19	7	9		64	36	
High school	76	15	4	6		62	38	
Trade, diploma, certificate	86	9	2	4		70	30	
Bachelor degree	84	10	3	2		67	33	
Post -graduate	58	24	9	10		72	28	
<i>Annual household income (NZ\$)</i>					$\leq 0.001$			$\leq 0.001$
$\leq 20,000$	65	15	8	12		61	39	
20,001-40,000	76	12	5	8		69	31	
40,001-80,000	85	11	3	1		67	33	
80,001-120,000	85	11	3	1		68	32	
>120,000	89	9	0	1		71	29	

Table 15 continued overleaf

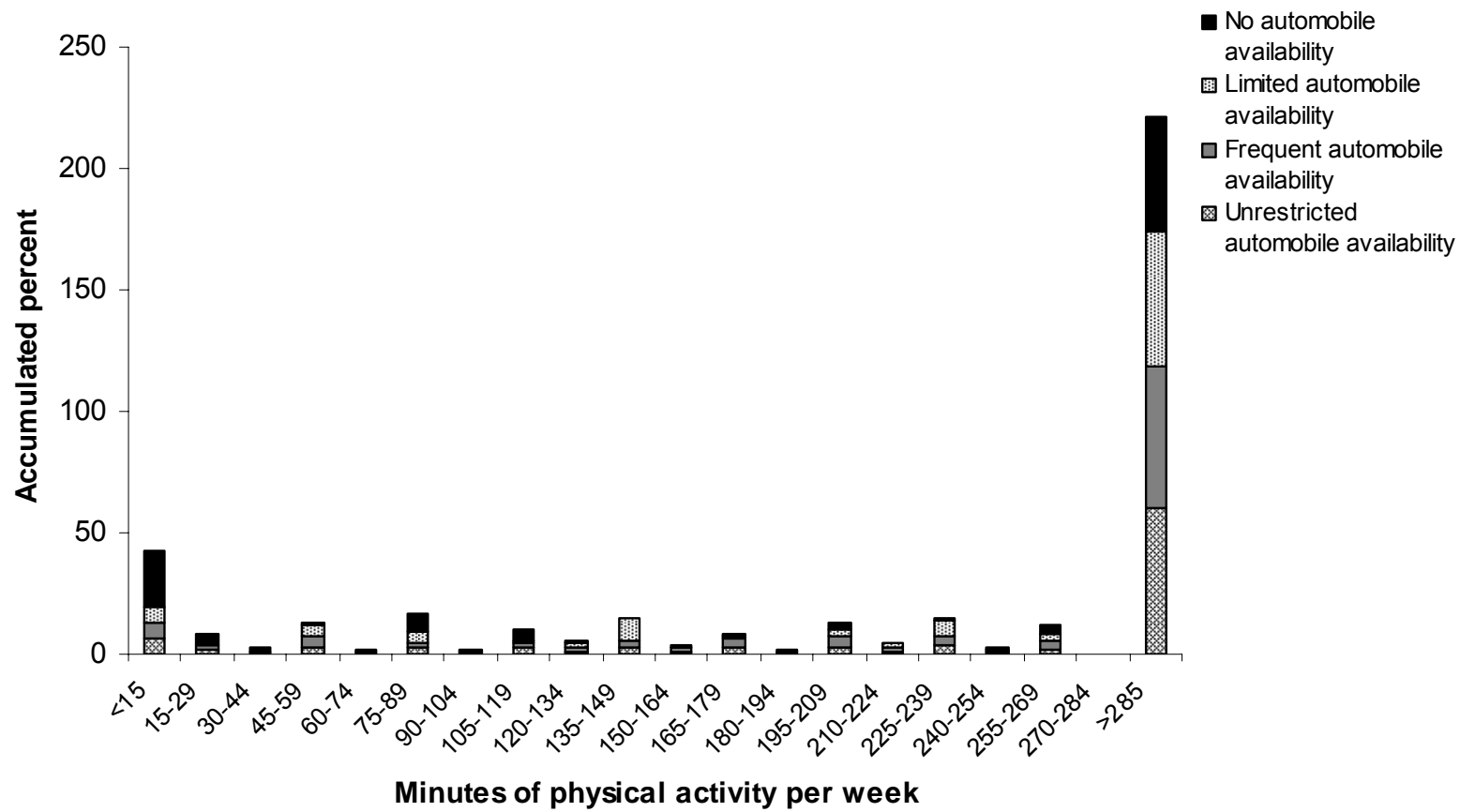
Some values do not add to 100% because of missing data.

Table 15 continued

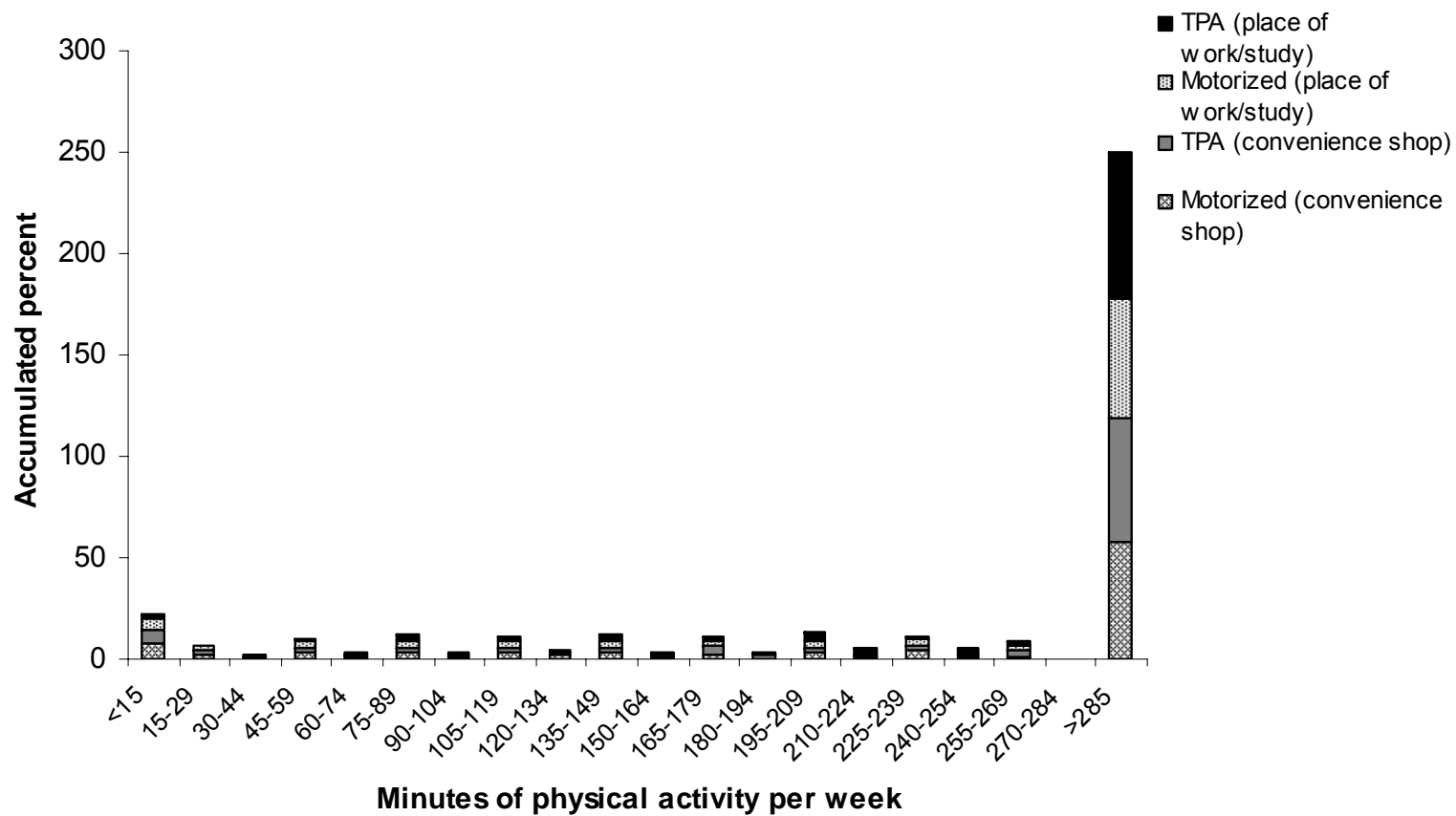
	<i>Travel mode to place of work/study</i>			<i>Travel mode to convenience shop</i>		
	<i>TPA</i> <i>(%)</i>	<i>Motorised</i> <i>(%)</i>	<i>p-value</i>	<i>TPA</i> <i>(%)</i>	<i>Motorised</i> <i>(%)</i>	<i>p-value</i>
<i>Overall</i>	7	89		30	61	
<i>Gender</i>			0.73			≤0.001
Male	7	89		32	64	
Female	6	89		32	63	
<i>Age (years)</i>			≤0.001			≤0.001
16-30	11	82		43	53	
31-50	5	90		33	63	
51-70	3	94		27	69	
>70	5	91		28	67	
<i>Education</i>			0.75			0.28
No high school	20	77		39	59	
High school	7	88		33	64	
Trade, diploma, certificate	4	94		29	67	
Bachelor degree	4	89		31	63	
Post -graduate	5	89		28	65	
<i>Annual household income (NZ\$)</i>			0.47			≤0.001
≤20,000	14	83		38	59	
20,001-40,000	8	89		35	62	
40,001-80,000	6	89		29	65	
80,001-120,000	5	91		29	64	
>120,000	2	92		29	69	

^ Weighted according to 2001 census [125]

Some values do not add to 100% because of missing data.



**Figure 2 :** Total minutes of PA accumulated per week compared by automobile availability



**Figure 3:** Total minutes of PA accumulated per week compared by travel mode to two destinations

Binary logistic regressions comparing the unrestricted and none categories of private automobile availability identified positive significant trends with household income (all levels of comparison) (Table 16). For example, participants from households that earned more than \$80,000 per annum were at least six times more likely than those earning \$40,001-\$80,000 to report unrestricted availability to a private automobile. An inverse trend existed for those earning less than \$40,000. Those who were younger or had a lower education attainment, relative to their respective referent category, were also significantly less likely to report unrestricted private automobile availability. When the logistic regression model was mutually adjusted, each significant relationship identified in the crude model, apart from gender, remained.

**Table 16:** Binary logistic regression models as defined by unrestricted private automobile availability in an adult sample

	<i>Crude unrestricted private automobile availability</i>		<i>Mutually adjusted unrestricted private automobile availability</i>	
	<i>OR</i>	<i>95% CI</i>	<i>OR</i>	<i>95% CI</i>
<i>Gender</i>				
Male	1.0	<i>referent</i>	1.0	<i>referent</i>
Female	0.5*	0.3-0.8	0.8	0.5-1.2
<i>Age (years)</i>				
16-30	1.0	<i>referent</i>	1.0	<i>referent</i>
31-50	0.4	0.2-1.2	0.8	0.3-1.8
51-70	1.1	0.5-2.4	1.1	0.5-2.3
>70	1.7	0.8-3.8	1.2	0.6-2.7
<i>Education</i>				
No high school	0.3*	0.1-0.5	0.4*	0.2-0.8
High school only	1.0	<i>referent</i>	1.0	<i>referent</i>
Trade, diploma, certificate	1.0	0.6-1.9	1.2	0.6-2.6
Bachelor degree	1.9	0.9-3.7	1.5	0.7-3.6
Post-graduate	2.8	0.9-9.2	2.1	0.5-9.0
<i>Annual household income (NZ\$)</i>				
≤20,000	0.2*	0.1-0.3	0.2*	0.1-0.3
20,001-40,000	0.4*	0.2-0.8	0.4*	0.2-0.8
40,001-80,000	1.0	<i>referent</i>	1.0	<i>referent</i>
80,001-120,000	6.5*	2.3-18.3	7.1*	2.5-20.3
>120,000	8.1*	1.9-33.4	8.0*	1.9-33.3

\* Significant relationship exists as 95%CI do not cross 1.0

**Table 17:** Classification of being sufficiently active for health benefits and binary logistic regression models as defined by private automobile availability in an adult sample

<i>Private automobile availability</i>	<i>Insufficiently active (%)<sup>^</sup></i>	<i>Sufficiently active (%)<sup>^</sup></i>	<i>Crude OR</i>	<i>95%CI</i>	<i>Adjusted OR<sup>a</sup></i>	<i>95%CI</i>
Unrestricted	79	80	1.0	<i>referent</i>	1.0	<i>referent</i>
Frequent	11	13	1.2	<i>0.9-1.6</i>	1.2	<i>0.8-1.6</i>
Limited	3	4	1.3	<i>0.7-2.2</i>	0.9	<i>0.5-1.7</i>
None	7	3	0.5*	<i>0.3-0.7</i>	0.3*	<i>0.2-0.6</i>

<sup>^</sup> Weighted according to 2001 census [125]

<sup>a</sup> Logistic regression model adjusted by gender, age, education, and annual household income

\* Significant relationship exists as 95%CI do not cross 1.0



OR were also employed to understand the association between private automobile availability and overall PA classifications as defined by the NZPAQ-SF. Data presented in Table 17 showed significant relationships between overall self-reported PA levels compared by private automobile availability. Respondents who reported no private automobile availability were less likely to meet the sufficiently active for health benefits classification when compared with those with unrestricted private automobile availability. When potential socio-demographic confounders were included in the model, respondents who reported no private automobile available were even less likely than the unadjusted model (OR=0.33 versus OR=0.46, respectively) to be classed as sufficiently active when compared with the referent group. No significant relationships existed for the other private automobile availability comparison levels. We further considered the paradoxical relationship of the 7% of respondents who reported no private automobile availability and were classified as insufficiently active. Within this group, 68% did not hold a valid drivers licence, 54% were aged 30 years or under, and 17% did not usually commute to a place of employment. Based on these findings, legally not being allowed to drive an automobile showed a substantial association with having no private automobile available and being classified as insufficiently active for health benefits.

An opposite relationship to the overall PA associations were shown when TPA engagement and private automobile availability was analysed (Table 18); those who reported limited or no private automobile availability were more likely to walk or cycle to destinations than respondents with unrestricted private automobile availability. As private automobile availability decreased, the likelihood of travelling to destinations by TPA modes increased regardless of whether travelling to place of work/study or the convenience shop was being assessed. After adjusting for potential confounders, including income and age, the logistic regression models indicated that respondents who did not have a private automobile available were over six times more likely to walk or cycle to place of work/study, and almost ten times more likely to use TPA modes to travel to the convenience shop, when compared with those who reported unrestricted private automobile availability. Despite the contrary associations shown between overall and transport-related PA, the consistent relationships

shown between TPA engagement and private automobile availability indicate that the TPA tool has effectively detected non-motorised travel engagement for the population.

**Table 18:** Adjusted binary logistic regression models of TPA engagement for travelling to destinations as defined by private automobile availability

<i>Private automobile availability</i>	<i>Travel of place work/study</i>				<i>Travel to convenience shop</i>			
	<i>Motorised (%)<sup>^</sup></i>	<i>TPA (%)<sup>^</sup></i>	<i>Adjusted OR<sup>a</sup></i>	<i>95%CI</i>	<i>Motorised (%)<sup>^</sup></i>	<i>TPA (%)<sup>^</sup></i>	<i>Adjusted OR<sup>a</sup></i>	<i>95%CI</i>
Unrestricted	84	64	1.0	<i>referent</i>	85	69	1.0	<i>referent</i>
Frequent	12	21	2.1*	1.0-4.2	11	15	1.2	0.9-1.7
Limited	2	8	6.0*	2.0-17.4	2	7	4.1*	2.2-7.7
None	2	7	6.3*	1.9-21.2	2	10	9.8*	4.9-19.6

<sup>^</sup> Weighted according to 2001 census [125]

<sup>a</sup> Logistic regression model adjusted by gender, age, education, and annual household income

\* Significant relationship exists as 95%CI do not cross 1.0

## Discussion

Consistent with previous research [115, 142], this study identified that the majority of respondents (92%) in this adult population-level sample report high private automobile availability. Also concurring with prior research [131], socio-demographic variables, particularly household income, mediate this relationship. Although clear relationships between private automobile availability and socio-demographic characteristics were shown, an interesting relationship was revealed when private automobile availability and PA levels were analysed. Compared with respondents who had unrestricted private automobile availability, those who reported no private automobile availability were less likely to be classified as sufficiently active for health benefits. When compared with respondents who identified unrestricted private automobile availability, those that did not have a private automobile available were more likely to engage in TPA. Therefore, on the basis of these presented data, high private automobile availability increased the likelihood of accumulating sufficient levels of PA, as well as increasing the reliance on motorised transport modes for travelling to destinations.

A US study investigated levels of PA accumulation from walking to and from public transit (Besser & Dannenberg, 2005). A similar socio-demographic profile was revealed for those who used public transit as those who reported low/no private automobile availability in the present study. Furthermore, the study reported the median time spent walking to and from transit was 19 minutes, and the authors concluded that walking to and from transit was a useful contributor to achieving the recommended PA levels. Although the current study also reported higher levels of TPA engagement for individuals with restricted private automobile availability, the increased levels of activity accumulated through travel for this group was not reflected in overall PA level accumulation.

These unusual PA associations may potentially exist because of the self-report nature of the NZPAQ-SF. Other studies using objective PA measures (accelerometers) with school-aged children have shown opposite relationships to what we have reported; those who commuted to/from school using TPA modes also recorded the highest PA levels overall [132, 133, 144]. To our knowledge, objective monitoring tools to measure the relationship of TPA and

overall PA have not been applied to the adult population. Furthermore, LTPA may be the greatest contributor to overall PA engagement, and therefore TPA engagement could have a limited contribution to overall PA levels.

Unfortunately, because the NZPAQ-SF assessed PA levels for all purposes, contributions of LTPA and TPA engagement cannot be assessed independently. Access to facilities may also be a reason for the differences shown; those who have reduced automobile availability may be unable to drive to recreational facilities.

Another explanation for the PA differences shown when compared by private automobile availability may be linked to socio-economic differences. Literature indicates wealthier people consistently report higher LTPA engagement levels when compared with lower income groups [4], as well as being more likely to travel by automobile [131]. Also, lower socio-economic status groups watch more television in their discretionary time when compared with higher income groups [146]. Therefore, those with reduced car availability (low socio-economic respondents) in our sample may have less leisure-time available in the first instance because of increased time spent travelling, while also being more likely use their discretionary time to watch television rather than engaging in PA when compared with those with high car availability (higher income) respondents.

Much research exists regarding travel behaviour, particularly regarding the relationship between increased geographic mobility and reduced discretionary time [147]. Transport planners have understood that in order to maximise opportunities, individuals attempt to substitute money (i.e., more expensive modes of travel) for time and adjust travel patterns accordingly [148]. These adjustments include trip chaining, commute route selection, and activity sequencing. The present findings regarding automobile availability parallel other research demonstrating that travel time expenditure is strongly related to individual- and household-level characteristics and purpose at the destination [147]. Another travel concept is the space-time prism; the three variables assessed within this concept are the attractiveness of the travel mode, time taken to travel by different modalities, and the remaining time available for activity participation [149]. It is likely an individual will base their travel mode decision in part on these variables, and the space-time prism model may help to

explain the travel modality differences shown between travel to place of work/study and the convenience shop.

Despite the inherent limitations of the NZPAQ-SF and other self-report measures, we are confident that the TPA tool implemented in this research appropriately demonstrated construct validity, as expected associations existed between private automobile availability and TPA engagement. The TPA tool detected a logical association between TPA and private automobile availability; as the availability of a private automobile decreased the likelihood of TPA engagement increased regardless of destination selection. The relationship presented between TPA and private automobile availability is a plausible association, because in most instances a car would be purchased primarily for the purposes of travelling to frequently visited destinations (such as place of employment or local shops). Furthermore, our findings indicated modality differences when accessing place of work/study and the convenience shop; 7% used TPA modes to access place of employment, yet 30% of the sample walked or cycled to the convenience shop. Also, when compared with the referent groups, the likelihood of utilizing TPA modes to travel to the convenience shop when no private automobile was available was much higher when compared with accessing place of employment. A potential reason for this may be because of the varying distances associated with travelling to either location from place of residency [112]. In an effort to develop successful TPA initiatives, future research should seek to explicitly understand the relationship between destination distance and travel mode selection.

## **Chapter 8: Objectively Measured Commute Distance: Associations with Actual Travel Modes and Perceptions for Adults Travelling to an Occupation**

### **Preface**

Although automobile reliance is high in the adult population, TPA engagement is advocated by national and international health agencies as an appropriate modality for travelling short distances. The findings presented in Chapter 6 identified that engaging in TPA modes to access an occupation was associated with health benefits, and documented evidence in Chapters 4 and 7 identified future research areas, such as establishing the relationship between commute distance with actual and perceived TPA engagement. As shown throughout the previous studies, TPA contributions to overall PA could not be established by the AFES, therefore the following two studies focus on the relationship between the built environment and TPA specifically. Use of objective measures has been advocated in TPA research, and the present study uses GIS-derived measures to establish commute network distances for occupation-related travel. As such, the aim of this study is to examine the relationship between commute network distance, travel modality, and TPA perceptions in relation to accessing place of work/study in the AFES sample. Understanding optimal distances for TPA engagement to place of work/study is likely to be of value to urban and transport planners and public health agencies.

## Introduction

Motorised transport is now the dominant form of travel for the majority of developed countries [20], contributing in part to increased traffic congestion, air pollution, infrastructure costs, single vehicle occupancy rates, and diminishing community cohesion [34]. Simultaneously, population-level data indicate that physical inactivity is a major public health concern for many of these countries [3]. One potential solution to minimise problems associated with automobile reliance and physical inactivity is to promote TPA modes for travelling at least short distances. Recent research suggests up to 40% of current motorised journeys could potentially be replaced by TPA modes [94], and TPA engagement positively contributes to overall PA levels [74, 132, 133, 150]. Therefore, TPA engagement may provide a sustainable solution for reducing motorised transport use for short journeys, thus minimising environmental and logistical problems associated with automobile reliance, while simultaneously improving population-level PA levels. For these reasons the WHO advocates transport policies to promote walking and cycling for distances less than five kilometres [20].

As yet, there is little research examining TPA engagement at the population-level. Assessing travel behaviours associated with accessing place of work/study is a logical place to start building TPA evidence. In most developed countries, including NZ, the majority of adults are engaged in the workforce or higher education [125]. Therefore, a substantial and diverse population would be targeted with any intervention to increase occupation-related TPA engagement. One component that moderates TPA engagement for this population is the job-housing balance. The job-housing balance is viewed as the ratio between commercial and residential properties within an area. If there is limited mixed land use present, vehicle distance travelled is likely to increase as people have greater commute distances to access their place of work/study from their residence. Supporting this, Cervero [112] examined this relationship in 36 case study worksites in the largest suburban employment centres in the US. He concluded that 50% of work trips were made by TPA modalities when individuals resided within the same suburb as they worked. TPA engagement decreased to 5% when residents lived in different suburbs from their occupation [112]. Other research has shown individuals who engage



in TPA have a shorter self-reported mean network distance to their occupation than those who commute by automobile (0.2 miles versus 13.5 miles, respectively) [131]. In addition, single land uses and time spent in automobiles have been positively associated with obesity prevalence and likelihood of being physically inactive [94]. Even so, one trend in urban design has been to reduce the job-housing balance. Neighbourhoods are becoming increasingly segregated, as single land uses become prevalent, resulting in greater network distances between residential and place of work/study locales [82, 151].

Although commute distance plays a pivotal role in transport modal choice, the importance of perceptions should also be considered. A survey of Michigan adults (n=3,808) revealed 8% of respondents deemed it unacceptable to walk any distance for transport purposes under optimal conditions. The study revealed the most common barriers prohibiting walking short distances for transport were driving was quicker and automobiles were perceived as more convenient [55]. Similarly, an Australian study reported perception of travel time was the most common barrier to TPA/transit engagement to university for employees and students, followed by perceived destination distance [152]. Perceptions of travel mode engagement, however, appear to be fluid in nature and have been broadly associated with an individual's socio-demographic profile, personality, previous travel experiences, and travel attitude [153, 154].

As such, perceptions surrounding time travel to destinations and commute distance are likely key variables associated with TPA engagement. Despite these probable relationships, residential density and mixed land use have been the primary variables investigated with TPA engagement [151]. Comprehensive TPA associations with objectively measured commute distances to place of work/study have not been made. To date, the only body of research that used an objective measure of distance (GIS-derived) in a TPA study examined the relationships between distance to cycle trails and retail stores with TPA engagement [155]. This study builds on the work by Krizek and Johnson [155] by using GIS-measured commute distance, and self-report actual travel modes and TPA perceptions in relation to accessing place of work/study for an adult regional population-representative sample. It is important to understand the relationships between these variables in order to design and develop appropriate interventions for the majority of the adult population.

## **Methods**

### *Study Sample*

The AFES was implemented in a regionally-representative adult sample of North Shore City (Auckland, NZ) residents in April 2005 (autumn). Potential participants were drawn randomly without replacement from the North Shore City electronic telephone white pages and contacted through CATI procedures. Telephone calls were made 10:00am-8:30pm during a one-month period, and a five time call-back system was implemented. Within each household contacted, the English-speaking adult ( $\geq 16$  years of age) with the next birthday was asked to partake in the survey and sampling continued until 2,000 respondents were recruited (31% response rate) (Appendix H). Case weights were applied retrospectively to align the sample with 2001 census data based on gender and age distributions for the region [135]. Participants provided informed consent prior to participating in the AFES and the AUTC approved the study (AUTC 05/40) (Appendix I).

### *Questionnaire Design*

The AFES was an 88-item instrument that was based on a recent NZ adult population-level survey [136], while also including a chronic condition section [134] and a TPA component [135]. Amongst other things, the AFES assessed variables related to travelling to place of work/study. These specifics included: perceptions of TPA accessibility, travel mode selection, and participants' residential and place of work/study addresses. Apart from the TPA [135] and general PA [135] components, no reliability or validity testing has been conducted on the AFES. A full copy of the questionnaire is shown in Appendix J.

### *Travel Behaviour Measures*

The TPA engagement component of this study was drawn from the survey section that reported typical travel modes for commuting from residence to place of work/study. Respondents were asked: 'How do you usually get to

and from your place of work/study?’ These answers were collapsed into three travel mode categories: ‘motorised’, ‘TPA’, and, ‘transit/combined’.

### *Transport-related Physical Activity Perceptions*

Participants were asked to report whether they recognised they could engage in TPA modes to access their place of work/study from their residence by responding yes or no to the question: ‘Do you think that you could access your place of work/study by travelling on foot or cycling?’

### *Commute Distance Measures*

Commute distances between residence and place of work/study were calculated using ArcView Version 9.1 (ESRI, CA) GIS software. Participants’ residential and place of work/study addresses were obtained directly from respondents and spatially geocoded. If participants did not provide exact street number addresses, a street number was randomly allocated, defined by suburb or nearest cross street, for the residence or place of work/study. The shortest street network distance between each origin and destination was calculated in metres for every resident using the ArcView Network Analyst OD Cost Matrix function [156]. Distances were then collapsed into four kilometre (km) categories: <1.0 km, 1.0 km-1.9 km, 2.0 km-4.9 km, and  $\geq 5.0$  km.

### **Statistical Analysis**

Comparisons between groups in contingency tables were made using Pearson’s  $\chi^2$  test or Fisher’s exact test where appropriate. PP and exact associated CI were made based on the binomial assumption. Crude and adjusted RR estimates were made using binomial logistic regression analyses for the regional population-representative sample, and Homer-Lemeshow goodness-of-fit tests were performed on the regression residuals to check model adequacy. Statistical comparisons were made using SPSS version 11.5 (SPSS Inc. 2003) and Stata version 8.0 (StataCorp, 2004). A significance level of  $\alpha=0.05$  was implemented.

## Results

Before the sample of 2,000 respondents was fulfilled for the entire AFES, 6,476 eligible respondents were contacted and invited to participate (31% response rate). Of these, 772 respondents from the overall sample were eligible for the present analysis as they resided and engaged in an occupation within North Shore City. Participants for this study had to live and work/study within the North Shore region for two reasons: firstly, GIS data were only available within North Shore City; and secondly, the main travel route to Auckland City (i.e., the primary regional business district) was restricted to motorised transport.

### *Sample Characteristics*

Overall, motorised travel was the dominant mode of transport to access place of work/study (87%; n=673), followed by TPA engagement (10%; n=75), and transit/combined (3%; n=24) travel modalities. Apart from ascertaining overall prevalence rates, the transit/combined category was excluded from further analyses as the engagement rate was low and the contribution of TPA and motorised transport within the transit journey could not be ascertained. Table 19 outlines the overall profile for the respondents; 60% were women, the two most prominent age categories were under 30 (30%) and 51-70 (28%) years of age, 66% of the sample identified with NZ European ethnicity, 41% of respondents held a tertiary education qualification, and \$40,001-\$80,000 was the most common income bracket (39%). This is in comparison to 2001 census data for North Shore City [125] where: 52% were female; the average age was 36 years; 82% were NZ European, 7% were Maori, and 13% were of Asian descent; 38% of residents held a tertiary qualification; and, the median household income was \$40,001-\$70,000 per annum.

**Table 19:** Socio-demographic profile of those who currently access, and perceive they can access, their place of work/study by TPA engagement in the AFES sample

<i>Variable</i>	<i>Sample profile</i>	<i>Actual TPA engagement</i>		<i>Perceived TPA engagement</i>	
	<i>n<sup>^</sup>(%)<sup>^</sup></i>	<i>n<sup>^</sup>(%)<sup>^</sup></i>	<i>p-value<sup>2</sup></i>	<i>n<sup>^</sup>(%)<sup>^</sup></i>	<i>p-value<sup>3</sup></i>
<i>Gender</i>			0.08		<0.01
Male	306(40)	37(49)		173(45)	
Female	466(60)	38(51)		212(55)	
<i>Age (years)</i>			<0.001		0.26
16-30	210(30)	36(51)		118(34)	
31-50	155(22)	14(18)		74(21)	
51-70	194(28)	9(13)		95(27)	
>70	134(19)	12(17)		63(18)	
<i>Ethnicity</i>			0.18		0.19
NZ European	500(66)	53(71)		262(69)	
Maori	36(5)	5(7)		18(5)	
Pacific Island	12(2)	3(4)		8(2)	
Asian	72(10)	5(7)		28(7)	
Other	135(18)	9(12)		65(17)	
<i>Annual household income (NZ\$)</i>			<0.05		0.39
<20,000	59(9)	11(18)		30(9)	
20,000-40,000	106(16)	11(18)		45(14)	
40,001-80,000	259(39)	23(38)		126(38)	
80,001-120,000	161(24)	13(22)		85(26)	
>120,000	77(12)	2(3)		43(13)	
<i>Highest education qualification</i>			<0.001		0.35
No high school	84(11)	21(28)		47(12)	
High school	169(22)	20(27)		82(21)	
Trade, diploma, certificate	204(26)	8(11)		93(24)	
University degree or higher	315(41)	26(35)		163(42)	

<sup>^</sup> Weighted according to 2001 census [125]

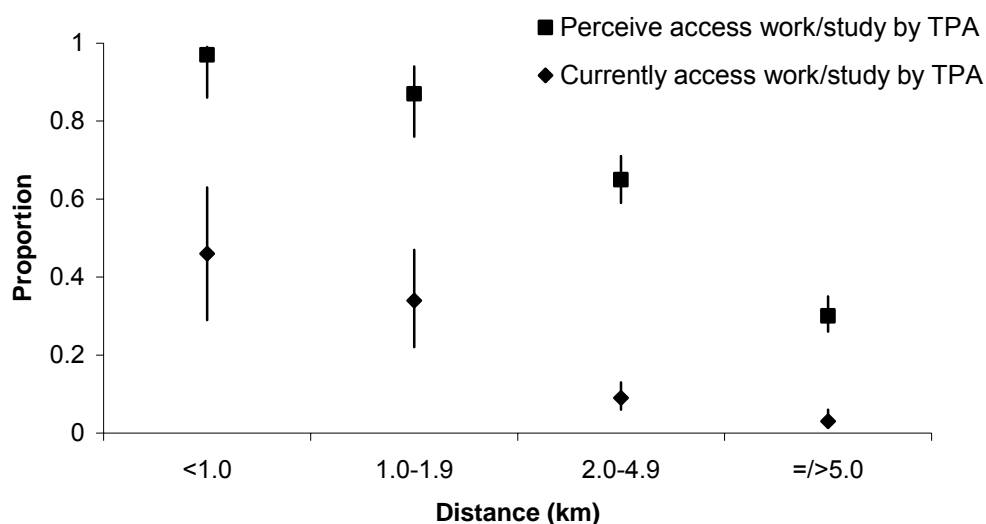
Data presented in Table 19 show a total of 75 people engaged in TPA to access their place of work/study, and 50% (n=385) of all respondents perceived they could travel to their occupation by TPA modes. Those aged 30 years and under were more likely to engage in TPA modes to commute to place of work/study, but did not demonstrate significantly different travel perceptions when compared with other age categories. Respondents with a trade, diploma, or certificate qualification were more likely to engage in motorised transport, but did not differ by perceptions, relative to other education classifications. When perceptions were examined, women were significantly more likely to recognise they could employ TPA modes for commuting to their occupation in comparison to men, however, gender differences were not evident when actual TPA

<sup>2</sup> The p-values presented were derived from comparisons of the actual travel mode (motorised versus TPA).

<sup>3</sup> The p-values presented were derived from comparisons of the perceived travel mode (could engage in TPA versus could not engage in TPA).

engagement was examined. Small sample sizes shown in some ethnicity and income brackets may have masked potential differences for actual and perceived TPA engagement.

#### *Commute Distance and Transport-related Physical Activity*



**Figure 4:** PP and 95%CI of actual, and perceived access to place of work/study by TPA engagement compared by commute distance in the AFES sample

Figure 4 outlines the relationship between place of work/study commute distance with actual TPA engagement and perceptions, represented as PP. Despite the directions being similar, perceptions of recognising using TPA modes to access place of work/study were more prevalent when compared with current TPA behaviour (97%, n=36 versus 46%, n=17), respectively, for distances less than or equal to one kilometre, decreasing to 30% (n=123) versus 4% (n=14), respectively, for distances five kilometres or greater. Although these differences existed, perceptions of, and actually using TPA modes, both showed declines as commute distance increased.

**Table 20:** Travel mode prevalence and logistic regression models of occupation-related TPA engagement defined by commute distance in the AFES sample

<i>Distance (km)</i>	<i>TPA travel</i>	<i>Motorised travel</i>	<i>Crude RR 95%CI</i>	<i>Adjusted RR<sup>a</sup> 95%CI</i>
	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>n<sup>^</sup> (%)<sup>^</sup></i>		
<1.0	17 (23)	18 (3)	1.0 <i>referent</i>	1.0 <i>referent</i>
1.0-1.9	21 (28)	37 (5)	0.6 0.3-1.4	0.4 0.1-1.3
2.0 – 4.9	23 (31)	230 (34)	0.1* 0.05-0.2	0.1* 0.03-0.3
≥5.0	14 (19)	388 (58)	0.04* 0.02-0.1	0.04* 0.01-0.1

\* Weighted according to 2001 census [125]

<sup>a</sup> Relative risk adjusted by gender, age, ethnicity, household income, and education

\* Significant relationship exists as 95%CI do not cross 1.0

Data in Table 20 further show commute distance and TPA engagement relationships, revealing the likelihood of an individual travelling to place of work/study by TPA modes decreasing as commute distance increases. When compared with respondents who resided within one kilometre of their occupation, the adjusted RR of a respondent using TPA modes to access their place of work/study progressively declined to 0.4 (1.0 km-1.9 km), 0.1 (2.0 km-4.9 km), and 0.04 (≥5.0 km). In the crude RR model, commute distance to place of work/study accounted for 17.9% of the variance in actual work travel mode observed for this sample of adults. When potential confounders were included into the model, the combination of variables explained 26.9% of the actual travel mode observed. The partial contribution associated with commute distance was 12.5%, indicating that distance to place of work/study was partially mediated by these covariates. There was no evidence to suspect the adjusted model failed to fit the observed data (Homer-Lemeshow goodness-of-fit test p-value=0.96), and no systematic differences occurred in actual travel mode distributions between respondents with complete (n=566) versus those with incomplete (n=182) covariate data (Fisher's exact test p-value=0.89).

It was assumed all respondents who reported engaging in TPA to access their occupation already perceived they could access it by TPA modes. As such, when perceptions of TPA engagement to access place of work/study were analysed as the dependent variable in the logistic regression models, only those who reported engaging in motorised travel were included (n=670) (Table 21). A strong association was observed between respondents perceiving they could employ TPA modes to access their occupation and commute distance ( $\chi^2=105.6$ , df=3, p-value<0.001). Furthermore, the adjusted regression analysis revealed that when compared with those residing within one kilometre of their

occupation, the likelihood of an individual perceiving they could use TPA modes to access their place of work/study decreased as commute distance increased (RR=0.4:1.0-1.9 km; RR=0.1:2.0-4.9 km; RR=0.04:≥5.0 km).

**Table 21:** Travel mode prevalence and logistic regression models of perceiving engaging in occupation-related TPA engagement defined by commute distance in the AFES sample

	<i>Perceived TPA engagement</i>			
	Yes	No		
<i>Distance (km)</i>	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>Crude RR</i>	<i>Adjusted RR<sup>a</sup></i>
			<i>95%CI</i>	<i>95%CI</i>
<1.0	17(6)	1(0)	1.0	1.0
1.0-1.9	29(10)	8(2)	0.2	0.4
2.0-4.9	137(48)	93(24)	0.1*	0.1*
>5.0	103(36)	285(74)	0.02*	0.04*

<sup>a</sup> Weighted according to 2001 census [125]

<sup>a</sup> Relative risk adjusted by gender, age, ethnicity, household income, and education

\* Significant relationship exists as 95%CI do not cross 1.0

The crude analysis in Table 21 explained 12.1% of the relationship between commute distance and perceptions of accessing place of work/study by TPA modes for participants who only engaged in motorised travel. Commute distance explained 10.2% of the variance in the adjusted RR model. There was no evidence to suspect the adjusted model failed to fit the observed data (Homer-Lemeshow goodness-of-fit test p-value=0.69). No systematic differences existed between distributions of TPA mode perceptions for respondents with complete (n=510) and incomplete (n=160) covariate profiles (Fisher's exact test p-value=0.20).

## Discussion

This study confirmed individuals who lived closer to their occupation were more likely to actually, and perceive they could, engage in TPA modes to access their place of work/study. Perception prevalence levels were substantially higher than current TPA engagement. Almost all respondents (97%) identified they could use TPA to access their place of work/study for distances one kilometre or less, however, less than half (46%) of this population currently employed TPA modes at this commute distance. Steady declines in TPA engagement and perceptions were also shown as commute distance increased. Despite the reduction in actual and perceived TPA engagement with



longer commute distances, when the five kilometre WHO TPA advocacy threshold [20] was applied to these findings, 47% of the adult working population commuted within this distance parameter, 68% of this group perceived they could use TPA modes to travel to their place of work/study, and 18% actually used TPA modes to commute. Based on the substantial support of recognition for TPA engagement at these shorter distances, TPA promotion for up to five kilometres appears to be a reasonable public health recommendation. Transport and public health agencies should continue to direct TPA campaigns at commute distances less than five kilometres.

This study confirmed proximity of residence and work/study location was related to an increased likelihood of recognising respondents could commute through TPA engagement. These findings concur with previous research that used an online survey with university staff and students (n=2,210) [152]. Shannon et al., [152] reported 30% of staff and students perceived they could replace their current motorised travel mode to university with TPA means, and a strong relationship existed between commute distance, time travel, and travel modality. Also in agreement with Plaut's [131] self-reported commute distance and travel modality findings, the present study illustrated people who resided close to their place of work/study were most likely to engage in TPA modes.

Although occupational travel behaviour was not examined, Krizek and Johnson [155] employed GIS techniques to measure distances from residence to local retail shops and bicycle trails in Minnesota, US (n=1,653). Similar to the present findings, proximal distances to these locations were also positively, significantly related to TPA engagement, with a non-linear relationship evident. The authors found for commute distance to have a significant effect on TPA engagement for travelling to retail stores or cycle trails, individuals had to live very close to their destination (<400 m for cyclists to access the cycle trail, <200 m for respondents to walk to the shops). These present data show a substantial portion of the NZ adult population engaged in TPA modes for commuting to place of work/study well beyond the distances reported by Krizek and Johnson [155].

The strong negative relationships evident between commute distance with actual, and perceived TPA engagement, support the importance of the job-housing balance. Infrastructure needs to minimise the network distances between residential and occupation locations. Cervero [112] modelled the

percentage of work trips undertaken by TPA modes in 36 case worksites within the US. Locations demonstrating a high degree of mixed land use also showed increased levels of TPA engagement. Indeed, 50% of work-related commute trips within the same suburb were conducted by TPA modes. This finding is analogous to these results, and likely reiterates the importance of mixed land use supporting short commute distances between residential and commercial locations.

The issue of neighbourhood self-selection based on work locality has previously been raised as a component of the job-housing balance [154, 157]. Initially the present findings lend themselves towards supporting the relationship that people who prefer to engage in TPA for commuting purposes live proximally to their occupation. When perceptions are taken into account, however, coupled with the low variance explained by the investigated relationships even after accounting for demographic differences, it appears other factors outside the scope of the study (e.g., personal factors, automobile availability, societal attitudes, physical environment) play substantial roles in influencing TPA engagement and neighbourhood selection. European researchers also identified TPA engagement was influenced by adequate social support (e.g., perceived benefits and barriers, self-efficacy, social factors), as well as built environment characteristics, explaining 4-12% of TPA engagement in Belgian and Portuguese adults (n=526) [158]. Furthermore, choice of transport modality is generally posited under the consumer choice theory and modal selection is based on available alternatives where the optimal mode will be employed to maximise benefits for the individual. Therefore, characteristics of the traveller and ancillary travel cost factors (e.g., time, money, convenience) are also important components of travel perceptions and attitudes, and ultimately, transport mode selection [153, 157].

Based on this transport modality framework, it was unsurprising perceived and actual TPA engagement were partially mediated by demographics. For example, younger people were more likely to engage in TPA modes. Aside from this group potentially having lower automobile ownership [131], younger people may also have substantial urban mobility [154] and better health status [1] when compared with older age groups. Other interesting travel variables and demographic associations were also shown. Respondents with a trade, diploma, or certificate qualification, relative to other education categories,

reported the least reliance on TPA modes for commuting to place of work/study. Potential reasons for this finding are that blue collar workers may be less likely to work in central business districts where car parking is limited, or may be more likely to work in heavy labour jobs when compared with white collar workers, and therefore less likely to choose to engage in TPA. Women were significantly more likely to perceive they could utilise TPA modes when compared with men, despite reporting similar levels of TPA engagement.

Although this study clearly showed the relationships between actual travel modes, perceptions of accessing place of work/study by TPA engagement, and commute distance, limitations were evident. Potential biases include: the study being restricted to households with telephone access (98.5% of the region), unlisted telephone numbers could not be contacted, and residents could only participate if they had a reasonable command of the English language. These may have affected the representativeness of the sample, however, when this group was compared with the regional demographics, similar prevalence levels were evident. Therefore it is asserted these findings adequately represented the wider North Shore region. Other study limitations were: the AFES response rate was relatively low, the design was a cross-sectional study of adults, only a relatively small sample size was examined, and perceptions and travel modalities were based on self-report. Importantly, measuring perceptions of TPA engagement is problematic; it is likely perceptions of TPA participation does not associate strongly with intent to engage in TPA modes. Nevertheless, the perception question served to provide a rudimentary indication of whether an individual recognised they could access their place of work/study through TPA means.

### *Conclusions*

Substantial divergences between travel behaviours and perceptions exist, and future TPA initiatives need to bridge the gap between perceptions and reality. Prospective work in this field should focus on shifting people's perceptions to actual behaviour change and develop appropriate infrastructure that supports reduced distances between place of work/study and residential localities. Place of work/study commute distances less than five kilometres showed considerable recognition of acceptability for TPA modes. Using an

objective tool (e.g., GIS) to examine commute distance and the regionally-representative adult sample added strength to the study's findings.

## **Chapter 9: Travel Behaviour and Objectively-measured Urban Design Associations for Adults Travelling to an Occupation**

### **Preface**

Evidence presented in Chapters 2 and 3 identified mixed land use, residential density, and street network connectivity as potentially important urban design variables for TPA engagement. Despite the increasing evidence base of the associations between these built environment aspects and TPA engagement, the lack of objective measurement and small sample sizes in many cases limit conclusions that could be drawn. This study seeks to overcome these limitations by employing GIS-derived measures of mixed land use, residential density, and street network connectivity to examine TPA behaviours for adults who commute to place of work/study in the AFES sample. The current study, however, cannot address the issues raised in Chapter 8, including neighbourhood self-selection, travel factors external to the urban design variables examined, or travel behaviour models and constraints. As revealed in Chapter 8, commute distance showed a negative association with TPA engagement and perceptions; therefore, the AFES sample used for this analysis was restricted to participants who commuted less than five kilometres to access their place of work/study. Understanding specifically how these macro-scale variables are associated with TPA engagement to place of work/study when commute distances are restricted may assist with developing future infrastructure that supports and promotes TPA behaviours.

## Introduction

TPA, such as walking or cycling for travel purposes, is now viewed as a potentially sustainable solution to reduce many public health and transport problems. Increases in TPA engagement may reduce traffic congestion, CO<sub>2</sub> emissions, and traffic infrastructure costs [95], while increasing overall PA levels [150] and enhancing perceptions of safety and aesthetics in neighbourhoods [33]. The increased development of low density, single land use, autocentric neighbourhoods, however, have reduced opportunities for TPA accumulation by increasing destination distances [29, 39, 83].

In an effort to improve population-level PA levels, the WHO advocates distances up to five kilometres as being acceptable and realistic for TPA engagement in adults [20]. However, strong, negative associations have been found between commute distance (to place of work/study) and actual or perceived TPA behaviours in NZ adults [159]. For example, when respondents lived less than two kilometres away from their place of work or study, 87% of participants perceived they could, and 34% actually did use TPA modes to travel to work. These figures dropped considerably to 30% and 3%, respectively, for commute distances of five kilometres or more. Consequently, people who live closer to their place of work or study are more likely to perceive they can, or actually engage in TPA for commuting purposes; as distance increases, TPA acceptability declines, particularly for distances greater than five kilometres.

Although commute distance plays an important role in the TPA decision-making process, other urban design variables that may affect TPA behaviours for adults at a neighbourhood scale have been identified. These are residential density, mixed land use, and street connectivity. Areas with higher population density and mixed land use may provide greater trip-end concentrations which minimise the necessity to travel outside the area [19]. Public transit and infrastructure may also be feasible [26], automobile ownership might be reduced [113], and there is likely to be localised traffic congestion [110]. Aligning residential and commercial properties proximally to one another will also probably increase the localised job-housing balance [18, 160], thereby shortening commute distances [161]. High street connectivity may minimise pedestrian commute distances and enhance perceptions of convenience by

providing more network connection points [39] and greater variation of road network availability [162]. Older neighbourhoods are more likely to have highly-grained grid networks with smaller property blocks, compared with newer developments that incorporate culs-de-sac and curvilinear networks [26].

The independent effect on TPA by these urban design variables, however, remains to be understood for the adult population that commutes less than five kilometres to access their occupation. One study has examined the influence of school commute distance and a variety of urban form features independently with student travel behaviour (n=374 households). Associations were shown between walking to and from school with commute distance, intersection density, and cul-de-sac density [163]. Although the paper identified interesting relationships, it is possible that urban design features have different TPA associations with diverse populations.

This study builds upon existing TPA and urban design evidence for adults by selecting participants from North Shore City, NZ. Similar to other non-European developed countries [115, 142], NZ is an autocentric nation; it reports the second highest car ownership rate per capita in the OECD [21] and only 21% of the adult population perceive they can replace automobile trips with TPA modes on at least two days per week [164]. Furthermore, objective measures (GIS) are incorporated to assess built environment characteristics and models the commute network for each respondent. These GIS-derived data are further employed to identify the independent relationships of residential density, mixed land use, and street connectivity with actual TPA engagement for commute distances less than five kilometres. It is critical to understand how these specific built environment characteristics are associated with TPA engagement in an automobile dominated country so future infrastructure developments can support and promote TPA behaviours through appropriate urban design.

## **Methods**

### *Study Sample*

The AFES was implemented in a representative adult sample of North Shore City (Auckland, NZ) residents in April 2005 (autumn). Potential participants were drawn randomly without replacement from the North Shore City electronic telephone white pages and contacted through CATI procedures.

Telephone calls were made between 10:00am and 8:30pm during a one-month period, and a five time call-back system was implemented. Within each household contacted, the English-speaking adult ( $\geq 16$  years of age) with the next birthday was asked to partake in the survey.

Overall, 6,476 eligible respondents were contacted and invited to participate in the AFES before the final sample of 2,000 respondents was recruited (31% response rate). From this sample, 364 respondents were eligible for the present analysis as they had complete travel behaviour information, travelled less than five kilometres from their residence to access their place of work or study, and resided and engaged in an occupation in the North Shore City region. The inclusion criterion of commuting less than five kilometres was to align with the WHO recommendations regarding commute distances appropriate for TPA engagement. The justification for respondents having to live and work in North Shore City was for two reasons; firstly, GIS data were only available within North Shore City; and secondly, the main travel route to Auckland City (the primary regional central business district) was restricted to motorised transport. Respondents provided informed consent prior to participating in the survey and the host institution ethics committee approved the study protocol (Auckland University of Technology Ethics Committee, 05/40).

#### *North Shore City Profile*

Coastal parts of North Shore City were initially settled in the early 1800's. From that time onwards North Shore City has become increasingly populated and developed. Currently the City encompasses 12,979 hectares of land, 140 km of coastline, and has approximately 212,000 residents. The topography is hilly and the climate is temperate. Urban design variables such as residential density, mixed land use, street connectivity, road design, aesthetics, and vegetation vary substantially across the region, however, the majority of streets have good quality sidewalks but no median strips. There are several main commercial settings in the region including industrial parks, universities, and a secondary central business district as identified in Figure 5, as well as smaller business communities existing in many suburbs (refer [www.northshorecity.govt.nz](http://www.northshorecity.govt.nz)).





**Figure 5:** Map of Auckland region (left) and North Shore City (right) with commercial planning zones, street networks and road hierarchy depicted

### *Questionnaire Design*

The AFES was an 88-item instrument based on a recent NZ adult population-level survey [136], and also included a TPA component [135]. Amongst other things, the AFES assessed variables related to travelling to place of work/study. These specifics included perceptions of TPA engagement, travel mode selection, and participants' residential and place of work/study addresses. Apart from the TPA [135] and general PA [145] components of the survey demonstrating appropriate test-retest reliability, no further testing has been conducted on the AFES. A copy of the complete questionnaire is available in Appendix J.

### *Travel Behaviour Measures*

#### Travel Mode and Perceptions

The travel mode component of this study was drawn from the survey section that reported typical transport modalities for commuting from residence to place of work or study. Respondents were asked: 'How do you usually get to and from your place of work or study?' These answers were collapsed into three travel mode categories: motorized, TPA, and transit/combined. Participants who did not engage in TPA modes to travel to their occupation were further asked to report whether they recognised they could engage in TPA modes to access their place of work/study from their residence by responding yes or no to the question: 'Do you think that you could access your place of work/study by travelling on foot or cycling?'

### *Urban Design Measures*

#### Commute Route

Commute distances between residence and place of work or study were calculated for all respondents using ArcView Version 9.1 (ESRI, CA) software. Participants' residential and place of work or study addresses were obtained directly from respondents and spatially geo-coded. If participants did not provide exact street number addresses, a street number was randomly allocated, defined by suburb or nearest cross street for their residence or place of work or

study. The shortest street network distance route between each origin and destination was calculated in kilometres for every participant using the Network Analyst OD Cost Matrix function. Respondents who travelled five kilometres or more from their residence to their place of work or study were excluded from this analysis. Distances were then collapsed into three categories: <1.0km, 1.0km-1.9km, and 2.0km-4.9km. The rationale for collapsing commute distances into these categories was that it was likely that different travel behaviours and perceptions would be revealed at these cut-points [159].

### Residential Density

Initially, a 200 metre buffer (100m either side from the road median) around an individual's commute network (as identified by the commute route) was created using ArcView software. Population density was ascertained by utilising mesh-block (geographic census units of approximately 100 households) data on the usually resident population from the New Zealand 2001 census [125]. The overall residential population density score of the commute route for each individual was estimated by identifying the mesh-blocks intersecting the 200m buffer zone of commute route for each respondent, and calculating a weighted average of the population density based on the area of each mesh-block contained within the buffer zone. The average population density along the commute route was then categorised into quartiles: 1) 132 - 1,649; 2) 1,650 - 2,195; 3) 2,196 - 2,491; and 4) 2,492 - 3,805 residents per km<sup>2</sup> along the commute route.

### Mixed Land Use

The mixed land use ratio was derived from dividing the residential parcel-level zone by the total commercial, educational, recreational, residential, and rural parcel-level zones (excluding road and sea) that were contained within the 200m buffered commute route for each participant [156]. Values closer to 100% indicated a higher portion of residential land use zoning along the commute route. Percentage of residential land use was categorised into quartiles: 1) 5% - 63%; 2) 64% - 76%; 3) 77% - 87%; and 4) 88% - 100%.

### Street Connectivity

Street connectivity was measured by calculating the connected node ratio [156]. This ratio was derived through dividing the number of street intersection nodes by the number of intersection and cul-de-sac nodes contained within a 500m buffer zone (250m either side of the road median) of a respondent's commute route [156]. A larger buffer zone was selected for street connectivity to capture adequate road network variability. Values closer to 100% indicated higher street network connectivity along the commute route. Street connectivity was categorized into quartiles: 1) 50%-65%; 2) 66%-70%; 3) 71%-75%; and 4) 76%-97%.

### **Statistical Analysis**

The three urban design components were separated into quartiles to ensure even distribution of data, thus strengthening potential binary logistic regression findings, and also to provide utility to urban design recommendations. Comparisons between groups in contingency tables were made using Pearson's  $\chi^2$  test. Crude and adjusted (controlling for socio-demographic variables and requiring an automobile for work/study purposes) OR were derived using binary logistic regression analyses for comparing those actually and perceiving engaging in TPA (dependent variable) versus those indicating no recognition of TPA engagement along the commute route with the three independent urban design variables (residential density, mixed land use, and street connectivity). Statistical comparisons were made using SPSS version 14.0. A significance level of  $\alpha=0.05$  was used to define statistical significances.

### **Results**

Overall, the sample (n=364) was 60% female; the modal age category was under 30 years (36%); 66% were European, 9% Asian, and 5% were of Maori descent; 37% of respondents held a tertiary qualification; and the median household income was NZ\$40,001-NZ\$80,000 (Table 22). This was in comparison to North Shore City census data [125] where 52% were female; the average age was 36 years; 82% were European, 13% were Asian, and 7%

were of Maori descent; 38% of residents held a tertiary qualification; and median household income was between NZ\$40,001-NZ\$70,000 per annum.

Respondents were further separated into three categories; those who actually engaged in TPA travel (17%; n=61), individuals who perceived they could engage in TPA travel but did not (55%; n=200), and respondents who did not recognise they could utilize TPA travel modes to access their occupation (28%; n=103) (Table 22). There were significant differences across these groups for age (p-value<0.05), education (p-value<0.05), and requiring an automobile for work purposes (p-value<0.05). When compared with other age categories, those aged less than 30 years were more likely to engage in TPA modes to commute to place of work/study. Respondents who did not have a high school qualification were most likely to actually engage in TPA modes, but were least likely to perceive they could use TPA modes when compared with other education categories. Further analysis with age and education attainment revealed those who were <30 years of age or did not hold a high school qualification were more likely to not hold a driver's license (<30 years: 18% versus 4% for the rest of the sample; no high school: 13% versus 7% for the rest of the sample) and reported reduced automobile access (<30 years: 18% versus 4% for the rest of the sample; no high school: 14% versus 5% for the rest of the sample). Based on these findings and previous research [131], we suggest that restricted automobile accessibility likely increases TPA engagement. Small sample sizes shown in some ethnicity categories may have masked potential differences for the different travel variable categories. Nearly half of the sample identified that they required an automobile to fulfill their employment obligations during the course of a working day. Differences, however, were shown by TPA engagement; those who walked or cycled to their occupation were less likely to report requiring an automobile during their employment.

**Table 22:** Demographic profile of adults who currently access, perceive they can access, and do not access their place of work/study by TPA engagement for commute distances less than five kilometres

	<i>Sample profile</i>	<i>Actual TPA engagement</i>	<i>Perceived TPA engagement</i>	<i>Do not engage in/perceive TPA</i>	
	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>n<sup>^</sup> (%)<sup>^</sup></i>	<i>p-value</i>
<i>Gender</i>					0.08
Male	147(40)	29(20)	83(57)	35(24)	
Female	217(60)	32(15)	117(54)	68(31)	
<i>Age (years)</i>					<0.05
<30	113(36)	30(27)	59(52)	24(28)	
31-50	65(20)	12(19)	32(49)	21(25)	
51-70	82(26)	7(9)	49(60)	26(34)	
>70	58(18)	9(16)	31(53)	18(27)	
<i>Ethnicity</i>					0.12
NZ European	237(66)	43(18)	132(56)	62(26)	
Maori	18(5)	5(28)	9(50)	4(22)	
Pacific Island	8(2)	1(13)	5(63)	2(25)	
Asian	31(9)	3(10)	17(55)	11(35)	
Other	64(18)	9(14)	34(53)	21(33)	
<i>Education</i>					<0.05
No high school	51(14)	18(35)	19(37)	14(28)	
High school	76(21)	16(21)	41(54)	19(25)	
Trade, diploma or certificate	101(28)	8(8)	59(58)	34(34)	
University degree or higher	136(37)	19(14)	81(60)	36(27)	
<i>Annual household income (NZ\$)</i>					0.21
<20,000	31(10)	7(33)	16(52)	8(26)	
20,000-40,000	44(15)	9(21)	25(57)	10(23)	
40,001-80,000	114(38)	18(16)	58(51)	38(33)	
80,001-120,000	76(25)	10(13)	46(61)	20(26)	
>120,000	35(12)	2(6)	24(69)	9(26)	
<i>Require automobile for work/study purposes</i>					<0.05
Yes	141(43)	12(9)	85(60)	44(31)	
No	188(57)	37(20)	101(54)	50(27)	

<sup>^</sup>Weighted according to 2001 census [125]

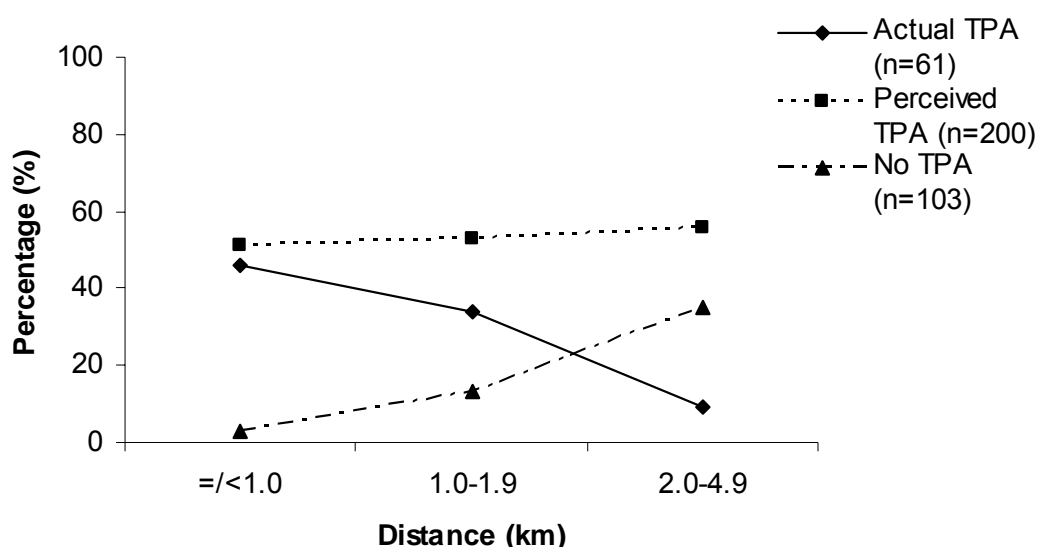
Data presented in Table 23 show the variability of the three urban design variables examined in comparison to the median North Shore City values. The lower median mixed land use and residential density values shown for North Shore City were likely shown because the majority of non-residential properties throughout the region encompassed larger land tracts (e.g., rural and recreational zoned parcels) and the road segments shown in more residential areas tended to be shorter, therefore the buffers were more likely to overlap.

**Table 23:** Descriptive profile of the variability the urban design variables by the three buffered commute distance categories

<i>Urban design variable</i>	<i>Survey transport routes</i>			<i>All North Shore City road segments</i>		
	<i>Median</i>	<i>Range</i>	<i>25%-75% range</i>	<i>Median</i>	<i>Range</i>	<i>25%-75% range</i>
<i>Residential density (# of residents/km<sup>2</sup>)</i>	2,196	132-3,805	1,650-2,492	2,550	0-6,204	1,657-3,109
<i>Mixed land use (% of land zoned as residential)</i>	77%	5%-100%	64%-88%	92%	0%-100%	68%-99%
<i>Street connectivity (connected node ratio)</i>	71%	50%-97%	66%-76%	71%	0-100%	60%-82%



After examining socio-demographic variations, the three TPA groups were compared by commute distance (Figure 6). As commute distance increased, actual TPA engagement decreased substantially, and prevalence of no TPA recognition increased. At distances between two and five kilometres, 56% of respondents perceived that they could access their place of occupation by TPA modes, yet only 9% of the sample employed TPA modes for that distance category.



**Figure 6:** Travel behaviours compared by commute distance categories

**Table 24:** Descriptive profile of the variability the urban design variables by the three buffered commute distance categories

Urban design variable	Commute distance (km)			p-value
	≤1.0 (%) <sup>^</sup>	1.0-1.9 (%) <sup>^</sup>	2.0-4.9 (%) <sup>^</sup>	
<i>Residential density (# of residents)</i>				0.06
132-1,649	27	13	27	
1,650-2,195	24	19	27	
2,196-2,491	22	27	24	
2,492-3,805	27	40	22	
<i>Mixed land use (quartiles)</i>				0.05
5%-63%	28	15	26	
64%-76%	31	16	26	
77%-87%	17	31	26	
88%-100%	25	39	22	
<i>Street connectivity (quartiles)</i>				<0.01
50%-65%	19	15	22	
66%-70%	11	27	30	
71%-75%	11	28	23	
76%-97%	58	31	25	

<sup>^</sup> Weighted according to 2001 census [125]

Those who commuted 1-2 kilometres were significantly more likely to travel through higher mixed land use environments (Quartiles 3 and 4). Also respondents who commuted less than one kilometre to their occupation were significantly more likely to travel through the most connected street networks. No differences were shown between residential density and commute distances (Table 24).

Logistic regression models were used to further understand the associations between the urban variables along the commute route with the odds of a respondent actually and perceiving they could engage in TPA to access their place of work/study in comparison to respondents who reported no TPA recognition. Crude and adjusted odds are presented in Table 25. Significant relationships were identified with actual TPA engagement and respondents travelling along the most connected (Quartile 4; 76%-97%) and limited connected (Quartile 2; 66%-70%) street networks when compared with those travelling through the least connected road networks.

In order to understand the independent effect of how each built environment variable was associated with TPA engagement and perceptions, the models were adjusted by socio-demographics and requiring an automobile throughout the work day as covariates. Findings showed that those who had the highest street connectivity along their commute network were approximately seven times as likely to actually engage in TPA to access their place of work or study when compared with respondents who travelled along the least connected routes. Those who had limited connectivity (Quartile 2) were approximately 90% less likely to engage in TPA modes to access their occupation when compared with those with the least connectivity (referent category). A potential reason for these conflicting relationships is because of street connectivity variability requirements. In other words, a certain street connectivity ratio threshold may need to be achieved before TPA engagement becomes feasible for the adult population. Interestingly, no other significant relationships were identified in the actual TPA engagement and perceived TPA engagement models. A small, but significant correlation (Spearman  $\chi^2 = 0.16$ ,  $p\text{-value} \leq 0.01$ ) was shown between population density and street connectivity, and a moderate correlation (Spearman  $\chi^2 = 0.37$ ,  $p\text{-value} \leq 0.001$ ) existed for population density and mixed land use. No association was shown between street connectivity and mixed land use. The magnitudes of the significantly

associated correlations, however, indicated these three variables largely measured different aspects of the built environment.

**Table 25:** TPA prevalence and logistic regression models of actual and perceived TPA engagement versus no TPA engagement defined by urban design variables for those who live less than five kilometres away from their place of work/study

	Actual TPA engagement	Perceived TPA engagement	No TPA engagement	Likelihood of actually engaging in TPA		Likelihood of perceiving engaging in TPA	
	<i>n</i> ^ (%) ^	<i>n</i> ^ (%) ^	<i>n</i> ^ (%) ^	Crude OR	Adjusted OR <sup>a</sup> (95%CI)	Crude OR(95%CI)	Adjusted OR <sup>a</sup> (95%CI)
<i>Residential density (# of residents)</i>							
132-1,649	13(21)	48(24)	29 (28)	1.10.6-2.1	1.40.7-2.9	1.0referent	1.0referent
1,650-2,195	11(18)	56(28)	25 (24)	1.10.6-2.0	1.30.6-3.0	1.10.6-2.1	1.40.7-2.9
2,196-2,491	19(31)	48(24)	22 (21)	0.80.4-1.4	0.60.3-1.2	1.10.6-2.0	1.30.6-3.0
2,492-3,805	18(30)	48(24)	27 (26)	1.00.5-2.2	0.80.2-2.5	0.80.4-1.4	0.60.3-1.2
<i>Mixed land use (quartiles)</i>							
5%-63%	13(20)	45(23)	32(31)	0.80.3-1.7	1.60.5-5.0	0.70.4-1.3	0.50.3-1.1
64%-76%	12(20)	54(27)	23(22)	1.20.5-2.9	1.30.4-4.8	1.60.9-2.8	1.90.9-4.0
77%-87%	14(23)	48(24)	30(29)	1.10.5-2.4	0.50.1-1.7	0.90.5-1.6	1.00.5-2.1
88%-100%	22(37)	52(26)	18(18)	1.0referent	1.0referent	1.0referent	1.0referent
<i>Street connectivity (quartiles)</i>							
50%-65%	6(10)	45(23)	23(23)	1.0referent	1.0referent	1.0referent	1.0referent
66%-70%	12(20)	51(34)	35(34)	0.4*(0.2-0.8)	0.1*(0.0-0.5)	0.60.4-1.1	0.60.3-1.2
71%-75%	13(20)	48(22)	22(22)	0.7(0.3-1.7)	0.8(0.2-2.8)	1.20.7-2.2	1.10.5-2.3
76%-97%	30(50)	54(22)	22(22)	3.2*(1.6-6.7)	6.9*(2.2-21.9)	1.40.8-2.6	1.80.8-3.8

\* Weighted according to 2001 census [125]

<sup>a</sup> Logistic regression model adjusted by gender, age, ethnicity, education, annual household income, and requiring an automobile for work or study purposes

\* Significant relationship exists as 95%CI do not cross 1.0

## Discussion

Overall, 72% of the sample actually did, or recognised they could engage in TPA modes to access their occupation for commute distances less than five kilometres. We acknowledge that perceptions are markedly different than actual behaviour; however, these findings show that TPA behaviours have a reasonable level of acceptance for travelling short distances in the NZ adult population. Future work in this field should concentrate on developing initiatives that target those who perceive they can engage in TPA modes. As well as showing prevalence levels, this study contributes to the transport, urban design, and health literature by understanding the objectively measured effects of specific built environment characteristics on TPA behaviours and perceptions.

Consistent with previous research [159], strong associations between TPA behaviours and perceptions with commute distance were evident. Respondents who lived closer to their place of employment were most likely to actually engage in TPA for commuting purposes. As commute distance increased, respondents were less likely to recognise that they could, or actually employ TPA modes to access their occupation. Furthermore, substantial differences existed between actual and perceived TPA engagement for commute distances longer than one kilometre, and commute distances less than five kilometres were perceived as being acceptable for TPA engagement for the majority of this population.

Those who engaged in TPA were more likely to commute by walking and cycling if the modelled route was through a well-connected street network. The regression analysis identified that people who commuted through the most connected street networks, when compared with respondents travelling along the least connected street networks, were approximately seven times more likely to actually engage in TPA modes to access their place of work or study. Those who travelled through the second least connected environments were less likely to engage in TPA. It is likely this result was an anomaly that arose through an inflated Type II error, as the sample size in this category was very small. No relationships were identified between perceived TPA engagement and street connectivity. Although the relationship was not as strong as our findings, Moudon et al., [105] examined 12 neighbourhood settings in Washington, US, and identified that approximately three times as much overall

PA occurred in urban neighbourhood settings compared with more recent suburban neighbourhoods because of reduced network connectivity within suburban neighbourhoods. Schlossberg et al., [163] also identified positive associations between high street connectivity (low cul-de-sac density, high intersection density) with increased levels of walking for commuting purposes. The data, drawn from four US schools, showed no other significant relationships with urban variables (route directness, major arterial road on school route) and children walking or cycling to or from school. To our knowledge, the present research is the first study that has assessed the independent effect of objectively measured street connectivity on TPA behaviours and perceptions along a commute route for an adult population. Our findings show that commuting through a highly connected street network is positively associated with TPA engagement to an occupation, and urban design policy should seek to develop well connected street networks within the built environments.

Although residing in areas with high mixed land use has been positively correlated with walking for errands [38, 161], our findings identified no associations with respondents living in more diverse settings engaging in or perceiving TPA modes to access their place of work/study. A potential reason for the lack of association is that this study focused on commuting behaviour specifically related to travelling to place of work or study, whereas Kockelman [161] and Leslie et al., [38] examined travel behaviours associated with accessing the local shops. As such, it is possible that different travel behaviours are associated with accessing diverse destinations, and this relationship has been supported in a recent study by Cervero and Duncan [160]. Differing land use mix assessment methods may have also influenced the relationships. Leslie et al., [38] derived land use mix scores from similar zoning classifications to those used in the present study, however, the land use mix scale was based on decile scores assigned to each neighbourhood based on an established neighbourhood walkability index [94], rather than values assigned to each participant. Kockelman's [161] land use entropy index was based on a 0.8 kilometre radius from the commuters' home, whereas commute range in this study extended up to five kilometres.

Similar to our findings, Kockelman [161] identified that the association of residential density to TPA behaviours for adults was minimal when other urban design characteristics were accounted for. The effect of density, however, may

be relative to the population studied. A study examined neighbourhood design with school-related travel (n=34 schools) [165] and demonstrated that higher residential density around the school (0.5 mile radius) was positively associated with children walking and cycling to school ( $p\text{-value} < 0.001$ ). The authors concluded that residential density was an indicator of the number of students who lived proximally to school. In our findings, however, 73% of adults in our sample travelled between two and five kilometres to access their occupation from their residence, therefore examining the immediate environment around places of employment would be largely irrelevant for this population. To further extend upon TPA behaviour and perception differences shown in differing populations, socio-demographic variations were identified in our sample. Those who were younger or less educated were more likely to actually engage in TPA modes to access their place of work/study. These relationships have been supported in previous research [131, 164].

It was surprising the investigated urban variables were not more strongly related to TPA behaviours and perceptions, as earlier research supports these relationships. Potential reasons for these discrepancies are that we only examined a modelled commute route, rather than identifying exactly where the individual travelled; we did not seek to capture perceptions of the investigated variables, instead we took only objective GIS measures; and, only travel related to accessing place of work or study was examined. As such, different urban design characteristics may support travel for diverse purposes or populations, and other variables not investigated may have a stronger impact on travel behaviour and perceptions. This is likely the case for respondents perceiving they could engage in TPA modes, as no significant relationships were identified between the investigated urban design variables and TPA perceptions. A further limitation of the study was that a high number of respondents required an automobile throughout the working day, yet, the purpose of automobile use was not examined. People may require motorized transport for trip chaining purposes, such as transporting children or shopping, as well as mobility throughout the day, and future research needs to understand these associations in order to develop effective interventions. Low variability of mixed land use and residential density may have also existed in our sample, and a threshold effect of the urban design variables may exist before TPA engagement becomes practicable. Consistency in the scales applied and

methodology used are also needed to make accurate comparisons between studies.

The urban design features were looked at in isolation within this study, rather than a composite measure. Although useful to look at the individual contribution of urban form features, such analyses may underestimate the relationships between the built environment and TPA. Previous research conducted by Ewing et al., [39] used a composite measure of urban sprawl to examine health outcomes. Negative associations existed for minutes walked for all purposes, and positive associations existed for hypertension and obesity with urban sprawl. Based on the presented findings and previous studies, it is clear that travel behaviour is a complex phenomenon with a variety of factors aside from urban design influencing travel modes and perceptions.

### *Conclusions*

The strengths of this study include the use of GIS measures to objectively assess the urban environment, the modelling of a likely commute path that a respondent took, the population-representative adult sample used, and the confined commute route distance of less than five kilometres. We are confident that these aspects of the research provide an accurate depiction of the associations between travel behaviours and perceptions with the urban environment for adults accessing an occupation. As such, our findings clearly showed that commute distance, even at shorter distances, has an influence on TPA behaviours related to accessing place of work or study, and street network connectivity affects TPA engagement. Future applications of these findings may include developing appropriate policy and infrastructure that supports TPA travel modes to place of work or study, such as improved street network connectivity and job-housing balance regulations in an attempt to minimise commute distances.



## **Chapter 10: Implications**

### **Thesis Conclusions**

At the initiation of this thesis, understanding associations between urban design variables and PA engagement was an emerging field of research. As such, the overarching aim of this thesis was to develop the public health knowledge base within this area by investigating the associations between overall PA and TPA engagement and perceptions, health outcomes, urban design, travel mode engagement, and socio-demographic variables. Initially, two literature reviews (Chapters 2 and 3) were rigorously constructed to identify and evaluate existing research drawn from urban planning, transport, and health literature, relative to PA engagement (both overall and transport-specific). These reviews served to update the evidence in this field, while also framing the context of the studies within the thesis.

After reviewing existing evidence, it was evident no large-scale research in this area had been conducted with NZ adults. To overcome this paucity of research, various urban design, travel, and PA associations were extracted from the OTA study and used to specifically examine the relationship between perceived replacement of automobile journeys with TPA modes (Chapter 4). The study (Chapter 4) focused on TPA perceptions, revealing approximately 20% of the population recognised they could replace automobile journeys on two days a week with TPA modes, and overall PA engagement and perceptions of TPA engagement (particularly walking) were positively associated with replacing automobile journeys with TPA modes. A strong socio-demographic variable effect was also shown; those who reported higher household income were less likely to recognise they could replace automobile journeys with TPA travel. The strengths of this study were that data were drawn from a population-representative sample of NZ adults and large sample sizes were employed in the research. As such, this robust analyses provided the first national evidence of relationships between urban design and PA contexts for adults, thereby potentially providing much utility for local government planning.

Although the study in Chapter 4 identified several research priority areas related to TPA engagement, these topics could not be investigated further with

the OTA dataset, as overall PA was not separated from TPA engagement within the survey. Furthermore, no survey tool existed internationally that specifically assessed TPA-specific behaviours, attitudes, and barriers. Therefore, in order to get more detailed TPA perspectives, a reliable measurement tool had to be developed in the first instance (Chapter 5). The tool was developed based on relationships identified in existing research as well as being specifically informed by the literature reviews presented in Chapters 2 and 3. After establishing acceptable test-retest reliability for the majority of the items in the AFES-TPA with a small sample of adults, the survey tool was then incorporated into a larger survey (AFES) and implemented in a regionally-representative sample of adults. Combining the AFES-TPA with the broader AFES, allowed key TPA research questions to be investigated, and data for the subsequent four chapters were drawn from the AFES.

Previous research identified clear relationships between health outcomes and TPA engagement in diverse populations. It was unknown, however, whether travel to place of work/study and the convenience shop conferred the same health benefits. The study in Chapter 6 examined these associations revealing: firstly, TPA engagement was low in the AFES sample, particularly for commuting to place of employment; and secondly, TPA engagement to an occupation was associated with increased PA engagement and decreased body mass benefits. Interestingly, health benefits were not shown for respondents commuting to the convenience shop by TPA modes. It is envisaged that identifying these relationships between health outcomes and TPA engagement will prioritise settings, such as worksites, as potential intervention sites.

After establishing motorised transport was the dominant travel mode for the AFES sample, associations between automobile availability and TPA engagement were investigated further (Chapter 7). The study built upon the general associations between automobile journey replacement and TPA perceptions shown in Chapter 4 by specifically examining the relationships between private automobile availability, socio-demographic variables, overall PA, and TPA engagement. Similar to other research [131], those reporting no automobile availability were more likely to be female, younger, less educated, and earning less. Prior to the study, however, little was known about the relationships between PA and automobile availability, and the findings revealed

those reporting no automobile available were more likely to engage in TPA modes to access their place of work/study and the convenience shop, yet less likely to be sufficiently active for health benefits in comparison to respondents reporting high automobile availability. These findings seemed somewhat paradoxical, and the reliance on self-report measures of overall (NZPAQ-SF) and transport-specific (AFES-TPA) PA tools potentially did not adequately capture these behaviours as the measures may not have been sensitive enough to detect daily PA accumulation within different contexts. Differing TPA prevalence rates were also identified when travel modes to both destinations were compared. This may have existed because of commute distance variations between the two destinations.

As a consequence, the following study (Chapter 8) sought to investigate the relationship between occupation-related commute distance and actual and perceived travel modalities. TPA travel to place of work/study was targeted because it was associated with health outcome benefits (Chapter 6), and therefore increasing the number of people engaging in occupation-related TPA travel would likely have high public health utility. Previous research surveyed respondents regarding appropriate distances for generic TPA engagement [55], yet no study had combined objectively derived commute distances, actual travel modality, and TPA perceptions to place of work/study. The data showed there was a strong distance effect with TPA engagement, and to a lesser extent perceptions. It was shown the WHO recommendation of adults engaging in TPA modes for distances less than five kilometres was well supported in principle, if not in practise, by this population. Based on these results, commute distances of five kilometres should be considered appropriate for TPA engagement for this population and local government ought to examine land use residential and commercial zoning regulations to maximise the job-housing balance.

The final study of the thesis (Chapter 9) sought to examine how other macro-scale urban design variables (i.e., mixed land use, residential density, street network connectivity) were associated with TPA engagement. These three variables were documented in previous research as being associated with TPA engagement, but prior to this study, have not been objectively assessed and compared independently with occupation-related travel behaviour. Findings in Chapter 8 established commute distance was strongly associated with TPA

engagement; therefore those who travelled more than five kilometres to access their place of work/study were excluded from the study. The findings presented in Chapter 9 showed mixed land use and residential density were not associated with occupation-related TPA engagement, however, high street network connectivity was positively related with walking and cycling to place of work/study.

As such, this body of work has substantially contributed to this field by examining the relationships between overall PA and TPA engagement and perceptions with urban design elements in adults. Similar to other international data [36, 115], TPA engagement was low in the NZ adult population, particularly for commuting to place of employment. Although this was the case, a substantial portion of adults recognised they could reduce their automobile reliance for travelling short journeys, and a large population segment perceived they could commute to their place of work/study using TPA modes for distances less than five kilometres. Targeting adults who recognise they can engage in TPA modes to access their place of work/study, and shifting their perceptions to actual behaviour change, will likely result in promising population health gains. Future TPA initiatives with adults should also focus on promoting walking for transport, as this behaviour was well supported as a potential TPA mode.

## **Methodological Issues**

Although the aforementioned findings helped to develop the evidence by understanding the associations between urban design and PA, future research needs to address the methodological issues raised in the thesis regarding accurate assessment of TPA engagement. The development of the AFES-TPA was useful for providing the first reliable TPA-specific measurement instrument. Although this tool substantially contributed to understanding TPA behaviours and perceptions, findings from Chapter 6 identified inconsistencies between overall PA (NZPAQ-SF-derived) and TPA (AFES-TPA-derived) engagement. It was purported some TPA engagement, especially to the convenience shop, may have remained uncaptured because of biases associated with self-report methodology, such as under-reporting in the AFES-TPA. It is critical TPA behaviours can be accurately assessed before interventions are developed. Objective measurement tools, such as accelerometers, will likely assist with

accurate TPA measurement, and global positioning systems (GPS) may also provide a novel approach for assessing household travel [166]. Although potentially burdensome for the participant, a combined approach of objective (e.g., accelerometers, GPS) and subjective (e.g., AFES-TPA, travel diaries) measurement tools will most likely provide the greatest accuracy for assessing TPA behaviours.

Measuring the built environment also needs further consideration. Understanding the underpinning conceptual paradigms, such as what constitutes a 'neighbourhood', how this definition may differ between individuals, the contexts where people travel through, and neighbourhood self-selection contributory factors are needed. Neighbourhood self-selection aspects are currently being investigated through the Australian-based RESIDential Environments (RESIDE) study and the US-based SMARTRAQ research [167], and it is likely a better understanding of these relationships will be revealed in the future. As alluded to in Chapter 9, adequate variability within the built environment is needed to detect relationships. An understanding of the impact of the roles of perceptions versus actual urban design infrastructure on PA engagement and attitudes are also needed.

Although there are objective (e.g., GIS) and subjective (e.g., NEWS, SPACES) environment measurement tools readily available, it is likely a more thorough understanding of urban design and PA relationships will come from consistent application of these instruments. A US-based research group [156] is seeking to fill this void by developing a GIS manual with common protocols and step-by-step coding instructions to assess a multitude of built environment features. Some of these procedures were used in this thesis (Chapters 8 and 9).

More complex models and analyses will also assist with enhancing the understanding of the relationships between PA engagement and urban design variables. Multi-level modelling is appropriate for understanding these associations as they allow for multiple-tiered models, using time, the individual, and the neighbourhood as levels of analyses [168]. These models are beginning to be incorporated into built environment and PA research [169]. Using these techniques allows for analyses that can account for individuals moving through different neighbourhood contexts for diverse purposes (e.g., work, shopping, recreation), by allowing weighting factors to be integrated into

the model based on time spent within each domain. Although complex, these approaches will provide a more accurate depiction of how an individual interacts with their built environment. As the understanding and application of multi-level modelling improves, it is likely these techniques will become commonplace in this field of research. Despite the strengths of multi-level modelling, this approach was not used in this thesis, as other statistical approaches were sufficient to answer the research objectives.

### **Role of Local and Central Government**

During the three-year duration of this thesis, the area of urban design and PA research has grown immensely. Governing bodies and academics are beginning to realise the impact and potential of the environment on human behaviour, and are seeking to design and develop environments where people can accumulate PA and gain health benefits, while limiting automobile use. As discussed in the review chapters, it is increasingly being recognised that public health, transport, and urban planning disciplines need to collaborate when designing environments. One potential reason why there is increased attention in this field is because of the indiscriminate nature of the built environment. Any infrastructure changes or developments will likely affect each individual who travels through or utilises that particular setting. This is largely why urban design interventions appear promising from a public health perspective: initiatives are generally simple, environmental changes are long-lasting, there is a high likelihood of behaviour change, and the audience may remain oblivious to the intervention.

Furthermore, the considerable cost and permanence of urban design features should, in theory, lead to all user groups being considered when developing or retrofitting infrastructure in order to maximise usage. Although this would be the ideal process, many local governments have not been provided with robust research that supports specific environmental design for PA engagement. The consequences of this shortfall have resulted in many residential and commercial settings being developed in an ad hoc manner, with little thought for PA accumulation and health outcomes. It is anticipated the present research will assist in bridging this gap by providing relevant evidence

to local government to assist with decision-making and legislative processes that support PA engagement.

Other potential driving forces for promoting TPA engagement come from three major global concerns, being climate change, peak oil, and obesity [20]. Although it would be naïve to assume providing appropriate environments for TPA engagement will completely resolve these issues, TPA engagement can reduce the impact of these problems by reducing reliance on automobiles (e.g., reducing auto-related pollutants and oil consumption) and conferring health benefits (e.g., decreasing the likelihood of obesity). Minimising climate change, however, is likely to be the biggest challenge our civilisation has faced. As such, the United Nations developed the Kyoto Protocol in 1997 in an effort to curb climate change by reducing green house gas emissions. To date, 169 countries have ratified the Protocol by committing to actively reducing national CO<sub>2</sub> and green house gas emissions from 2005 onwards, with more stringent measures being implemented from 2012 [170]. NZ is a signatory to the Kyoto Protocol, therefore, a strong possibility exists that in the coming years, local and central government will develop legislation and policies to reduce individual-level carbon emissions to fulfil the Kyoto Protocol criteria. If this is the case, increased TPA engagement may increase, not because of obesity concerns, but through international pressure to minimise carbon emissions. Climate change legislation and policies will most likely have the strongest impact on increasing TPA engagement at the population-level, for example: limiting number of automobiles owned per household, enforcing car-less days, taxation strategies to limit vehicle use, and providing enhanced public transport options and subsidies.

## **Future Directions**

One of the key aspects to understanding overall PA and urban design research is developing appropriate research methodologies that can be used consistently. Much of this has been covered in the methodological issues raised within this chapter. Applying consistent measurement tools will provide a more robust and holistic picture of the relationships between PA and TPA engagement with urban design. Once a more thorough understanding of these associations exists, appropriate interventions can be developed and the

success of these can be established accurately. Forthcoming research in the field of urban design and PA should seek to draw data from countries with diverse macro-scale environments to understand how different physical infrastructure and social norms affect TPA engagement. An international dataset would provide adequate urban design variability and strengthen the power to identify potential relationships. Indeed, this is what the International Physical Activity and Environment Network is proposing to do by using common measurement protocols in at least eight countries. This collaboration will assist with developing international best practice urban design and PA policies and guidelines. There is also scope to develop longitudinal studies which track TPA engagement and perceptions across the lifespan. To date, no travel survey captures this information and it remains unknown if travelling to school by walking or cycling has any long-term implications on future travel mode choices. A modified version of the AFES-TPA would be appropriate for use in this context.

Potentially, worksites have utility for TPA intervention settings. In this thesis, health benefits were shown for those who engaged in TPA to access their place of work/study and TPA recognition for occupation-related commute distances less than five kilometres was well accepted. Furthermore, a worksite is a confined environment where policy changes can be effectively incorporated, thereby often affecting a substantial number of people who engage in regular travel to a singular destination. As mentioned in Chapter 3, only two worksite TPA interventions appear to have been published in peer-reviewed journals [99, 103]. As such, there is much scope to develop TPA initiatives in the worksite. Potential interventions would likely fall under an ecological framework and strategies might include: providing housing subsidies for employees to reside closer to their worksite, providing incentives to employees for TPA engagement, restricting company car allocations, limiting employer-provided car parking availability, flexi-time allowances; providing showers, changing facilities, and storage areas at the worksite, and developing PA supportive urban design infrastructure around the worksite, such as crossings and footpaths. It is likely many of these interventions, however, will only succeed if local and central government support such initiatives.

To conclude, the associations between PA behaviours and urban design remain complex. This thesis has served to address many of these relationships,



but there is still much work to be conducted. Based on the presented findings, specific socio-demographic variables and built environment features are related to PA behaviours and perceptions. There is an apparent lack of TPA interventions; however, many of the methodological issues need to be resolved before developing such initiatives. With regards to future interventions, these should seek to target those who recognise they can engage in TPA, walking-based TPA initiatives are likely to have promise for the NZ adult population, and developing TPA promotion strategies in the worksite may have utility. Despite these recommendations, it is likely macro-scale urban design modifications (e.g., improved job-housing balance, highly-grained street networks) and legislation (e.g., automobile use restrictions) hold the greatest promise for increasing TPA engagement at the adult population-level.

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## Appendices



## **Appendix A: OTA Survey**

## Section A – Attitudes and Opinions

'Physical activities' are things you do that increase your breathing and/or heart rate (this includes, but is not limited to, exercise). Examples of these activities include brisk walking, biking, swimming, dancing, aerobics, gardening, sports and other activities that 'get you moving'.

1. Below are a number of statements with which you may or may not agree. For each statement, please indicate how much you personally agree or disagree with it. If you don't understand a statement, please leave that line blank. After each statement there are five boxes numbered 1 to 5. Mark X on each line. (That is, please X the box beside 1 if you strongly disagree, 2 if you moderately disagree, 3 if you neither disagree or agree, 4 if you moderately agree, or 5 if you strongly agree.)

		Strongly disagree		Neither agree or disagree		Strongly agree
		↓		↓		↓
a	I get enough 'physical activity' to keep me healthy					
b	I eat enough fruit and vegetables to keep me healthy					
c	If I get enough 'physical activity', I don't really have to worry about what I eat					
d	If I eat right, I don't really have to worry about 'physical activity'					
e	I prefer to be physically active on my own rather than in a group with an exercise leader					
f	I am more physically active than typical people for my age					
g	I eat more fruit than typical for people my age					
h	I eat more vegetables than typical for people my age					
i	Lately I have been under a lot of stress					
j	I am so busy at work that I am too tired to be physically active when I get home					
k	I get enough 'physical activity' according to recommended guidelines					
l	I get enough fruit and vegetables' according to recommended guidelines					
m	People who are not physically active are at risk of health problems					
n	People who don't eat fruit and vegetables are at risk of health problems					
o	Being physically active is a priority in my life					
p	Having healthy eating habits is important to me					
q	I used to be better at sports and other 'physical activities'					
r	I don't pay attention to recommended 'physical activity' guidelines because they are always changing					
s	I don't pay attention to recommended healthy eating guidelines because they are always changing					

t	I go out of my way to buy organically grown fruit and vegetables					
u	Frozen vegetables are as healthy as fresh vegetables					

'Regular physical activity' means at least 15 minutes of vigorous activity (makes you 'huff and puff') or a total of 30 minutes or more of moderate activity (causes a slight but noticeable increase in breathing and heart rate) each day for 5 or more days each week. Include brisk walking.

2. Please indicate how much time you personally agree or disagree with each statement.  
(Mark X one box on each line)

		Strongly disagree		Neither agree or disagree		Strongly agree
		↓		↓		↓
a	Regular physical activity' will help me live a healthy life					
b	Eating fruit and vegetables will help me live a healthy life					
c	Regular physical activity' decreases the risk of heart disease					
d	Eating fruit and vegetables decreases the risk of heart disease					
e	Regular physical activity' decreases the risk of cancer					
f	Eating fruit and vegetables decreases the risk of cancer					
g	Most weeks I could replace car trips with walking or cycling on at least 2 days (without too much difficulty)					
h	Dinner doesn't seem right without meat (chicken, pork, beef, lamb)					
i	I am concerned about the amount of pesticides on my fruit and vegetables					
j	I don't need to eat a lot of fruit and vegetables because I take multivitamin tablets					
k	Eating healthier means giving up the foods I like					
l	I would count 100% fruit juice as a serving of fruit					
m	I would count dried fruit (raisins, dried apricots, etc) as a serving of fruit					

3. For each of the following, how important is it to you that you...

		Strongly disagree		Neither agree or disagree		Strongly agree
		↓		↓		↓
a	Live a healthy life					
b	Do things to lower your risk of heart disease					
c	Do things to lower your risk of developing cancer					
d	Make changes in your daily routine in order to prevent cancer					
e	Follow recommended health guidelines					

4. In your opinion, about what percentage of the following people do 'regular physical activity'?

	0%	20%	40%	60%	80%	100%	n/a
a	Your family members						
b	Your friends						
c	People your age in New Zealand						

A 'serving' of fruit means 1 medium piece of fruit, or 2 small pieces of fruit, or ½ cup of stewed fruit.  
*Example: 1 apple + 2 small apricots = 2 servings. Do not include fruit juice or dried fruit.*

A 'serving' of vegetables means 1 medium potato/kumara, or ½ cup cooked vegetables, or 1 cup of salad vegetables.  
*Example: 2 medium potatoes + ½ cup peas = 2 servings. Do not include vegetable juices.*

5. In your opinion, about what percent of the following people eat five or more 'servings' of fruit and vegetables a day?

	0%	20%	40%	60%	80%	100%	n/a
a	Your family members						
b	Your friends						
c	People your age in New Zealand						

## Section B – Your Health

1. In general, would you say your health is... (Mark X one box)

Poor	Fair	Good	Very good	Excellent

2. How would you describe your weight?

Very underweight	Slightly underweight	About the right weight	Slightly overweight	Very overweight or obese

3. Are you trying to...

Gain weight	Lose weight	Neither of these

4. During the past 12 months have you had (or currently have) any of these health conditions?  
(Mark X all boxes that apply)

High blood pressure		Anxiety disorder	
High cholesterol		Depression or mood disorder	
Asthma		Breast cancer	
Respiratory tract infection		Colon cancer	
Hay fever or seasonal allergies		Prostate cancer	
Heart attack, heart disease, or angina		Other cancer	
Diabetes		Other physical condition	
Osteoporosis		Other mental health condition	
Arthritis		None of the above	

5. During the past 12 months, has a doctor, nurse, or other health professional...

	Yes ↓	No ↓	Not sure ↓
a Told you to be more physically active			
b Told you to eat fewer foods that are high in fat			
c Told you to eat more fruit and vegetables			
d Given you a Green Prescription (recommended or prescribed physical activity)			
e Given you any advice or treatment at all			

6. The following is a list of possible results people may experience when they do things to improve their health (such as regular physical activity or eating at least 5 servings of fruit and vegetables a day). Please indicate how personally important each result is to you.

How <u>important</u> it is to YOU to...	Not important at all				Very important
	↓				↓
a Look better (appearance)					
b Lose or maintain weight					
c Have more energy					
d Feel more relaxed					
e Feel more in control of your life					
f Set a good example for others					
g Live a longer life					
h Have fun					
i Sleep more soundly					
j Avoid constipation					
k Feel good about yourself					
l Get to be with people/socialise					
m Improve overall fitness level					

## Section C – Health Behaviour

1. Assume that you want to do each of the following. How confident are that you can do each, beginning this week and continuing for ONE month? (Mark X one box for each statement)

How confident are you that you could...	Not confident at all				Extremely confident
	↓				↓
a Be physically active at least 5 days per week for a total of at least 30 minutes a day					
b Eat a low fat diet (eating less fried food, chips, mayonnaise, cream, etc)					
c Maintain a healthy weight, or begin to lose excess weight					
d Get 7 or more hours of sleep each night					
e Try a new fruit or vegetable this month to see if you like it					
f Try a new physical activity this month to see if you like it					
g Eat at least five servings of fruit and vegetables every day					

2. Have you had a drink containing alcohol in the last year?

Yes	No	Don't know

↓

→ Go to 6.

3. How often do you have a drink containing alcohol?

Monthly or less	2 to 4 times a month	2 to 3 times a week	4 or more times a week

4. How many drinks containing alcohol do you have on a typical day when you are drinking?

As a guide, a drink is a can or small bottle of beer, a small glass of wine, a nip of spirits (a 'single' in a pub).

1 or 2	3 or 4	5 or 6	7 to 9	10 or more

5. How often do you have 5 or more drinks on one occasion?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

6. During the past 30 days, on about how many days did you smoke cigarettes?  
(If you did not smoke at all in the last 12 months, write an X)

Days

--

7. During the past 30 days, on all the days you smoked, about how many cigarettes did you usually smoke?  
(If you did not smoke at all, write an X)

Cigarettes each day

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## Section D – Physical Activity

1. Please indicate how much you personally agree or disagree with each statement.  
(If you don't understand a statement, please leave that line blank)

	When I am <u>physically active</u> , it is because...	Strongly disagree		Neither agree or disagree		Strongly agree
		↓		↓		↓
a	I enjoy physical activity					
b	It is an important choice I really want to make					
c	I would feel guilty or ashamed of myself if I didn't					
d	I believe it is a very good thing for my health					
e	Others would be upset with me if I didn't					
f	I feel pressure from others to be physically active					
g	It is consistent with my life goals					
h	I want others to approve of me					
i	I want others to see that I can do it					
j	Not doing so puts my health at serious risk					
k	My family wants me to					
l	I want to take responsibility for my own health					
m	I want to be a good role model for my children					
n	I care about keeping in shape					
o	My work is physically active					
p	It is important that my dog gets enough exercise					



2. Do you have (or share) responsibility for regularly exercising a dog?

Yes	No

3. How much encouragement do you get from the following people to be physically active?

	None						A lot	n/a
	↓						↓	
a Your spouse or partner								
b Your family, whanau, children (other than spouse/partner)								
c Your close friends								
d People you work with								
e People at your church or place of worship								
f Your doctor or health care provider								
g Your employer								
h People at your marae								

4. Overall, would you say the amount of encouragement you get is ...

Not enough			About right			Too much

5. The following is a list of possible results people may experience when they engage in 'regular physical activity'. Please indicate how likely YOU are to experience each result if you engage in physical activity.

How <u>likely</u> is it YOU would...	Not at all likely				Very likely
	↓				↓
a Look better (appearance)					
b Lose or maintain weight					
c Have more energy					
d Feel more relaxed					
e Feel more in control of your life					
f Set a good example for others					
g Live a longer life					
h Have fun					
i Sleep more soundly					
j Feel good about yourself					
k Get to be with people/socialise					
l Improve your overall fitness level					

6. The following is a list of possible things that keep some people from being physically active. For each one, please indicate how much each influences your own activity level.

		Doesn't influence me at all					Influences me a lot	
		↓					↓	
a	Lack of energy/too tired							
b	Lack of time due to work							
c	Lack of time due to family responsibilities							
d	Arthritis or other health problems							
e	Costs too much (clothes, equipment, etc)							
f	Facilities (parks, gyms) too hard to get to							
g	It's too hard to stick to a routine							
h	No one to do physical activities with							
i	I worry about my safety							
j	I would have to get someone to watch my children							
k	I'm too old							
l	I get bored quickly							
m	There are other things I'd rather do during my free time							
n	Others discourage me from being physically active							
o	I have too many household chores to do							
p	Physical activity is uncomfortable for me							
q	I'm too out of shape to start							
r	I feel I am too overweight to be physically active							
s	I don't know how to be physically active							
t	I don't like to sweat							
u	I don't like feeling out of breath							
v	I don't like other people to see me being physically active							

w	Physical activity takes too much effort							
---	---	--	--	--	--	--	--	--

7. Below is a list of things that you may or may not have in your neighbourhood or at work. First in column A mark one box that best indicates whether or not you would use each of these things if they were available to you.

Secondly, in column B please mark one box to indicate which ones you consider are readily available to you now.

		Column A					Column B	
		Would you use this if it were available to you?					Is it readily available in your neighbourhood or at work?	
		Definitely would not			Definitely would		Yes	No
a	Cycle lanes or paths							
b	Walking group							
c	Walking tracks							
d	Public parks with playing fields							
e	Swimming pool, beach or lake							
f	School gym/pool open to the community on weekends							
g	Netball or tennis courts							
h	Community recreation centre							
i	Health club or gym near work							
j	Health club or gym near home							
k	Shower at work							
l	Home exercise equipment							
m	Organised sports (touch rugby, netball, etc)							
n	Sports shop							

8. I would be more physically active if...

		Not at all likely				Very likely	n/a
		↓				↓	↓
a	I could call a toll-free number to get advice from an expert						
b	I could get a free pamphlet on how to do it						
c	I could get a free or low-cost gym membership						
d	My health insurance company rewarded me with lower premiums						
e	Every time I was physically activity I would earn points towards free things like magazines, clothes, and travel						
f	I had an extra hour of free time during my day						
g	Someone agreed to support me/check my progress						
h	I could get someone to watch my children						
i	My employer offered a gym membership						
j	My employer allowed time for it						
k	My employer paid me to be more physically active						
l	I thought it would get my children to be more active						
m	I had someone to go with						

9. Which of the following (if any) apply to your neighbourhood and put you off being physically active?  
(Mark X all boxes that apply)

<input type="checkbox"/>	There are not enough footpaths
<input type="checkbox"/>	Footpaths are not maintained
<input type="checkbox"/>	Traffic is too heavy
<input type="checkbox"/>	There are steep hills
<input type="checkbox"/>	There is not enough street lighting
<input type="checkbox"/>	There are not enough cycle lanes or paths
<input type="checkbox"/>	There are too many stop signs/lights
<input type="checkbox"/>	The scenery is not that nice
<input type="checkbox"/>	I rarely see people walking or being physically active
<input type="checkbox"/>	There is a lot of crime
<input type="checkbox"/>	Dog nuisance
<input type="checkbox"/>	None of the above

10. Is there a bicycle (in working order) usually available for you to use?

Yes

No

--	--

11. How often have you ridden a bicycle during the last 3 months? (Mark X the first box that applies)

<input type="checkbox"/>	Never learned to ride properly
<input type="checkbox"/>	Not at all during the last 3 months
<input type="checkbox"/>	Only once or twice
<input type="checkbox"/>	1-2 times a month
<input type="checkbox"/>	About once a week
<input type="checkbox"/>	2-3 days a week
<input type="checkbox"/>	Most days

12. For a short journey when the weather was fine and you have nothing to carry, would you... (Mark X one box)

<input type="checkbox"/>	Not even consider using a bicycle
<input type="checkbox"/>	Realise that you could use a bicycle but wouldn't actually do it
<input type="checkbox"/>	Think seriously about the pros and cons but rarely do it
<input type="checkbox"/>	Try cycling on some occasions
<input type="checkbox"/>	Cycle quite often
<input type="checkbox"/>	Almost always cycle

13. For this question only: if you have a bicycle, please assume that it is temporarily unavailable. For a journey of 1.5 km (about 15 minutes walk at normal walking speed), when the weather was fine and you have nothing heavy to carry, would you... (Mark X one box)

<input type="checkbox"/>	Not even consider walking
<input type="checkbox"/>	Realise that you could walk but wouldn't actually do it
<input type="checkbox"/>	Think seriously about the pros and cons of walking but rarely do it
<input type="checkbox"/>	Walk on some occasions
<input type="checkbox"/>	Walk quite often
<input type="checkbox"/>	Almost always walk

14. The next questions ask about physical activity that you may have done in the past 7 days. Please answer each question even if you do not consider yourself to be an active person. Think about the activities you do at work, as part of your housework and gardening, to get from place to place, and in your spare time for recreation, exercise, or sport. The questions ask you separately about brisk walking, moderate activity, and vigorous activity.

*Do not count the same time more than once:*

*Example 1: You run for 20 minutes. Count this time as vigorous activity only, not as moderate.*

*Example 2: A 45 minute ball game with 30 minutes at moderate intensity then 15 minutes at vigorous intensity. Count this activity as 30 minutes moderate and 15 minutes vigorous.*

## A. Walking

During the last 7 days, on how many days did you walk at a brisk pace? (A pace at which you are breathing harder than normal.) This includes walking at work, walking to travel from place to place, and any other walking you did solely for recreation, sport, exercise, or leisure.

Think about only that walking done for at least 10 minutes at a time. (Mark X one box)

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much time did you usually spend doing brisk walking on each of those days?  
(Write in number)

Minutes  
a day

or

Hours a  
day

## B. Moderate activity

During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. (*Moderate activity will cause a slight but noticeable, increase in breathing and heart-rate*)

Think about only those physical activities done for at least 10 minutes at a time. (Mark X one box)

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How much time did you usually spend doing brisk walking on each of those days?

(Write in number)

Minutes  
a day

or

Hours a  
day

### C. Vigorous Activity

During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, running, rugby, netball, or fast bicycling? (Vigorous activity is activity that makes you 'huff and puff', and where talking in full sentences is difficult)

Think about only those physical activities done for at least 10 minutes at a time. (Mark X one box)

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days

How much time did you usually spend doing brisk walking on each of those days?  
(Write in number)

Minutes  
a day

--

or

Hours a  
day

--

15. *Crucial Question! Please answer carefully.* Thinking about all your activities (brisk walking, moderate, or vigorous), on how many of the last 7 days were you active? ('Active' means doing 15 minutes or more of vigorous activity, or a total of 30 minutes or more of moderate activity or brisk walking).

0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days

16. Were your answers to the last questions (Q14 – Q15) clearly affected because of pregnancy, injury, illness, or disability? (Mark X all boxes that apply)

	No
	Yes, because of pregnancy
	Yes, because of a temporary illness
	Yes, because of a long-term illness
	Yes, because of a temporary injury
	Yes, because of a permanent injury or disability



17. Overall, how physically active do you consider yourself to be?

Not at all physically active						Very physically active

18. How long have you been at this level?

Less than one month	1-3 months	4-6 months	7-9 months	10-12 months	More than 12 months

19. Over the next 6 months, do you think you will be...

Less physically active		About the same		More physically active

20. Are you 'regularly physically active' according to the definition below? (Mark X one box)

'Regular physical activity' means at least 15 minutes of vigorous activity (makes you 'huff and puff') or a total of 30 minutes or more of moderate activity (causes a slight but noticeable, increase in breathing and heart-rate) each day for 5 or more days each week. Include brisk walking.

	No, and I do not intend to be in the next 6 months
	No, but I am thinking about starting to be in the next 6 months
	No, but I intend to start in the next 30 days
	Yes, I am but only began in the last 6 months
	Yes, I am and have been for more than 6 months

## Section E – Nutrition

1. How much do you personally agree or disagree with each statement?

When I eat fruit and vegetables it is because...	Strongly disagree			Neither agree or disagree			Strongly agree
	↓			↓			↓
a I enjoy eating fruit and vegetables							
b It is an important choice I really want to make							
c I would feel guilty or ashamed of myself if I didn't							
d I believe it is a very good thing for my health							
e Others would be upset with me if I didn't							
f I feel pressure from others to eat healthier							
g It is consistent with my life goals							
h I want others to approve of me							
j Not doing so puts my health at serious risk							
k My family wants me to							
l I want to be a good role model for my children							
m I want to take responsibility for my own health							
n Fruit makes an easy snack							
o I want to get more vitamins							

2. How much encouragement do you get from the following people to eat fruit and vegetables?

	None ↓							A lot ↓	n/a
a Your spouse or partner									
b Your family, whanau, children (other than spouse/partner)									
c Your close friends									
d People you work with									
e People at your church or place of worship									
f Your doctor or health care provider									
g Your employer									
h People at your marae									

3. Overall, would you say the amount of encouragement you get is...

Not enough			About right			Too much

4. The following is a list of possible results people might experience when they eat at least five servings of fruit and vegetables a day. Please indicate how likely YOU are to experience each result if you eat at least five servings of fruit and vegetables daily.

How <u>likely</u> is it YOU would...	Not at all likely ↓					Very likely ↓
a Look better (appearance)						
b Lose or maintain weight						
c Have more energy						
d Feel more in control of your life						
e Set a good example for others						
f Live a longer life						
g Avoid constipation						
h Feel good about yourself						

5. The following is a list of possible things that keep people from eating fruit and vegetables each day. For each one, please indicate how much each influences the number of fruit and vegetables you eat each day.

		Doesn't influence me at all			Influences me a lot		
		↓					↓
a	Fruit costs too much						
b	Vegetables cost too much						
c	Fresh fruit spoils too quickly						
d	Fresh vegetables spoil too quickly						
e	I prefer to eat other snacks (like chips and biscuits)						
f	They don't give me 'quick energy' like a chocolate bar does						
g	I'm not a good cook						
h	Fruit and vegetables are not available where I work						
i	The supermarket doesn't carry a lot of different fruit and vegetables						
j	I can't get good quality fruit and vegetables at my local shops						
k	Fruit takes too much time to prepare (clean, cut up, cook)						
l	Vegetables take too much time to prepare (clean, cut up, cook)						
m	Fruit isn't filling enough						
n	Vegetables aren't filling enough						
o	I don't like most fruit						
p	I don't like most vegetables						
q	My family doesn't like fruit						
r	My family don't like vegetables						
s	Fruit is difficult to eat when I'm 'on the go'						
t	Vegetables are difficult to eat when I'm 'on the go'						

6. Please indicate how likely you would be to eat more fruit and vegetables if...

		Not at all likely				Very likely	n/a
		↓				↓	↓
a	I could call a toll-free number to get advice from an expert on how to prepare or cook fruit and vegetables						
b	I could get a free pamphlet on how to prepare or cook fruit and vegetables						
c	Fruit and vegetables came in more convenient packages (pre-washed, cut-up)						
d	My employer offered free or low-cost fruit and vegetables at work						
e	There was more information on TV about how to prepare or cook fruit and vegetables						
f	The place I buy my lunch had more fruit and vegetables						
g	My doctor or nurse told me it would improve my health						
h	I could collect barcodes from fruit and vegetables which go into prize draws						
i	I could get free advice from a dietician						
j	I could get a free cookbook about fruit and vegetables						

7. On average how many 'servings' of fruit ( fresh, frozen, canned, or stewed) do you eat per day? Do not include fruit juice or dried fruit.

A 'serving' of fruit means 1 medium piece of fruit, or 2 small pieces of fruit, or ½ cup of stewed fruit.

*Example: 1 apple + 2 small apricots = 2 servings.*

	I don't eat fruit
	Less than 1 serving per day
	1 serving per day
	2 servings per day
	3 servings per day
	4 servings per day
	5 or more servings per day

8. Do you consistently eat 2 or more 'servings' of fruit a day? (Mark X one box)

<input type="checkbox"/>	No, and I do not intend to in the next six months
<input type="checkbox"/>	No, but I intend to in the next 6 months
<input type="checkbox"/>	No, but I plan to in the next 30 days
<input type="checkbox"/>	Yes, I have been, but for less than 6 months
<input type="checkbox"/>	Yes, and I have been for more than 6 months

9. On average, how many 'servings' of vegetables (fresh, frozen, canned) do you eat a day? Do not include vegetable juices.

A 'serving' of vegetables means 1 medium potato/kumara, or ½ cup cooked vegetables, or 1 cup of salad vegetables.

Example: 2 medium potatoes + ½ cup peas = 2 servings.

<input type="checkbox"/>	I don't eat vegetables
<input type="checkbox"/>	Less than 1 serving per day
<input type="checkbox"/>	1 serving per day
<input type="checkbox"/>	2 servings per day
<input type="checkbox"/>	3 servings per day
<input type="checkbox"/>	4 servings per day
<input type="checkbox"/>	5 or more servings per day

10. Do you consistently eat 3 or more 'servings' of vegetables a day? (Mark X one box)

<input type="checkbox"/>	No, and I do not intend to in the next six months
<input type="checkbox"/>	No, but I intend to in the next 6 months
<input type="checkbox"/>	No, but I plan to in the next 30 days
<input type="checkbox"/>	Yes, I have been, but for less than 6 months
<input type="checkbox"/>	Yes, and I have been for more than 6 months

11. Overall, how do you feel about the amount of fruit and vegetables that you typically eat?

Not enough			About right			Too much
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

12. Over the next 6 months, do you think you will...

Eat fewer fruit and vegetables			Eat about the same			Eat more fruit and vegetables
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. Do you consider yourself to be a vegetarian?

Yes (no meat or fish)	No
<input type="checkbox"/>	<input type="checkbox"/>

14. Who usually does the cooking in your house?

<input type="checkbox"/>	I do
<input type="checkbox"/>	Someone else living with me
<input type="checkbox"/>	Shared equally
<input type="checkbox"/>	Other (e.g., my meals are delivered)

15. When vegetables are cooked in your house, how are they usually prepared? *(Mark X all that apply)*

<input type="checkbox"/>	Deep fry them in oil
<input type="checkbox"/>	Steam or microwave them
<input type="checkbox"/>	Pan fry/sauté them in oil, butter, or margarine
<input type="checkbox"/>	Boil them
<input type="checkbox"/>	Bake or grill them
<input type="checkbox"/>	Roast them
<input type="checkbox"/>	Don't know

16. If you wanted to add a vegetable to your diet, when would be the easiest time to do it? *(Mark X one box)*

<input type="checkbox"/>	At breakfast
<input type="checkbox"/>	At lunch
<input type="checkbox"/>	At dinner
<input type="checkbox"/>	As a dessert
<input type="checkbox"/>	As a snack

17. If you wanted to add a fruit to your diet, when would be the easiest time to do it? *(Mark X one box)*

<input type="checkbox"/>	At breakfast
<input type="checkbox"/>	At lunch
<input type="checkbox"/>	At dinner
<input type="checkbox"/>	As a dessert
<input type="checkbox"/>	As a snack

18. How many nights do you usually eat out or bring home take-away food instead of preparing dinner at home?

<input type="checkbox"/>	Less than once a month
<input type="checkbox"/>	1-2 times a month
<input type="checkbox"/>	About 1 time a week
<input type="checkbox"/>	About 2 times a week
<input type="checkbox"/>	About 3 times a week
<input type="checkbox"/>	About 4 times a week
<input type="checkbox"/>	About 5-7 times a week

19. How many nights a week do you eat dinner while watching television?

0 nights	1 night	2 nights	3 nights	4 nights	5 nights	6 nights	7 nights
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20. Have you heard of '5+ a day'?

Yes	No
<input type="checkbox"/>	<input type="checkbox"/>



## Section F – Getting Health and Physical Activity Information

1. Please indicate how much you would trust each of the following sources for health and physical activity information.

	Don't trust at all				Trust a lot
	↓				↓
a Your doctor					
b Your doctor's nurse					
c Dietician					
d Naturopath or homeopath					
e Other health professional (e.g., physiotherapist)					
f Pharmacist/chemist					
g Your local hospital					
h Your local Public Health Unit					
i Your local District Health Board					
j The Ministry of Health					
k SPARC/Push Play Campaign					
l Regional Sports Trusts					
m Cancer Society					
n Diabetes New Zealand					
o Heart Foundation					
p Gym personnel or personal trainer					
q Your family					
r Your friends					
s The Internet					
t Books or journals					
u Magazine articles					
v Newspaper articles					
w Television programmes					
x Radio programmes					

2. Which of the following health areas would you be most interested in learning more about? (Mark X all that apply)

<input type="checkbox"/>	Physical activity/exercise
<input type="checkbox"/>	Nutrition/food choices
<input type="checkbox"/>	Weight control
<input type="checkbox"/>	Quitting smoking
<input type="checkbox"/>	Stress management
<input type="checkbox"/>	Blood pressure control
<input type="checkbox"/>	Improving sleep
<input type="checkbox"/>	Information on specific diseases and conditions
<input type="checkbox"/>	Information on drugs and medications
<input type="checkbox"/>	Information on alternative therapies
<input type="checkbox"/>	How to stay healthy
<input type="checkbox"/>	None of these

3. How often do you use the internet to find health information (including health-related news, information about specific conditions, etc)?

<input type="checkbox"/>	Never
<input type="checkbox"/>	A few times a year
<input type="checkbox"/>	Once a month
<input type="checkbox"/>	Several times a month
<input type="checkbox"/>	A few times a week
<input type="checkbox"/>	Every day

4. When you log on to the internet for personal reasons (not for work), what is your homepage?

<input type="checkbox"/>	Not applicable
<input type="checkbox"/>	nzoom
<input type="checkbox"/>	Yahoo
<input type="checkbox"/>	nzherald
<input type="checkbox"/>	nzjobs.co.nz
<input type="checkbox"/>	xtramsn.co.nz
<input type="checkbox"/>	Alta Vista
<input type="checkbox"/>	Google
<input type="checkbox"/>	stuff.co.nz
<input type="checkbox"/>	Other
<input type="checkbox"/>	Don't know

5. Which of the following websites do you commonly use? *(Mark X all boxes that apply)*

<input type="checkbox"/>	None of those below
<input type="checkbox"/>	Yahoo
<input type="checkbox"/>	xtramsn.co.nz
<input type="checkbox"/>	Alta Vista
<input type="checkbox"/>	Google

## Section G – About Yourself

1. Are you...

Male

Female

<input type="checkbox"/>	<input type="checkbox"/>
--------------------------	--------------------------

2. What is your height without shoes?

cm

or

Feet and  
inches

3. What is your weight without shoes?

kg

or

Stone and  
pounds

4. Are you... (Mark X the one box which best describes you now)

<input type="checkbox"/>	Single
<input type="checkbox"/>	Married/living with a partner
<input type="checkbox"/>	Separated/divorced
<input type="checkbox"/>	Widowed
<input type="checkbox"/>	Other

5. Which location best describes where you live?

<input type="checkbox"/>	Large city (more than 100,000 people)
<input type="checkbox"/>	Smaller city (30,000 to 100,000 people)
<input type="checkbox"/>	Town (1,000 to 29,999 people)
<input type="checkbox"/>	Small town, community, or village (less than 1,000 people)
<input type="checkbox"/>	Don't know/not sure

6. Which ethnic group do you belong to? (Mark X all boxes that apply)

<input type="checkbox"/>	New Zealand European
<input type="checkbox"/>	Maori
<input type="checkbox"/>	Samoan
<input type="checkbox"/>	Cook Island Maori
<input type="checkbox"/>	Tongan
<input type="checkbox"/>	Niuean
<input type="checkbox"/>	Chinese
<input type="checkbox"/>	Indian
<input type="checkbox"/>	Other Asian (such as Korean, Filipino, Japanese)
<input type="checkbox"/>	British/European
<input type="checkbox"/>	Other

7. To which of these age groups do you belong?

<input type="checkbox"/>	16-17 years
<input type="checkbox"/>	18-19 years
<input type="checkbox"/>	20-24 years
<input type="checkbox"/>	25-29 years
<input type="checkbox"/>	30-34 years
<input type="checkbox"/>	35-39 years
<input type="checkbox"/>	40-44 years
<input type="checkbox"/>	45-49 years
<input type="checkbox"/>	50-54 years
<input type="checkbox"/>	55-59 years
<input type="checkbox"/>	60-64 years
<input type="checkbox"/>	65-69 years
<input type="checkbox"/>	70-74 years
<input type="checkbox"/>	75-79 years
<input type="checkbox"/>	80 years and over

8. What is your highest secondary school qualification? *(Mark X one box)*

<input type="checkbox"/>	None
<input type="checkbox"/>	NZ School Certificate in one or more subjects, or National Certificate Level 1
<input type="checkbox"/>	NZ Sixth Form Certificate in one or more subjects, or National Certificate Level 2
<input type="checkbox"/>	NZ University Entrance before 1986 in one or more subjects
<input type="checkbox"/>	NZ Higher School Certificate, or Higher Leaving Certificate
<input type="checkbox"/>	NZ A or B Bursary, Scholarship, or National Certificate Level 3
<input type="checkbox"/>	Other NZ secondary school qualification
<input type="checkbox"/>	Overseas secondary school qualification

9. Apart from secondary school qualifications, do you have another qualification? Don't count incomplete qualifications or qualifications that take less than 3 months of full-time study (or the equivalent) to get.  
*(Mark X all boxes that apply)*

<input type="checkbox"/>	No
<input type="checkbox"/>	Bachelor degree or higher degree
<input type="checkbox"/>	Other complete qualification taking 3 or more months of full-time study, or the equivalent (e.g., diploma, trade certificate)

10. Which one of the following best describes you?

*Mark one box – if more than one category applies, mark the one you spend most time doing over a week)*

<input type="checkbox"/>	Working full-time
<input type="checkbox"/>	Working part-time
<input type="checkbox"/>	Unemployed/actively seeking a job
<input type="checkbox"/>	At home
<input type="checkbox"/>	Retired
<input type="checkbox"/>	Sick/invalid
<input type="checkbox"/>	Student (full-time including secondary school)
<input type="checkbox"/>	Other

11. Which one of these best describes where you work?

<input type="checkbox"/>	Not doing paid work
<input type="checkbox"/>	Mainly in an office
<input type="checkbox"/>	Mainly in a shop
<input type="checkbox"/>	Mainly in a factory
<input type="checkbox"/>	Mainly outside
<input type="checkbox"/>	Mainly at home (inside)
<input type="checkbox"/>	None of the above

12. How many people (including working owners) work for your organisation at the place where you work? *Include both full-time and part-time workers. Ignore any physically separate sites your organisation may have.*

<input type="checkbox"/>	Not doing paid work
<input type="checkbox"/>	1-5
<input type="checkbox"/>	6-9
<input type="checkbox"/>	10-49
<input type="checkbox"/>	50 or more

13. When you are at work, which of the following best describes what you do? Would you say...

<input type="checkbox"/>	Mostly sit
<input type="checkbox"/>	Mostly stand
<input type="checkbox"/>	Mostly walk or perform light labour
<input type="checkbox"/>	Mostly do heavy labour or physically demanding work
<input type="checkbox"/>	Not applicable

14. Which of these best describes your personal income before tax in the last 12 months? This includes benefit and retirement income, as well as paid income from all sources.

<input type="checkbox"/>	Zero income or loss
<input type="checkbox"/>	\$1-\$5,000
<input type="checkbox"/>	\$5,001-\$10,000
<input type="checkbox"/>	\$10,001-\$15,000
<input type="checkbox"/>	\$15,001-\$20,000
<input type="checkbox"/>	\$20,001-\$30,000
<input type="checkbox"/>	\$30,001-\$40,000
<input type="checkbox"/>	\$40,001-\$50,000
<input type="checkbox"/>	\$50,001-\$70,000
<input type="checkbox"/>	\$70,001-\$100,000
<input type="checkbox"/>	\$100,001 or more
<input type="checkbox"/>	Don't know

15. Which one of these best describes the total household income before tax in the last 12 months. This includes benefit and retirement income, as well as paid income from all sources.

<input type="checkbox"/>	Same as personal income
<input type="checkbox"/>	Up to \$10,000
<input type="checkbox"/>	\$10,000-\$20,000
<input type="checkbox"/>	\$20,001-\$30,000
<input type="checkbox"/>	\$30,001-\$40,000
<input type="checkbox"/>	\$40,001-\$50,000
<input type="checkbox"/>	\$50,001-\$70,000
<input type="checkbox"/>	\$70,001-\$100,000
<input type="checkbox"/>	\$100,001 or more
<input type="checkbox"/>	Don't know
<input type="checkbox"/>	Not applicable – flat, hostel, boarding, etc

16. Which of the following best describes your address?

<input type="checkbox"/>	Private household
<input type="checkbox"/>	Home for the elderly
<input type="checkbox"/>	Other institution (e.g., Hostel)
<input type="checkbox"/>	Other (please specify)

---

17. Counting yourself (and any boarders), how many people in total live at this address? *Only count people usually living with you at least 4 days a week.*

Total people

Of these, how many were...

People aged  
18 years or  
more

People aged  
16-17 years

Children aged  
5-15 years

Children aged  
0-4 years

19. Are any of the people aged under 18 years at this address...

<input type="checkbox"/>	Your child/children
<input type="checkbox"/>	Your grandchild/grandchildren

20. At a later stage, we would like to contact a few people for some follow-up research. If you are happy to be contacted, please write your telephone number here:



## **Appendix B: OTA Weighting Procedures**

## Weighting calculations

The weighting was carried out by James Reilly of Statistical Insights Ltd. Following is the report from James Reilly that is taken verbatim from the OTA technical report [171].

### *Introduction*

Case weights are commonly calculated and applied during the analysis of survey data. They serve to adjust for the sample design and can help reduce the potential for non-response bias. For example, in a general population survey of individuals where one person is randomly selected from each address (such as the OTA study), unweighted results would be biased for any response that is correlated with household size. This bias is due to respondents having different selection probabilities. Applying inverse probability weights removes this bias, although it may lead to a much-reduced effective sample size if the selection probabilities are highly variable. Even after correcting for sample selection probabilities, the demographic profile of the sample may exhibit some skews relative to known population figures. These may be due to differential non-response. If the demographic variables collected in the survey are comparable to the census data, methods such as post-stratification or rim weighting can adjust for these differences and may help reduce potential non-response bias in other survey variables. After outlining relevant aspects of the sample design for the OTA study, this report describes the weighting methods applied to address the above issues for this data, and documents the formulae and population figures used.

Although Statistical Insights was not involved in developing the sample design for this survey, the design has a strong bearing on the weighting procedures used. The relevant features of the design are therefore summarised below. The OTA population consisted of all people living in New Zealand aged 16 or more. A stratified two-stage sample has been drawn from this population for the OTA study. First a stratified sample of people was selected from the electoral roll, with strata being defined by region and ancestry (whether of Maori descent or not). Region sample sizes were allocated in proportion to the population aged 16 or more, and this was split between Maori and non-Maori to give a 26% higher number of Maori than their share of the population. People aged 18-24 were also given a 66% higher chance of being chosen, not by further stratification but by giving them larger 'size' weights and selecting people with probability proportional to size. Duplicate addresses were removed from the sample and replaced with a randomly selected person from the stratum. Questionnaires were sent to the addresses of people selected in this first stage, addressed 'To residents at <address>'. The person with the first birthday after 1 June (out of those aged 16 or more living at the address) was asked to complete the questionnaire.

### *Selection probabilities*

Selection probabilities for people on the electoral roll during the first stage of sampling were given by:

$$p_{1,hi} = \frac{n_h c_i}{3N_{ha} + 5N_{hb}}$$

where  $n_h$  was the desired sample size for the current stratum  $h$ ;  $c_i = 3$  if person  $i$  is aged 25+, and  $c_i = 5$  if person  $i$  is aged 18-24;  $N_{ha}$  is the number of people on the electoral roll in stratum  $h$  who are aged 25+; and  $N_{hb}$  is the number of people on the electoral roll in stratum  $h$  who are aged 18-24.

The selection probability for the address of person  $j$  is therefore:

$$p_{1,j} = 1 - \prod (1 - p_{1,hi})$$

where  $A_j$  includes all people on the electoral roll who live at that address. The second stage of selection involved selecting the person aged 16 or more with the first birthday after 1 June at that address. Assuming that birthdays can be considered as distributed at random, this means that the final selection probabilities are given by  $p_i = p_{1,j}/s_{16+}$  is the number of people aged 16 or more who live at that address. Inverse probability weights  $w_i$  were then calculated as  $w_i = 1/p_i$ .

### *Demographic profiles*

Initial demographic profiles were produced by applying these inverse probability weights (or pre-weights) to the survey data. These pre-weighted sample profiles were compared to population profiles from the 2001 census.

### *Rim weighting*

Cell weighting (or post-stratification) could not be used to adjust for these sample skews because at a minimum it was desirable to control for gender, age (including 16-17 year olds) and ethnicity (including Pacific people). However, this would generate many cells, some with sample sizes that were very small, and would therefore produce unstable results. It was decided that rim weighting would be used instead, with three rims: one rim for region, another rim for ethnicity by gender by broad age groups (under 40 versus 40 years or more), and a third rim for gender by detailed age groups. The categories shown in the tables above were used, with the exception of the broad age groups described earlier and the residual ethnicity categories (not elsewhere specified/not answered), which were combined with NZ European.

Population figures for each rim cell were calculated as the 2001 census population figure multiplied by 1.0814 to account for census undercount and the increase in the population between 2001 and 2003. The 'household' size variable showed large differences between the census and the OTA profiles, which at first glance might suggest that these too should be adjusted for. However, in the OTA study this variable is based on the number of people living

at that address, not the number living in the household as reported in the census, so these profiles are not comparable. The observed differences (fewer small housing units in the OTA study, and larger ones) are in the direction that would be expected due to some addresses covering multiple dwellings, and some dwellings containing multiple households. Since post-stratification and raking weighting require profiles for comparable variables, it was decided not to use 'household' size in this part of the weighting process.

The weights originally produced by this process were highly variable, resulting in a design effect greater than 5 and an effective sample size of about 1,600. To reduce the extent of this problem, a maximum value of 10 was imposed on the 'household' size used when calculating the inverse probability pre-weight. This decreased the weighting effect to 2.0 and increased the effective sample size to over 4,000. However, it has introduced some potential bias, reducing the contribution of people living in large 'households' to the survey results. The 45 capped records accounted for over 10% of the population according to the old weights, but using the final weights they made up only 2.7% of the total. Weights were not calculated for 128 cases with missing demographic or 'household' size information, and these cases have been omitted from weighted analyses of the survey data.

## *Results*

Good agreement with the population weighting targets was achieved. The distribution of the final weights is shown below. This distribution resulted in an overall weighting effect of 1.97. The average weight was 366.9, and the maximum was 6,973.

## *Conclusion*

The weighting procedure used in the OTA study has accounted for varying sample selection probabilities. The weights have also been adjusted for demographic skews relative to population where appropriate, reducing the potential bias due to non-response. However there may be some remaining non-response bias, since the demographic control variables used will probably only adjust for part of any non-response skews on other variables. It is also important to realise that the inverse probability weights were adjusted to increase the effective sample size, but this adjustment may have caused the results to under-represent people who share an address with many other people.

## **Appendix C: OTA Participant Information**

## Initial Participant Information Sheet

Thank you for helping with an important study about the physical activity and eating habits of New Zealanders. Sport and Recreation New Zealand (SPARC, formerly the Hillary Commission) and the Cancer Society will use this study to improve the health of New Zealanders. By chance, your address has been chosen to be part of this study. Only one person in your house should complete this questionnaire – **the adult who has the first birthday after 1 June**. (Adult means someone aged 18 or over.)

Your answers will be totally private. No one other than the researchers will be able to tell that it was someone from your house who answered the survey. Each person's answers will be put together with those of others to show the results.

You can return your completed questionnaire in the Freepost envelope supplied.

If you have any questions, ACNielsen will be happy to talk with you. Their toll free number is 0800 226 737.

Call any time (including nights and weekends) and ask for Gordon Stewart or Sandra Dodds.

We'd like to thank you in advance for your time and effort.

Sincerely

Nicholas Hill  
Chief Executive, SPARC

Neil Chave  
Chief Executive, Cancer Society of New Zealand



### How to answer

Use a **blue** or **black** pen (that does not soak through the paper), or a **dark** pencil. Put an **X** inside the box provided. (Do not mark any areas outside the box.)

☐ 1 ☒ 2 ☐ 3 ☐ 4 ☐ 5

If you change your mind or make a mistake:

Fill in the whole box and mark the correct one as shown.

☐ 1 ☒ 2 ☒ 3 ☐ 4 ☐ 5

## Obstacles to Action Reminder Postcard (front and back)



**Have you seen this?**

If you are the adult who has the first birthday after **1st June**, you need to see this!

If undelivered return to PO Box 602, Wellington


*A few days ago we sent a questionnaire about physical activity and eating habits to your address. We need the adult who has the first birthday after 1 June to complete the questionnaire. Please make sure that this person gets this card.*

*If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, please do so today. By sharing your views and experiences you will help us improve the lives of New Zealanders.*



*If you have any questions you can call Gordon Stewart or Sandra Dodds at ACNielsen toll-free at 0800 226 737 (any time including nights and weekends).*

*Thankyou*

*SPARC (Sport and Recreation NZ)  
Cancer Society of New Zealand*

New Zealand Permit No. 95330	Permit 
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**Mrs J Smith  
55 Howard Road  
Point Howard  
EASTBOURNE**

## Potential Phone Enquiries from Respondents

### *Survey Issues (general)*

Q. I've misplaced my questionnaire, can you please send me another one?

A. Certainly we can do that. Take Caller's name, contact phone number, address details, and note 'resend survey' in the spreadsheet.

Q. I've mucked up the survey answers – can you send me another copy?

A. Certainly we can do that. Take Caller's name, contact phone number, address details, and note 'resend survey' in the spreadsheet.

Q. I've lost the freepost envelope.

A. No problem, I can give you the freepost address to send it back so it won't cost you anything.

The freepost address is Freepost 727, AC Nielsen, PO Box 11 346, Wellington.

Q. Is this survey genuine?

A. Yes it is. It is being done for SPARC (Sport and Recreation NZ) and the Cancer Society. We are an independent market research company commissioned to do the survey. You can check on this if you like by looking at the SPARC website <http://www.sparc.org.nz/>.

Q. What do I get for filling it in?

A. We appreciate the time it takes for people to fill it in and you are most welcome to keep the pen attached. However, it is a voluntary survey so you do not have to fill it in if you don't want to. Unfortunately, we cannot offer respondents anything except for the pen attached.

Q. The survey seems really long, do I really have to fill it out?

A. We do appreciate your help if you would fill it out as it will be used to help all New Zealanders. It may take you 30 – 40 minutes to complete as the survey is very thorough but we would really like your help to complete the survey and return it.

Q. Some of my friends/family members have received a survey but I never got one, could you please send one to me?

A. Thank you for your enthusiasm and helpfulness but sorry, it is very important for the accuracy of our results that only the people randomly sampled complete the questionnaire. We simply are not allowed to use answers from other people.

Q. How do I fill it in?

A. All you need to do is to put a cross inside the box for each question. The instructions on how to fill it in are also on page 3 of the survey.

Q. I've had a look at it and I've decided that I'm not going to fill it in.

A. That's fine. Can I just take down the number that starts with 'SN' on the top left hand corner of your questionnaire.

### Survey Issues (filling in the questionnaire)

Q. I'm confused about who needs to fill it in.



A. <If residential i.e., House, flat, 'normal' home> The adult in your household who will be having their birthday next, after the 1 June, should be the person filling in the survey.

<If resthme, prison, hostel, etc> You will need to pass this on to the person who is named in the footnote of the letter.

<If name not in footnote> Can I just take down the number that starts with 'SN' on the top left hand corner of your questionnaire? Alternatively, the address we used to reach you. Please wait while I look up special instructions for your sample number/address.

<Look up address/sample number in mailout spreadsheet

H:\Common\SPARC\Enhancing Push Play\Project

management\SAMPLE2(from Keith)200503.xls> Please give this questionnaire to <Name in SAMPLE>. (If they are no longer at this address, please deliver to the adult occupying their room or closest to it.)

Q. The letter says that the adult who has the first birthday after 1 June should fill it out, that is <someone else>, can I fill it out instead?

A. No, we need to have the adult who has the first birthday after 1 June to fill it out as it is a random selection. Could you please pass it on to that person.

Q. My birthday is on 1 June; should I fill out the questionnaire, or a different person with the next birthday?

A. Thanks for being so careful. The (different) person with the first birthday AFTER 1 June should complete the questionnaire.

Q. The person who should fill it out is away for 2 weeks, can I fill it out instead?

A. No, we need to have the adult who has the first birthday after 1 June to fill it out as it is a random selection. Could you please pass it on to that person when they come back.

Q. The person who should fill it out is away for 2 months, can I fill it out instead?

A. If you are the next person with the birthday after 1 June, then yes that is fine. Otherwise, if you could pass it onto that person, that would be appreciated.

Q. The person who has their birthday next after 1 June is mentally or physically incapable of answering such questionnaire.

A. Thank you for letting us know. That person is ineligible for the survey. Please tell me the sample number marked on the questionnaire or cover letter (top left of cover, beginning SN) and your address so that I can stop reminder questionnaires being sent.

Q. The person who has their birthday next after 1 June is visiting from overseas. Should they fill it in?

A. Thanks for checking. As you have probably guessed, this is a survey about New Zealanders. So we would like it to be answered only by people usually resident in New Zealand. Please pass it on to the person who has their birthday next after 1 June.

Q. The person who has their birthday next after 1 June is visiting from <elsewhere in NZ>. Should they fill it in?

A. If they are at your address for most of June, they should complete the questionnaire.

Q. I am sick/injured this week, should I still complete questionnaire?

A. Yes, please complete the questionnaire - we want the results to represent all New Zealanders. We do have a question in the middle for you to tell us that sickness or injury is affecting your answers. If the sickness/injury is just affecting you for a few days (a fortnight or less), please do your best to answer the questions for the time just before your sickness/injury.

Q. I've already filled it out and I've got this reminder letter/another survey.

A. That's fine, we may not have received it yet. Just ignore the reminder letter.

Q. I've had several reminders and another questionnaire about this. Please do not send any more to this address.

A. Sorry for the inconvenience. Can I just take down the number that starts with 'SN' on the top left hand corner of your questionnaire so we do not send any more out to you.

Q. I don't do any <or much> exercise/ I don't eat any <or much> fruit and vegetables. Do you still want me to fill it out?

A. Yes please. We want to get answers from a wide range of people to accurately represent all New Zealanders. Even if you think you do not exercise/eat fruit and vegetables, we would really appreciate it if you could fill it in.

Q. This survey is very repetitive/This survey has some questions in it that are the same/double up/repeated.

A. The survey is very thorough and some questions may appear to be the same, they actually are not.

<If respondent insistent that there are some exact questions, ASK which ones, then explain that they are not>

#### Survey Issues (specific)

Q. I cannot answer the question because I do not work/do not have kids.

A. That is fine. Please miss out that question, or mark 'Does not apply' if that is an option. At the end of the questionnaire, we learn from you whether or not you do paid work or have children, and so we can ensure that we use such questions properly.

Q. I don't understand question <D14>.

A. Ok. We can go through it together if you like. The first question asks you in the last 7 days, how many days you walked at a brisk pace. That is when you were walking and you were breathing harder than normal. You will need to mark the box under the number of days (you had walked in the last 7 days). Then if you could write in the number of minutes (or hours) that you were walking for on each of those days in the box underneath.

#### Confidentiality Issues

Q. Is this survey really private/confidential/anonymous?

A. Yes it is. Your name does not appear anywhere on the questionnaire, nor does your address. Your phone number will only be there if you choose to write it in, and that is entirely optional. We do need to keep track of which households

have returned questionnaires or not, but your address will not be linked to your answers nor would it ever be passed on to the client or sold etc. We are researchers, not direct marketers. To deliver results, your answers will be put together with those of others.

Q. Why are there identification numbers on the survey when you say my answers are private?

A. That number is only for AC Nielsen to note which households have returned the questionnaire. Because we cannot tell who has filled in the survey from your household, we cannot identify you. Also, the results will be put together with those of others.

Q. Why do you need my phone number (at the end of the survey)?

A. At a later stage, we would like to do some follow up research with some of the people who have filled in the questionnaire. However, you don't have to write in your phone number if you don't want to.

Q. Where did you get my address from?

A. We got your addresses by random selection from the electoral roll.

Q. How did you select my address/household to participate <OR I want to know how you did the random selection>?

A. It was a random sample of all addresses from the Electoral Roll.

Other Issues

Q. Is this <SPARC/Cancer Society of NZ>?

A. Sorry, you have reached AC Nielsen, the independent market research company. Unfortunately as we are not part of <SPARC/Cancer Society of NZ>. If you have a query that relates to <SPARC/Cancer Society>, I cannot help you with your query.

Q. I don't live at this address but only collect the mail. What do I do with the questionnaire?

A. Thank you for calling to check. Will anyone be living at this address by early July?

<IF NO> Can you please tell me the sample number on the top left of the questionnaire beginning SN (alternative: Address questionnaire was sent to)?

<IF YES> Please leave the questionnaire for those people to answer when they arrive.

Q. Can I get a copy of the results when you are finished? <OR Can you send me the results?>

A. Sorry but we will need to report the results to our client. SPARC will be putting a summary of some of the results on the Research part of their website.

<Language difficulties, try to get the Sample Number and tell them that is all we require. Note down as language difficulties. Okay for someone else to help them fill it out though.>

<Anything really technical, please note down respondent name and phone number and tell them that you will get one of the researchers to call them back.>

Close:

Thank you very much for calling.

h:\common\sparc\enhancing push play\project management\phone queries\_v2.doc

#### Notes on the Questionnaire

This questionnaire is about physical activity and eating habits (in particular, fruit and vegetable intake) of New Zealanders.

Section A: This section includes a lot of statements about physical activity and fruit and vegetable consumption. It is designed to collect respondents' attitudes and opinions on different issues.

Section B: This section is about the respondents' current health status.

Section C: This section is about how confident respondents' feel they can do each of the 'health' items, their alcohol and smoking behaviour.

Section D: This section is about the respondents' current physical activity levels. Q5. Note that this appears to be the same question as B6 but this asks about how LIKELY people would experience each item when doing physical activity. Q14, Q15. These are the hard questions. Note that we need respondents to put down average minutes per day (or hours if people cannot work out in minutes).

Section E: This section is about nutrition (fruit and vegetables). Many of these questions and statements are similar to those already used in the physical activity section but we also need a rating regarding fruit and vegetable consumption/behaviours and attitudes.

Section F: This section is about trusting and getting information (on physical activity).

Section G: Demographics.

Q20. Phone number for follow up research is totally voluntary.

## Conversions

Height:

imperial ->		metric
1 inch [in]		2.54 cm
1 foot [ft]	12 in	0.3048 m

Example: If someone is 1.6 metres tall:  $1.6 \div 0.3048 = 5.2$  (5 foot, 2 inches)

Example: If someone is 6 foot, 1 inch:  $6.1 \times 0.3048 = 1.9$  metres

Weight:

1 pound [lb]	16 oz	0.4536 kg
1 stone	14 lb	6.3503 kg

Example: If someone is 67 kilograms:  $67 \div 6.3503 = 10.6$  stone

Example: If someone is 12.5 stone:  $12.5 \times 6.3503 = 79$  kg

Example: If someone is 112 pound:  $112 \times 0.4536 = 51$  kg

Minutes/Hours

Example: 2.5 hours of physical activity per day:  $2.5 \times 60 = 150$  minutes

Example: 8 hours of physical activity per day:  $8 \times 60 = 480$  minutes

Example: 13 hours of physical activity per day:  $13 \times 60 = 780$  minutes

## **Appendix D: OTA AUTECH Query**

Centre for Physical Activity and Nutrition Research  
Faculty of Health and Environmental Sciences  
AUT University

20 January 2005

To Whom It May Concern,

The Centre for Physical Activity and Nutrition Research has received raw data from a population-level, randomised mail-out survey. This was part of a larger study conducted by Sport and Recreation New Zealand (SPARC) and the New Zealand Cancer Society in June-December 2003. This is a high quality data set that will prove invaluable for examining the relationships between physical activity levels, environmental variables, and health outcomes in the New Zealand population. This data has been made available in kind for analysis to specific members of the Centre for Physical Activity and Nutrition Research. Unfortunately, consent to conduct the research was not gained from an ethical body at the time of data collection. All participants however, remain anonymous to Centre for Physical Activity and Nutrition Research members, and no information from the dataset identifies individuals. Analyses of the dataset will result in several submissions to academic journals for publication and two PhD thesis chapters.

Because of the retrospective nature of the data collection, we are not writing to AUTEK to apply for ethical consent, but instead to seek ethical guidance when proceeding with analysis. Any recommendations and comments AUTEK has regarding treatment of the data would most appreciated.

Regards,

Hannah Badland and Grant Schofield

**Appendix E: AUTC Approval for Test-retest Reliability Study of the  
AFES-TPA Pilot Survey**





**MEMORANDUM**  
**Academic Services**

To: Grant Schofield  
From: Madeline Banda  
Date: 20 December 2004  
Subject: 04/220 Active friendly environments: Transport-related physical activity questionnaire pilot testing and reliability

Dear Grant

Thank you for providing amendment and clarification of your ethics application as requested by AUTEK.

Your application was approved for a period of two years until 20 December 2006.

You are required to submit the following to AUTEK:

A brief annual progress report indicating compliance with the ethical approval given.  
A brief statement on the status of the project at the end of the period of approval or on completion of the project, whichever comes sooner.  
A request for renewal of approval if the project has not been completed by the end of the period of approval.

Please note that the Committee grants ethical approval only. If management approval from an institution/organisation is required, it is your responsibility to obtain this.

The Committee wishes you well with your research.

Please include the application number and study title in all correspondence and telephone queries.

Yours sincerely

A handwritten signature in black ink, appearing to read 'M. Banda', is written over a horizontal line.

Madeline Banda  
Executive Secretary  
AUTEK

cc: Hannah Badland, hannah.badland@aut.ac.nz

## **Appendix F: AFES-TPA Participant Feedback**

## **ACTIVE FRIENDLY ENVIRONMENTS AND TRAVEL SURVEY RELIABILITY STUDY FEEDBACK**

### **Background**

Thank you for participating in the reliability survey. The survey was conducted as a pilot survey as part of a PhD thesis, which seeks to investigate the relationships between environmental variables, facility accessibility, travel modes, and physical activity behaviour. The pilot survey served to determine the stability of the questions during a one week period as well as identifying potential comprehension issues. Thirty AUT employees completed both surveys.

The major survey will be conducted in April-May 2005 and is part of an initiative with the North Shore City Council (funded by Sport and Recreation New Zealand) to assist with understanding perceptions of the environment and travel behaviour. The survey will be conducted with approximately 2,000 North Shore residents. Some preliminary key findings from the pilot survey are presented below.

### **Transport and Travelling**

The average time that people reported as being reasonable to travel for transport using non-motorised modes was 30 minutes. Distance was the main barrier for walking or cycling to work, with only 17% people regularly walking to work. Driving was perceived as being quicker and more convenient when travelling to the convenience shop, although nearly half reported walking regularly (43%). Average travelling times reported were 30 minutes to work and 5 minutes to the convenience shop.

Please do not hesitate to contact me if you have any further queries regarding this survey. Your participation is much appreciated.

Regards,

Hannah Badland

## **Appendix G: AFES-TPA Pilot Survey**

## **AFES-TPA PILOT SURVEY RELIABILITY TESTING [TIME 1 & 2]**

### **INTRO [TIME 1]**

Good morning (or afternoon). My name is Hannah Badland and I am a PhD student in the Health and Environmental Sciences Faculty at AUT. Is now a convenient time to call, or would you prefer me to call back later?

I am conducting a pilot study to understand the perceptions of your neighbourhood environment and facilities and how you travel places. The survey is completely voluntary and entirely confidential. If you complete the survey it is deemed as consent. However, you are free to end the interview at any time. Should you withdraw from the survey, no data will be used from this interview. If you come to a question that you would prefer to not answer, just let me know and I'll skip over it. The survey will take about 15 minutes of your time, and will also need to be repeated sometime over the following week.

If you choose to complete both surveys you will receive a brief report detailing the main findings. Would you like to begin the first survey?

- 1 YES
- 2 NO  
IF (ANS=1) SKP QPE1

NOTAT Thank you for your time. Have a nice day.

OR

### **INTRO [TIME 2]**

Good morning (or afternoon). My name is Hannah Badland and I am a PhD student in the Health and Environmental Sciences Faculty at AUT. I am calling back to do the pilot survey regarding neighbourhood environment and facilities and how you travel places. Is now a convenient time to call, or would you prefer me to call back?

As before, the survey is completely voluntary and entirely confidential. If you complete the survey it is deemed as consent. However, you are free to end the interview at any time. Should you withdraw from the survey, no data will be used from this interview. If you come to a question that you would prefer to not answer, just let me know and I'll skip over it. The survey will take about 15 minutes of your time.

If you choose to complete the survey you will receive a brief report detailing the main findings. Would you like to begin the second survey?

- 1 YES
- 2 NO  
IF (ANS=1) SKP QPE1

NOTAT Thank you for your time. Have a nice day.

## TRANSPORT-RELATED PHYSICAL ACTIVITY SECTION

This series of questions ask about travelling to and from places.

- QAT1. In fine weather, how many minutes for you do think is reasonable to walk or cycle as a means of transport, if you had the time, could change your clothes, and did not need to transport anything?  
[NOTE TO INTERVIEWER: ASK FOR AN ESTIMATE IF THE RESPONDENT SAYS "I DON'T KNOW"]  
ENTER COUNT [ANSWER IN MINUTES]  
999 NO RESPONSE

The following questions ask about travelling to your usual convenience shop. Examples of convenience shops include dairies, supermarkets, or petrol stations. Think of your USUAL convenience shop and use that to answer the following questions.

- QAT2. What type of store is your usual convenience shop?  
1 DAIRY  
2 PETROL STATION  
3 SUPERMARKET  
4 OTHER  
999 NO RESPONSE  
IF (ANS<7) SKP QATQ3

QAT2a. SPECIFY OTHER [OPEN ENDED RESPONSE]

- QAT3. What is the approximate distance from home to your usual convenience shop?  
ENTER COUNT [ANSWER IN KILOMETRES]  
999 NO RESPONSE

- QAT4. How do you usually get to and from your usual convenience shop?  
[NOTE TO INTERVIEWER: CAN ONLY CHOOSE ONE TRAVEL MODE. DO NOT READ OUT THE LIST, USE ONLY AS PROMPTS]  
1 CAR  
2 MOTORCYCLE  
3 BUS  
4 WALK  
5 CYCLE  
6 CAR AND WALK  
7 BUS AND WALK  
8 OTHER  
999 NO RESPONSE  
IF (ANS>8) SKP QATQ5  
IF (ANS=4 or 5) SKP over QAT6 and QAT7

QAT4a. SPECIFY OTHER [OPEN ENDED RESPONSE]

- QAT5. How long does it usually take you to get to your usual convenience shop?  
[NOTE TO INTERVIEWER: TIME IN MINUTES FOR TRAVELLING ONE WAY]  
ENTER COUNT  
999 NO RESPONSE

QAT6. What would you say is the main reason that you do not walk or cycle to the convenience shop?  
 [NOTE TO INTERVIEWER: DO NOT READ LIST OUT]

1 POOR HEALTH/DISABLED  
 2 TOO TIRED/LACK ENERGY  
 3 DON'T ENJOY WALKING/CYCLING  
 4 BAD WEATHER  
 5 NOT SAFE TO WALK  
 6 NO FOOTPATHS  
 7 TOO REMOTE/LIVE IN COUNTRY  
 8 TOO FAR  
 9 TAKES TOO MUCH TIME/DRIVING IS QUICKER  
 10 OTHER  
 999 NO RESPONSE  
 IF (ANS<10) SKP QAT7  
 IF (ANS=8) SKP QAT8

QAT6a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QAT7. Do you think your usual convenience shop is within walking or cycling distance from home?

1 YES  
 2 NO  
 999 NO RESPONSE  
 IF (ANS>1) SKP QAT9

QAT8. How often do you walk or cycle to or from your usual convenience shop?

1 DAILY  
 2 AT LEAST ONCE A WEEK  
 3 ONCE A WEEK  
 4 AT LEAST ONCE A FORTNIGHT  
 5 AT LEAST ONCE A MONTH  
 6 LESS THAN ONCE A MONTH  
 7 NEVER  
 999 NO RESPONSE

We are interested in what the environment is like surrounding your convenience shop. For each of the following statements please answer yes or no.

QAT9. I know people who walk or cycle to the convenience shop.

1 YES  
 2 NO  
 999 NO RESPONSE

QAT10. If needed, I can always access car parking near the convenience shop.

1 YES  
 2 NO  
 999 NO RESPONSE

QAT11. Items purchased at the convenience shop are often too heavy or inconvenient to carry home.

1 YES  
 2 NO  
 999 NO RESPONSE

The next set of questions asks about travelling to and from your usual worksite or place of study. Think of your USUAL worksite or place of study and use that to answer the following questions.

- QAT12. Do you usually travel to and from a worksite or place of study?  
[NOTE TO INTERVIEWER: OCCUPATION=WORK/STUDY. WORKING FROM HOME IS NOT COUNTED AS TRAVELLING TO AN OCCUPATION]
- 1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QDM1
- QAT13. How do you usually get to and from your worksite or place of study?  
[NOTE TO INTERVIEWER: CAN ONLY CHOOSE ONE TRAVEL MODE. DO NOT READ OUT THE LIST, USE ONLY AS PROMPTS]
- 1 CAR  
2 MOTORCYCLE  
3 BUS  
4 FERRY  
5 WALK  
6 RUN  
7 CYCLE  
8 TRAIN  
9 CAR AND WALK  
10 BUS AND WALK  
11 FERRY AND WALK  
12 FERRY AND CYCLE  
13 FERRY AND TRAIN  
14 TRAIN AND WALK  
15 TRAIN AND CYCLE  
16 FERRY, TRAIN, AND WALK  
17 FERRY, TRAIN, AND CYCLE  
18 OTHER  
999 NO RESPONSE  
IF (ANS<18) SKP QAT14  
IF (ANS=5, 6, OR 7) SKP over QAT16, QAT17
- QAT13a. SPECIFY OTHER [OPEN ENDED RESPONSE]
- QAT14. How long does it usually take you to get to your worksite or place of study?  
[NOTE TO INTERVIEWER: TIME IN MINUTES FOR TRAVELLING ONE WAY]  
ENTER COUNT
- 999 NO RESPONSE
- QAT15. Do you need to travel across the Auckland Harbour to get to your worksite or place of study?
- 1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS=1) SKP QAT19  
IF (ANS=999) SKP QAT19



- QAT16. What would you say is the main reason that you do not walk or cycle to your worksite or place of study?  
[NOTE TO INTERVIEWER: DO NOT READ LIST OUT]
- 1 POOR HEALTH/DISABLED
  - 2 TOO TIRED/LACK ENERGY
  - 3 DON'T ENJOY WALKING/CYCLING
  - 4 BAD WEATHER
  - 5 NOT SAFE TO WALK
  - 6 NO FOOTPATHS
  - 7 TOO REMOTE/LIVE IN COUNTRY
  - 8 TOO FAR
  - 9 TAKES TOO MUCH TIME/DRIVING IS QUICKER
  - 10 OTHER
  - 999 NO RESPONSE
- IF (ANS<10) SKP QAT18  
IF (ANS=8) SKP QAT19
- QAT16a. SPECIFY OTHER [OPEN ENDED RESPONSE]
- QAT17. Do you think that you could access your worksite or place of study by travelling on foot or cycling?
- 1 YES
  - 2 NO
  - 999 NO RESPONSE
- IF (ANS>1) SKP QAT19
- QAT18. How often do you walk, run, or cycle to or from your worksite or place of study?
- 1 DAILY
  - 2 AT LEAST ONCE A WEEK
  - 3 ONCE A WEEK
  - 4 AT LEAST ONCE A FORTNIGHT
  - 5 AT LEAST ONCE A MONTH
  - 6 LESS THAN ONCE A MONTH
  - 7 NEVER
  - 999 NO RESPONSE
- QAT19. We are interested in looking at possible travelling routes to that occupation. Please let me remind you that all the information is confidential and anonymous. Could I please have the physical address of your occupation?  
[NOTE TO INTERVIEWER: STREET AND/OR SUBURB IS FINE]
- 1 YES
  - 2 NO
  - 999 NO RESPONSE
- IF (ANS>1) SKP QAT20
- QAT19a. ENTER NAME
- QAT19b. ENTER STREET
- QAT19c. ENTER SUBURB

The next statements are about the environment surrounding your occupation. For each of the following statements please answer yes or no.

- QAT20. I know people who walk or cycle to or from my worksite or place of study.
- 1 YES
  - 2 NO
  - 999 NO RESPONSE

QAT21. If needed, I can always access car parking at or near my worksite or place of study.

1 YES

2 NO

999 NO RESPONSE

# **DEMOGRAPHIC SECTION**

I now need to ask you some questions that give us a description of the people who participated in this survey. Please let me remind you that the information you tell us is confidential.

QDM1. What is your gender?

1 MALE

2 FEMALE

999 NO RESPONSE

QDM2. How tall are you without shoes on?

[NOTE TO INTERVIEWER: ANSWER IN CENTIMETRES]

ENTER ACTUAL COUNT

999 NO RESPONSE

QDM3. What is your weight without shoes on?

[NOTE TO INTERVIEWER: ANSWER IN KILOGRAMS]

ENTER ACTUAL COUNT

999 NO RESPONSE

QDM4. Which best describes your living arrangements?

1 SINGLE

2 MARRIED/LIVING WITH A PARTNER

3 SEPARATED/DIVORCED

4 WIDOWED

999 NO RESPONSE

QDM5. Which ethnic group(s) do you most identify with?

1 NEW ZEALAND EUROPEAN

2 NEW ZEALAND MAORI

3 SAMOAN

4 COOK ISLAND MAORI

5 TONGAN

6 NIUEAN

7 CHINESE

8 KOREAN

9 INDIAN

10 OTHER ASIAN (Filipino, Japanese)

11 BRITISH/EUROPEAN

12 SOUTH AFRICAN

13 OTHER

999 NO RESPONSE

IF (ANS<13) SKP QDMQ6

IF (ANS=999) SKP QDMQ6

QDM5a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QDM6. What age group do you belong to?

- 1 16—24 YEARS
- 2 25—30 YEARS
- 3 31—40 YEARS
- 4 41—50 YEARS
- 5 51—60 YEARS
- 6 61—70 YEARS
- 7 >70 YEARS
- 999 NO RESPONSE

QDM7. What is your highest academic qualification?

- 1 DID NOT FINISH HIGH SCHOOL
- 2 FINISHED HIGH SCHOOL
- 3 APPRENTICESHIP, DIPLOMA, OR TRADE CERTIFICATE
- 4 BACHELOR DEGREE
- 5 POSTGRADUATE DEGREE
- 999 NO RESPONSE

QDM8. Which ONE of the following best describes your main current employment situation?

- 1 FULL TIME PAID WORK
  - 2 PART TIME PAID WORK
  - 3 CASUAL PAID WORK
  - 4 VOLUNTARY WORK
  - 5 HOME DUTIES AND NOT LOOKING FOR WORK
  - 6 STUDENT
  - 7 UNEMPLOYED - LOOKING FOR WORK
  - 8 RETIRED
  - 9 PERMANENTLY UNABLE TO WORK
  - 10 OTHER
  - 999 NO RESPONSE
- IF (ANS<10) SKP QDM9  
IF (ANS=999) SKP QDM9

QDM8a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QDM9. APPROXIMATELY what is your combined household income before tax in the last 12 months?

[NOTE TO INTERVIEWER: THIS INCLUDES ALL BENEFITS AS WELL AS PAID INCOME FROM ALL SOURCES]

- 1 ZERO
- 2 <\$10 000
- 3 \$10 001-\$20 000
- 4 \$20 001-\$30 000
- 5 \$30 001-\$40 000
- 6 \$40 001-\$50 000
- 7 \$50 001-\$70 000
- 8 \$70 001-\$100 000
- 9 >\$100 001
- 999 NO RESPONSE

QDM10. Regardless if you drive, what level of access do you have to a personal motorised vehicle?

- 1 UNRESTRICTED
- 2 FREQUENT
- 3 LIMITED
- 4 NONE
- 999 NO RESPONSE

QDM11. Do you hold a current drivers licence?  
1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QDMQ14

QDM12. Does the nature of your occupation require the use of a motorised vehicle?  
1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QDMQ14

QDM13. Do you have unrestricted access to a company car?  
1 YES  
2 NO  
999 NO RESPONSE

QDM14. Which of the following best describes your dwelling situation?  
1 A HOUSE  
2 A FLAT/UNIT/APARTMENT  
3 A CARAVAN/TENT/CABIN/HOUSEBOAT  
4 OTHER  
999 NO RESPONSE  
IF (ANS<4) SKP QDMQ15  
IF (ANS=999) SKP QDMQ15

QDM14a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QDM15. How old is your home (i.e., usual place of residence)?  
1 0-10 years  
2 11-20 years  
3 21-35 years  
4 36-50 years  
5 >50 years  
999 NO RESPONSE

# CONCLUSION

THANKS Thank you for participating in this survey. I will contact you within the next week to repeat this survey [TIME 1].

OR

THANKS Thank you for participating in the survey. Your answers have assisted us in getting a clearer picture regarding physical activity in your community. I will email out a brief report to you in the next couple of weeks [TIME 2].

## **Appendix H: AFES Response Rate Summary**

AFE PROJECT SUMMARY RESPONSE RATE		
JOB NUMBER:	C101300029	
QUOTA:	2000	
QUOTA ACHIEVED:	2000	
ACTUAL FIELDWORK DATES:	1-30 April 2005	
TYPE OF RESPONDENT:	16+	
	Conversion	45%
	Response	22%
Rate per hour	1.41	
Average Interview Length (mins)	19.47	
Number of calls to each number	5	
<b>TOTAL SAMPLE SUPPLIED</b>	<b>17603</b>	
less Virgins		
less Virgins Quota Full	8406	
<b>A] TOTAL SAMPLE USED</b>	<b>9197</b>	
<b>NON APPLICABLES</b>		
Business/Residential Number	142	1.5%
Fax /Answer Machine	169	1.8%
Paging Service	1	0.0%
Non-Working Numbers	353	3.8%
	<b>664</b>	<b>7.2%</b>
<b>B] TOTAL USABLE CONTACTS MADE</b>	<b>8533</b>	
<b>RESPONDENT NON ELIGIBLES</b>		
<b>Kills</b>		
25/1 NE1- No one of correct age	405	4.4%
25/2NE2-Quota Full	161	
25/3 NE3- Not available for duration of survey	781	8.5%
25/9 NE9- Unsuitable for interview (language, etc)	470	5.1%
25/10 NE10- Already done survey	23	0.3%
Quota Full	28	0.3%
Failed Sample	189	2.1%
	<b>2057</b>	<b>22.4%</b>
<b>C] TOTAL ELIGIBLE CONTACTS MADE</b>	<b>6476</b>	
<b>RESPONDENT OUTCOMES</b>		
13/0 Refused interview	3026	32.9%
13/1 Refused to continue	36	0.4%
13/2 Refused during screener	2	0.0%
13/3 Refused during questionnaire	13	0.1%
13/5 Refused selected person	804	8.7%
13/6 Refused subject matter	194	2.1%
Engaged		0.0%
No answer		0.0%
Appointment not kept-soft		0.0%
Appointment not kept-hard		0.0%
Call back routine completed	401	4.4%
	<b>4476</b>	
<b>D] COMPLETED INTERVIEWS</b>	<b>2000</b>	
<b>*Conversion Rate</b>	<b>45%</b>	
<b>*Response Rate</b>	<b>22%</b>	

\* Response rate calculations (response=D/A; conversion=D/C)

## **Appendix I: AUTECH Approval for the AFES**



**MEMORANDUM**  
**Academic Services**

To: Grant Schofield  
From: Madeline Banda  
Date: 18 March 2005  
Subject: Ethics Application Number 05/40 Active friendly environments: North Shore City residents telephone survey.

Dear Grant

I am pleased to advise that the Auckland University of Technology Ethics Committee (AUTEC) approved your ethics application at their meeting on 14 March 2005. Your application is now approved for a period of three years until 18 March 2008.

I advise that as part of the ethics approval process, you are required to submit to AUTEC the following:

1. A brief annual progress report indicating compliance with the ethical approval given using form EA2 which is available online at [http://www.aut.ac.nz/research\\_showcase/pdf/appendix\\_g.doc](http://www.aut.ac.nz/research_showcase/pdf/appendix_g.doc) , including a request for extension of the approval if the project will not be completed by the above expiry date;
2. A brief report on the status of the project using form EA3 which is available online at [http://www.aut.ac.nz/research\\_showcase/pdf/appendix\\_h.doc](http://www.aut.ac.nz/research_showcase/pdf/appendix_h.doc) . This report is to be submitted either when the approval expires on 18 March 2008 or on completion of the project, whichever comes sooner.

You are reminded that, as applicant, you are responsible for ensuring that any research undertaken under this approval is carried out within the parameters approved for your application. Any change to the research outside the parameters of this approval must be submitted to AUTEC for approval before that change is implemented. Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this. To enable us to provide you with efficient service, we ask that you use the application number and study title in all written and verbal correspondence with us. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at [charles.grinter@aut.ac.nz](mailto:charles.grinter@aut.ac.nz) or by telephone on 917 9999 at extension 8860. On behalf of the Committee and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Madeline Banda  
Executive Secretary  
Auckland University of Technology Ethics Committee



## Appendix J: AFES

## INTRODUCTION

INTRO 1: This is \_\_\_\_\_ calling from AC Nielsen Market Research Company. I would like to speak to the person over 16 years of age with the next birthday in the household.

This is \_\_\_\_\_ calling from AC Nielsen Market Research Company. We are conducting a study funded by Sport and Recreation New Zealand (SPARC) and need to talk to as many residents as possible on the North Shore. Is now a convenient time to talk or would you prefer me to call back?

Interviewer: PRESS 1 TO CONTINUE

We are interested in the perceptions of your neighbourhood environment, how you travel places, and your health-related physical activity. [NOTE TO INTERVIEWER - We need both ACTIVE and NON-ACTIVE participants to avoid bias entering into our responses, please pursue those who appear to be declining participation because they "don't do anything"]

Interviewer: PRESS 1 TO CONTINUE

INTRO 2: [REINTRODUCE INTRO IF NECESSARY] This interview is completely voluntary and entirely confidential. The survey will take about 25 minutes of your time. You are free to end the interview at any time. Should you withdraw from the study; no data will be used from this interview. If you come to a question that you would prefer to not answer, just let me know and I'll skip over it.

Would you like to begin the survey?  
PRESS 1 to continue  
PRESS 2 to end

IF (ANS=2) SKP NOTQAT

[NOTE TO INTERVIEWER: 999=NO RESPONSE AND/OR DON'T KNOW]

## PERCEIVED ENVIRONMENT SECTION

We want to know about your perceptions of your neighbourhood. Think about your neighbourhood to answer the following questions. Please use a 1-5 scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.

QPE1. There are enough footpaths in my neighbourhood.  
1 STRONGLY DISAGREE  
2 DISAGREE  
3 NEUTRAL  
4 AGREE  
5 STRONGLY AGREE  
999 NO RESPONSE

QPE2. It is easy to walk from street to street in my neighbourhood.  
1 STRONGLY DISAGREE  
2 DISAGREE  
3 NEUTRAL  
4 AGREE  
5 STRONGLY AGREE  
999 NO RESPONSE

QPE3. It is safe to walk in my neighbourhood  
1 STRONGLY DISAGREE  
2 DISAGREE  
3 NEUTRAL  
4 AGREE  
5 STRONGLY AGREE  
999 NO RESPONSE

QPE4. There are a lot of steep hills in my neighbourhood that make walking difficult.

1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE5.	There are busy streets to cross when walking or cycling in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE6.	There are safe places to cross busy streets in my neighbourhood
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE7.	The footpaths are in good condition in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE8.	There are interesting views, buildings, or scenery in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE9.	The streets are well lit in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE

QPE10.	Overall, my neighbourhood is kept clean and tidy.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE11.	There is a high level of crime in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE12.	I often see people walking, jogging, or cycling in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE13.	There is heavy traffic in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE14.	The people in my neighbourhood are friendly.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE15.	Dogs frighten me when I walk in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QPE16.	Public transportation is easily accessible in my neighbourhood.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE

### ACCESS TO FACILITIES SECTION

This next set of questions asks about why you MAY or MAY NOT use your local physical activity and recreational facilities, parks or beaches. Think about your local area, and use that for the following statements. Please use a 1-5 scale for the following statements, where:

- QAF1. My local physical activity and recreational facilities, parks or beaches are easy to get to.
- 1 STRONGLY DISAGREE
  - 2 DISAGREE
  - 3 NEUTRAL
  - 4 AGREE
  - 5 STRONGLY AGREE
  - 9 DON'T KNOW
  - 999 NO RESPONSE
- QAF2. My local (physical activity and recreational) facilities, parks or beaches are safe.
- 1 STRONGLY DISAGREE
  - 2 DISAGREE
  - 3 NEUTRAL
  - 4 AGREE
  - 5 STRONGLY AGREE
  - 9 DON'T KNOW
  - 999 NO RESPONSE
- QAF3. My local (physical activity and recreational) facilities, parks or beaches are clean and well maintained.
- 1 STRONGLY DISAGREE
  - 2 DISAGREE
  - 3 NEUTRAL
  - 4 AGREE
  - 5 STRONGLY AGREE
  - 9 DON'T KNOW
  - 999 NO RESPONSE
- QAF4. I prefer to go to (physical activity and recreational) facilities, parks or beaches outside my local area.
- 1 STRONGLY DISAGREE
  - 2 DISAGREE
  - 3 NEUTRAL
  - 4 AGREE
  - 5 STRONGLY AGREE
  - 9 DON'T KNOW
  - 999 NO RESPONSE
- QAF5. There are affordable physical activity and recreational facilities in my local area.
- 1 STRONGLY DISAGREE
  - 2 DISAGREE
  - 3 NEUTRAL
  - 4 AGREE
  - 5 STRONGLY AGREE
  - 9 DON'T KNOW
  - 999 NO RESPONSE

The next few questions ask about your knowledge and use of specific facilities in your neighbourhood. For the following questions please indicate yes or no to the availability of these facilities in your neighbourhood and rate how often you use them.

QAF6. Are you aware of cycle lanes or cycle paths being readily available in your neighbourhood?

- 1 YES
  - 2 NO
  - 999 NO RESPONSE
- IF (ANS>1) SKP QAF6b

QAF6a. [IF YES] How often do you use them?

- 0 NEVER
- 1 AT LEAST ONCE A DAY
- 2 AT LEAST ONCE A WEEK
- 3 AT LEAST ONCE A MONTH
- 4 AT LEAST ONCE EVERY SIX MONTHS
- 5 AT LEAST ONCE A YEAR
- 999 NO RESPONSE

QAF6b. [IF NO] Would you use them if they were available?

- 1 YES
- 2 NO
- 999 NO RESPONSE

QAF7. Are you aware of public parks, walking tracks or beach walks being readily available in your neighbourhood?

- 1 YES
  - 2 NO
  - 999 NO RESPONSE
- IF (ANS>1) SKP QAF7b

QAF7a. [IF YES] How often do you use them?

- 0 NEVER
- 1 AT LEAST ONCE A DAY
- 2 AT LEAST ONCE A WEEK
- 3 AT LEAST ONCE A MONTH
- 4 AT LEAST ONCE EVERY SIX MONTHS
- 5 AT LEAST ONCE A YEAR
- 999 NO RESPONSE

QAF7b. [IF NO] Would you use them if they were available?

- 1 YES
- 2 NO
- 999 NO RESPONSE

QAF8. Are you aware of school gyms or pools open to the community on weekends being readily available in your neighbourhood?

- 1 YES
  - 2 NO
  - 999 NO RESPONSE
- IF (ANS>1) SKP QAF8b

QAF8a. [IF YES] How often do you use them?  
0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF8b. [IF NO] Would you use them if they were available?  
1 YES  
2 NO  
999 NO RESPONSE

QAF9. Are you aware of public swimming pools, beaches or lakes being readily available in your neighbourhood?  
1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF9b

QAF9a. [IF YES] How often do you use them?  
0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF9b. [IF NO] Would you use them if they were available?  
1 YES  
2 NO  
999 NO RESPONSE

QAF10. Are you aware of outdoor courts (e.g., netball, tennis), greens (e.g., bowling, golf courses), or playing fields being readily available in your neighbourhood?  
1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF10b

QAF10a. [IF YES] How often do you use them?  
0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF10b. [IF NO] Would you use them if they were available?  
1 YES  
2 NO  
999 NO RESPONSE

QAF11. Are you aware of community halls or studios (eg dance or martial arts) being readily available in your neighbourhood?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF11b

QAF11a. [IF YES] How often do you use them?

0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF11b. [IF NO] Would you use them if they were available?

1 YES  
2 NO  
999 NO RESPONSE

QAF12. Are you aware of community recreation centres, health clubs, gyms or indoor courts (e.g., squash, badminton) being readily available in your neighbourhood?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF12b

QAF12a. [IF YES] How often do you use them?

0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF12b. [IF NO] Would you use them if they were available?

1 YES  
2 NO  
999 NO RESPONSE

QAF13. Are you aware of physical activity or recreational programmes being readily available at your local Church, Marae or other cultural and religious centres?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF13b

QAF13a. [IF YES] How often do you use them?

0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF13b. [IF NO] Would you use them if they were available?

1 YES  
2 NO  
999 NO RESPONSE



QAF14. If you work or study, are you aware of showers, changing rooms, or bicycle storage facilities being readily available at that location?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF14b

QAF14a. [IF YES] How often do you use them?

0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF14b. [IF NO] Would you use them if they were available?

1 YES  
2 NO  
999 NO RESPONSE

QAF15. Are you a member of a gym, health, sports, recreational club or group?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAF15c

QAF15a. Are you a member of a club or group that is located in your neighbourhood?

1 YES  
2 NO  
IF (ANS>1) SKP QAF15c

QAF15b. [IF YES] How often do you use it?

0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

QAF15c. [IF NO] Would you belong to a club or group if it was available in your neighbourhood?

1 YES  
2 NO  
999 NO RESPONSE

QAF16. Do you have home exercise equipment?  
[NOTE TO INTERVIEWER: HOME EXERCISE EQUIPMENT IS THINGS THAT CANNOT BE REMOVED FROM THE HOME, E.G., WEIGHTS, EXERCYCLE]

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QPAQ1

QAF16a. [IF YES] How often do you use it?

0 NEVER  
1 AT LEAST ONCE A DAY  
2 AT LEAST ONCE A WEEK  
3 AT LEAST ONCE A MONTH  
4 AT LEAST ONCE EVERY SIX MONTHS  
5 AT LEAST ONCE A YEAR  
999 NO RESPONSE

## PHYSICAL ACTIVITY SECTION

The following questions are about the time you spent being physically active in the last 7 days [EMPHASISE TIME PERIOD]. Think about activities at work, school or home, getting from place to place, and any activities you did for exercise, sport, recreation or leisure. I will ask you separately about brisk walking, moderate activities, and vigorous activities. Please answer each question even if you do not consider yourself to be an active person.

Think about the time you spent walking at a brisk pace during the last 7 days. A brisk pace is a pace at which you are breathing harder than normal. This includes walking at work or school, while getting from place to place, at home and at any activities that you did solely for recreation, sport, exercise or leisure.

QPA1. During the last 7 days on how many DAYS did you walk at a brisk pace for at least 10 minutes at a time (remember think only about brisk walking)?  
ENTER NUMBER  
999 NO RESPONSE (0 = None)  
IF (ANS=0) SKP QPAQ4  
IF (ANS=999) SKP QPAQ4

How much time did you typically spend walking at a brisk pace on EACH of those days?  
[NOTE TO INTERVIEWER: WE WANT THE ANSWER IN HOURS AND MINUTES, E.G., 6 HOURS AND 15 MINS]

QPA2. ENTER HOURS

QPA2a. ENTER MINUTES

QPA3. Where do you normally do most of your walking?  
1 NEIGHBOURHOOD STREETS  
2 WALKING TO YOUR OCCUPATION  
3 AT THE GYM  
4 AT THE MALL  
5 AT A PARK  
6 ALONG THE BEACH  
7 OTHER  
999 NO RESPONSE  
IF (ANS<7) SKP QPAQ4

QPA3a. SPECIFY OTHER [OPEN ENDED RESPONSE]

Now think about the physical activities that take moderate physical effort that you did in the last 7 days. Moderate activities make you breathe harder than normal, but only a little - like carrying light loads, or bicycling at a regular pace. Do not include walking of any kind.

QPA4. During the last 7 days, on how many DAYS did you do moderate physical activities? Again, think only about those physical activities that you did for at least 10 minutes at a time.  
ENTER NUMBER  
999 NO RESPONSE  
IF (ANS=999) SKP QPAQ6  
IF (ANS=0) SKP QPAQ6

How much time did you typically spend doing moderate physical activities on EACH of those days?  
[NOTE TO INTERVIEWER: WE WANT THE ANSWER IN HOURS AND MINUTES, E.G., 6 HOURS AND 15 MINS]

QPA5. ENTER HOURS

QPA5a. ENTER MINUTES

Now think about vigorous physical activities which you did in the last 7 days. Vigorous activities make you breathe a lot harder than normal (huff and puff) - like heavy lifting, digging, aerobics, or fast bicycling.

QPA6. During the last 7 days, on how many days did you do vigorous physical activities? Remember to only think about those physical activities that you did for at least 10 minutes at a time.

ENTER NUMBER

999 NO RESPONSE (0 = None)

IF (ANS=0) SKP QPAQ8

IF (ANS=999) SKP QPAQ8

How much time did you typically spend doing vigorous physical activities on EACH of those days?

[NOTE TO INTERVIEWER: WE WANT THE ANSWER IN HOURS AND MINUTES, E.G., 6 HOURS AND 15 MINS]

QPA7. ENTER HOURS

QPA7a. ENTER MINUTES

QPA8. Think about all your activities over the last 7 days, including brisk walking. On how many days did you engage in at least 30 minutes of moderate activity (including brisk walking) that made you breathe a little harder than normal OR at least 15 minutes of vigorous activity that made you breathe a lot harder than normal?

ENTER NUMBER

999 NO RESPONSE (0 = None)

### **TRANSPORT-RELATED PHYSICAL ACTIVITY SECTION**

The next series of questions ask about travelling to and from places.

QAT1. How many minutes do you think is reasonable for you to walk or cycle as a means of transport?

[NOTE TO INTERVIEWER: ASK FOR AN ESTIMATE IF THE RESPONDENT SAYS "I DON'T KNOW". ASSUME RESPONDENTS HAVE THE TIME, COULD CHANGE THEIR CLOTHES, DID NOT NEED TO TRANSPORT ANYTHING, AND THE WEATHER WAS FINE]

ENTER COUNT [ANSWER IN MINUTES]

999 NO RESPONSE

The following questions ask about travelling to your usual convenience shop. Examples of convenience shops include dairies, supermarkets, or petrol stations. Think of your USUAL convenience shop and use that to answer the following questions.

QAT2. What type of store is your usual convenience shop?

1 DAIRY

2 PETROL STATION

3 SUPERMARKET

4 OTHER

999 NO RESPONSE

IF (ANS<7) SKP QATQ3

QAT2a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QAT3. What is the approximate distance from home to your usual convenience shop?  
ENTER COUNT [ANSWER IN KILOMETRES]

999 NO RESPONSE

QAT4. How do you usually get to and from your usual convenience shop?  
[NOTE TO INTERVIEWER: CAN ONLY CHOOSE ONE TRAVEL MODE. DO NOT READ OUT THE LIST, USE ONLY AS PROMPTS]

1 CAR  
2 MOTORCYCLE  
3 BUS  
4 WALK  
5 CYCLE  
6 CAR AND WALK  
7 BUS AND WALK  
8 OTHER  
999 NO RESPONSE  
IF (ANS>8) SKP QATQ5  
IF (ANS=4 or 5) SKP over QATQ6 and QATQ7

QAT4a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QAT5. How long does it usually take you to get to your usual convenience shop?  
[NOTE TO INTERVIEWER: TIME IN MINUTES FOR TRAVELLING ONE WAY]  
ENTER COUNT  
999 NO RESPONSE

QAT6. What would you say is the main reason that you do not walk or cycle to the convenience shop?  
[NOTE TO INTERVIEWER: DO NOT READ LIST OUT]

1 POOR HEALTH/DISABLED  
2 TOO TIRED/LACK ENERGY  
3 DON'T ENJOY WALKING/CYCLING  
4 BAD WEATHER  
5 NOT SAFE TO WALK  
6 NO FOOTPATHS  
7 TOO REMOTE/LIVE IN COUNTRY  
8 TOO FAR  
9 ACCESS STORE AS PART OF A TRIP-CHAIN  
10 TAKES TOO MUCH TIME/DRIVING IS QUICKER  
11 HAVE TO CARRY HEAVY OR AWKWARD ITEMS  
12 OTHER  
999 NO RESPONSE  
IF (ANS<12) SKP QATQ7  
IF (ANS=8) SKP QATQ9

QAT6a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QAT7. Do you think your usual convenience shop is within walking or cycling distance from home?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QATQ9

QATQ8. How often do you walk or cycle to or from your usual convenience shop?

1 DAILY  
2 AT LEAST ONCE A WEEK  
3 ONCE A WEEK  
4 AT LEAST ONCE A FORTNIGHT  
5 AT LEAST ONCE A MONTH  
6 LESS THAN ONCE A MONTH  
7 NEVER  
999 NO RESPONSE

We are interested in what the environment is like surrounding your convenience shop. For each of the following statements please answer yes or no.

QAT9. I know people who walk or cycle to the convenience shop.

1 YES

2 NO

999 NO RESPONSE

QAT10. If needed, I can always access car parking near the convenience shop.

1 YES

2 NO

999 NO RESPONSE

QAT11. Items purchased at the convenience shop are often too heavy or inconvenient to carry home.

1 YES

2 NO

999 NO RESPONSE

The next set of questions asks about travelling to and from your usual worksite or place of study. Think of your USUAL worksite or place of study and use that to answer the following questions.

QAT12. Do you usually travel to and from a worksite or place of study?

[NOTE TO INTERVIEWER: OCCUPATION=WORK/STUDY. WORKING FROM HOME IS NOT COUNTED AS TRAVELLING TO AN OCCUPATION]

1 YES

2 NO

999 NO RESPONSE

IF (ANS>1) SKP QBPA1

QAT13. How do you usually get to and from your worksite or place of study?

[NOTE TO INTERVIEWER: CAN ONLY CHOOSE ONE TRAVEL MODE. DO NOT READ OUT THE LIST, USE ONLY AS PROMPTS]

1 CAR

2 MOTORCYCLE

3 BUS

4 FERRY

5 WALK

6 RUN

7 CYCLE

8 TRAIN

9 CAR AND WALK

10 BUS AND WALK

11 CAR AND WALK

12 FERRY AND WALK

13 FERRY AND CYCLE

14 FERRY AND TRAIN

15 TRAIN AND WALK

16 TRAIN AND CYCLE

17 FERRY, TRAIN, AND WALK

18 FERRY, TRAIN, AND CYCLE

19 OTHER

999 NO RESPONSE

IF (ANS<19) SKP QAT14

IF (ANS=5, 6, OR 7) SKP over QAT15, QAT16, and QAT17

QAT13a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QAT14. How long does it usually take you to get to your worksite or place of study?

[NOTE TO INTERVIEWER: TIME IN MINUTES FOR TRAVELLING ONE WAY]  
ENTER COUNT

999 NO RESPONSE

QAT15. Do you need to travel across the Auckland Harbour to get to your worksite or place of study?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS=1) SKP over QAT16, QAT17, and QAT18  
IF (ANS=2) SKP QAT16  
IF (ANS=999) SKP QAT19

QAT15a. If it was allowed, would you consider travelling across the Auckland Harbour Bridge by walking or cycling to get to your worksite or place of study?

1 YES  
2 NO  
999 NO RESPONSE

QAT16. What would you say is the main reason that you do not walk or cycle to your worksite or place of study?  
[NOTE TO INTERVIEWER: DO NOT READ LIST OUT]

1 POOR HEALTH/DISABLED  
2 TOO TIRED/LACK ENERGY  
3 DON'T ENJOY WALKING/CYCLING  
4 BAD WEATHER  
5 NOT SAFE TO WALK  
6 NO FOOTPATHS  
7 TOO REMOTE/LIVE IN COUNTRY  
8 TOO FAR  
9 TAKES TOO MUCH TIME/DRIVING IS QUICKER  
10 HAVE TO CARRY HEAVY OR AWKWARD ITEMS  
11 OTHER  
999 NO RESPONSE  
IF (ANS<11) SKP QAT17  
IF (ANS=8) SKP QAT19

QAT16a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QAT17. Do you think that you could access your worksite or place of study by travelling on foot or cycling?

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAT19

QAT18. How often do you walk, run, or cycle to or from your worksite or place of study?

1 DAILY  
2 AT LEAST ONCE A WEEK  
3 ONCE A WEEK  
4 AT LEAST ONCE A FORTNIGHT  
5 AT LEAST ONCE A MONTH  
6 LESS THAN ONCE A MONTH  
7 NEVER  
999 NO RESPONSE

QAT19. We are interested in looking at possible travelling routes to that occupation. Please let me remind you that all the information is confidential and anonymous. Could I please have the physical address of your occupation?  
[NOTE TO INTERVIEWER: STREET AND/OR SUBURB IS FINE]

1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QAT20

QAT19a. ENTER NAME

QAT19b. ENTER STREET

QAT19c. ENTER SUBURB

The next statements are about the environment surrounding your occupation. For each of the following statements please answer yes or no.

QAT20. I know people who walk or cycle to or from my worksite or place of study.

1 YES

2 NO

999 NO RESPONSE

QAT21. If needed, I can always access car parking at or near my worksite or place of study.

1 YES

2 NO

999 NO RESPONSE

### **BARRIERS TO PHYSICAL ACTIVITY SECTION**

The following are a list of possible things that keep some people from being physically active. For each one, please indicate how much each influences your own activity level by using a 1-5 scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.

QBPA1. You lack energy or feel too tired.

1 STRONGLY DISAGREE

2 DISAGREE

3 NEUTRAL

4 AGREE

5 STRONGLY AGREE

999 NO RESPONSE

QBPA2. You lack time due to work pressures.

1 STRONGLY DISAGREE

2 DISAGREE

3 NEUTRAL

4 AGREE

5 STRONGLY AGREE

999 NO RESPONSE

QBPA3. You lack time due to family responsibilities.

1 STRONGLY DISAGREE

2 DISAGREE

3 NEUTRAL

4 AGREE

5 STRONGLY AGREE

999 NO RESPONSE

QBPA4. You suffer from health problems that stop you being physically active.

1 STRONGLY DISAGREE

2 DISAGREE

3 NEUTRAL

4 AGREE

5 STRONGLY AGREE

999 NO RESPONSE

QBPA6.	It costs too much.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QBPA7.	Facilities are too hard to get to.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QBPA8.	It's too hard to stick to a routine.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE
QBPA9.	There is no one to do physical activities with.
1	STRONGLY DISAGREE
2	DISAGREE
3	NEUTRAL
4	AGREE
5	STRONGLY AGREE
999	NO RESPONSE

## HEALTH SECTION

The following questions ask about your health status.

QHE1.	Have you ever been told by a doctor that you have any chronic or long-term health problems?
1	YES
2	NO
999	NO RESPONSE
	IF (ANS>1) SKP QDM1
QHE1a.	What would that be?
1	DIABETES (HIGH BLOOD SUGAR)
2	HEART DISEASE
3	HIGH BLOOD PRESSURE
4	STROKE
5	THROMBOSIS (BLOOD CLOT)
6	ARTHRITIS
7	EMPHYSEMA
8	OSTEOPOROSIS
9	BREAST CANCER
10	COLON CANCER
11	SKIN CANCER
12	OTHER CANCER
13	DEPRESSION
14	ANXIETY/NERVOUS DISORDER
15	OTHER (SPECIFY)
	IF (ANS<15) SKP QHE2
QHE1b.	SPECIFY OTHER [OPEN ENDED RESPONSE]



QHE2. Have you ever been told by a doctor that you have any OTHER (2nd prompt)  
chronic or long-term health problems?  
1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QDM1

QHE2a. What would that be?  
1 DIABETES (HIGH BLOOD SUGAR)  
2 HEART DISEASE  
3 HIGH BLOOD PRESSURE  
4 STROKE  
5 THROMBOSIS (BLOOD CLOT)  
6 ARTHRITIS  
7 EMPHYSEMA  
8 OSTEOPOROSIS  
9 BREAST CANCER  
10 COLON CANCER  
11 SKIN CANCER  
12 OTHER CANCER  
13 DEPRESSION  
14 ANXIETY/NERVOUS DISORDER  
15 OTHER (SPECIFY)  
IF (ANS<15) SKP QHE3

QHE2b. SPECIFY OTHER [OPEN ENDED RESPONSE]

QHE3. Have you ever been told by a doctor that you have any OTHER (final prompt)  
chronic or long-term health problems?  
1 YES  
2 NO  
999 NO RESPONSE  
IF (ANS>1) SKP QDM1

QHE3a. What would that be?  
1 DIABETES (HIGH BLOOD SUGAR)  
2 HEART DISEASE  
3 HIGH BLOOD PRESSURE  
4 STROKE  
5 THROMBOSIS (BLOOD CLOT)  
6 ARTHRITIS  
7 EMPHYSEMA  
8 OSTEOPOROSIS  
9 BREAST CANCER  
10 COLON CANCER  
11 SKIN CANCER  
12 OTHER CANCER  
13 DEPRESSION  
14 ANXIETY/NERVOUS DISORDER  
15 OTHER (SPECIFY)  
IF (ANS<15) SKP QDM1

QHE3b. SPECIFY OTHER [OPEN ENDED RESPONSE]

## DEMOGRAPHIC SECTION

I now need to ask you some questions that give us a description of the people who participated in this survey. Please let me remind you that the information you tell us is confidential.

QDM1. What is your gender?  
1 MALE  
2 FEMALE  
999 NO RESPONSE

- QDM2. How tall are you without shoes on?  
[NOTE TO INTERVIEWER: ANSWER IN CENTIMETRES]  
ENTER ACTUAL COUNT  
999 NO RESPONSE
- QDM3. What is your weight without shoes on?  
[NOTE TO INTERVIEWER: ANSWER IN KILOGRAMS]  
ENTER ACTUAL COUNT  
999 NO RESPONSE
- QDM4. Which best describes your living arrangements?  
1 SINGLE  
2 MARRIED/LIVING WITH A PARTNER  
3 SEPARATED/DIVORCED  
4 WIDOWED  
999 NO RESPONSE
- QDM5. Which ethnic group(s) do you most identify with?  
1 NEW ZEALAND EUROPEAN  
2 NEW ZEALAND MAORI  
3 SAMOAN  
4 COOK ISLAND MAORI  
5 TONGAN  
6 NIUEAN  
7 CHINESE  
8 KOREAN  
9 INDIAN  
10 OTHER ASIAN (Filipino, Japanese)  
11 BRITISH/EUROPEAN  
12 SOUTH AFRICAN  
13 OTHER  
999 NO RESPONSE  
IF (ANS<13) SKP QDM6  
IF (ANS=999) SKP QDM6
- QDM5a. SPECIFY OTHER [OPEN ENDED RESPONSE]
- QDM6. What age group do you belong to?  
1 16—24 YEARS  
2 25—30 YEARS  
3 31—40 YEARS  
4 41—50 YEARS  
5 51—60 YEARS  
6 61—70 YEARS  
7 >70 YEARS  
999 NO RESPONSE
- QDM7. What is your highest academic qualification?  
1 DID NOT FINISH HIGH SCHOOL  
2 FINISHED HIGH SCHOOL  
3 APPRENTICESHIP, DIPLOMA, OR TRADE CERTIFICATE  
4 BACHELOR DEGREE  
5 POSTGRADUATE DEGREE  
999 NO RESPONSE
- QDM8. Which ONE of the following best describes your main current employment situation?  
1 FULL TIME PAID WORK  
2 PART TIME PAID WORK  
3 CASUAL PAID WORK  
4 VOLUNTARY WORK  
5 HOME DUTIES AND NOT LOOKING FOR WORK  
6 STUDENT  
7 UNEMPLOYED - LOOKING FOR WORK

8 RETIRED  
 9 PERMANENTLY UNABLE TO WORK  
 10 OTHER  
 999 NO RESPONSE  
 IF (ANS<10) SKP QDM9  
 IF (ANS=999) SKP QDM9

QDM8a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QDM9. APPROXIMATELY what is your combined household income before tax in the last 12 months?  
 [NOTE TO INTERVIEWER: THIS INCLUDES ALL BENEFITS AS WELL AS PAID INCOME FROM ALL SOURCES]

1 ZERO  
 2 <\$20 000  
 3 \$20 001—\$40 000  
 4 \$40 001—\$60 000  
 5 \$60 001—\$80 000  
 6 \$80 001—\$100 000  
 7 \$100 001—\$120 000  
 8 \$120 001—\$140 000  
 9 \$100 001—\$160 000  
 10 >\$160 000  
 999 NO RESPONSE

QDM10. Regardless if you drive, what level of access do you have to a personal motorised vehicle?

1 UNRESTRICTED  
 2 FREQUENT  
 3 LIMITED  
 4 NONE  
 999 NO RESPONSE

QDM11. Do you hold a current drivers licence?

1 YES  
 2 NO  
 999 NO RESPONSE  
 IF (ANS>1) SKP QDM14

QDM12. Does the nature of your occupation require the use of a motorised vehicle?

1 YES  
 2 NO  
 999 NO RESPONSE  
 IF (ANS>1) SKP QDM14

QDM13. Do you have unlimited access to a company car?  
 [NOTE TO INTERVIEWER: THIS INCLUDES BEING ABLE TO TAKE THE CAR HOME]

1 YES  
 2 NO  
 999 NO RESPONSE

QDM14. Which of the following best describes your dwelling situation?

1 A HOUSE  
 2 A FLAT/UNIT/APARTMENT  
 3 A CARAVAN/TENT/CABIN/HOUSEBOAT  
 4 OTHER  
 999 NO RESPONSE  
 IF (ANS<4) SKP QDM15  
 IF (ANS=999) SKP QDM15

QDM14a. SPECIFY OTHER [OPEN ENDED RESPONSE]

QDM15.	How old is your home (i.e., usual place of residence)?
1	0—10 years
2	11—20 years
3	21—35 years
4	36—50 years
5	>50 years
999	NO RESPONSE
QDM16.	For research purposes, can we please confirm your home address with you? Is it READ OUT ADDRESS HERE?
1	YES
2	NO
999	NO RESPONSE
	IF (ANS=1) SKP THANKS
	IF (ANS=999) SKP THANKS
QDM16a.	ENTER NUMBER
QDM16b.	ENTER STREET
QDM16c.	ENTER SUBURB
<b>CONCLUSION</b>	
THANKS	Thank you for participating in the survey. Your answers have assisted us in getting a clearer picture regarding physical activity in your community.
NOTQAT	Thank you for your time. I hope you will be able to participate in future surveys.

## **Appendix K: Transport, the Built Environment, and Physical Activity: An Evidence-based Update**

## Transport, urban design, and physical activity: an evidence-based update

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### Abstract

The urban environment and modes of transport are increasingly being linked to physical activity participation and population health outcomes. Much of the research has been based on either health or urban design paradigms, rather than from collaborative approaches. Previous health reviews in the urban design area have been constrained to perceptions of the neighborhood or walking behaviors, consequently limiting the understanding of built environment influences on physical activity modalities. This review focuses on existing evidence surrounding various urban design factors and physical activity behaviors. Based on the available evidence, fostering suitable urban environments is critical to sustaining physical activity behaviors. In turn, these environments will provide part of the solution to improving population health outcomes. Key urban design features attributable to transport-related physical activity are density, subdivision age, street connectivity, and mixed land use. Future directions for research include consistent use of transport and health measurement tools, an enhanced understanding of traffic calming measures, and further collaborative work between the health, transport, and urban design sectors. Presenting these findings to transport and urban design audiences may influence future practice, thereby increasing the sustainability of health-related physical activity at the population level.

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## 1. Introduction

Sedentary lifestyles in industrialized countries are increasingly becoming a major health risk, and it is estimated that insufficient physical activity causes 1.9 million deaths worldwide annually (World Health Organization, 2004, Department of Health Physical Activity and Health Improvement and Promotion, 2004). Local streets have been consistently identified as the most common place for engaging in physical activity (Giles-Corti and Donovan, 2002a, Brownson et al., 2001), with a substantial body of evidence linking leisure time physical activity (LTPA) and transport-related physical activity (TPA) to built environment and transport fundamentals.

Over the last few decades, immense urban changes have occurred in many industrialized countries, including reduced population density in cities and increased sprawl of housing, resulting in the residential migration to suburban developments (Frank, 2000). In many cases, urban design has caused a population-level reliance on automobiles for daily travel (Land Transport Safety Authority, 2000), reduced accessibility to facilities (Estabrooks et al., 2003), and alterations of community perceptions and cohesion (Timperio et al., 2004). Concurrently, many countries are reporting low physical activity levels and increases in obesity prevalence (World Health Organization, 2004). Although the link between the urban environment and health has been established, understanding the impact of the built environment on physical activity behavior has been inadequately addressed by both the health and transport sectors.

Health promotion, transport, and urban design policies all have similar objectives. These are to produce practical, cost-efficient, and successful interventions that apply to a broad cross-section of the population. Urban design principles can easily be aligned with ecological health models to increase incidental physical activity, and therefore total energy expenditure. Examples of these collaborative approaches include restricting city blocks to pedestrian only access, placing car parks away from building entrances, and making stairways more accessible and convenient. The aforementioned design modifications are conducive to physical activity, providing small individual changes. At the population-level, such changes could bring considerable long-term benefits, including reductions in healthcare expenditure, local traffic congestion, pollution, and infrastructure costs. Despite these advantages, the potential for such changes is based on a limited understanding of travel behavior influences.

Several general reviews of the built environment and physical activity relationship exist. Humpel et al. (2002) examined 19 studies in diverse settings, detailing consistent associations between physical activity and perceptions of accessibility, opportunities, and the aesthetics of the environment. Weaker relationships were demonstrated between weather and safety with physical activity, possibly due to the subjective nature of these variables. A strength of the paper was that the authors attempted to separate out aggregate environmental measures by isolating numerous variables that could potentially impact on physical activity levels. More recently, McCormack et al. (2004) examined 30 physical activity studies, and evaluated the findings under the broad categories of neighborhood functionality, safety, aesthetics, and destinations. The review added little to the existing body of knowledge, but reaffirmed previous findings detailed by Humpel et al. Another review focused on 18, predominantly cross-sectional, walking environment studies. Three of the four TPA studies detailed positive associations between walking for transport and open space access, higher composite environmental scores, and high neighborhood walkability (Owen et al., 2004).

Transport literature has also been evaluated from a public health perspective. One review by Sallis et al. (2004) provided the basis for merging urban design, transport, and physical activity at a policy level, but demonstrated limited exploration of previous evidence. Readers were directed to another paper where a small number of United States studies were evaluated (Saelens et al., 2003b). Consistent positive correlations existed between physical activity levels and mixed land use, density, and street connectivity. Although the previous general and transport-related physical activity reviews are comprehensive in their own right, all are primarily limited to cross-sectional designs, walking behavior, homogenous groups, and were reliant on small study numbers, subsequently limiting the amalgamation of knowledge from urban design and physical activity fields. The aim of the present paper is to build upon these previous reviews, as well as incorporating other relevant academic literature from health, urban design, and transport disciplines. This paper systematically draws together the evidence surrounding neighborhood differences and traffic calming effects based on urban design fundamentals, the impact of the localized environment for at risk populations, non-motorized travel characteristics, and measurement issues associated with merging physical activity, urban design, and transport research.

## 2. Neighborhood differences

Pre-World War II, cities were highly localized places that subsisted on the premise of low automobile ownership. The infrastructure that existed allowed daily requirements to be achieved within a comfortable walking distance, or with the combination of transit. Post-war economics led to increased disposable income and decentralization of cities to suburban centers and single land uses (Frank et al., 2003). As a result, automobiles are relied on for traveling the long inter-destination distances associated with suburban sprawl. Traffic congestion, single-occupant automobile travel, increased pollution, rising infrastructure costs, and degeneration of communities have now become serious concerns for transport sectors in developed nations (Lavisso-Mourey and McGinnis, 2003, Frank et al., 2003). Consequently, in many urban environments physical activity opportunities have shifted from TPA to LTPA.

Subdivision age has been used as a proxy measure of urban form. Older urban environments often show increased walkability because of higher population and building density, grid street design, complete sidewalks, and mixed land use diversity associated with pre-World War II necessities (Berrigan and Troiano, 2002, Handy and Clifton, 2001, Handy et al., 2002). At the disaggregate level, living in older homes has been associated with walking. Adjusted findings indicated that residents in pre-1973 dwellings walked at least one mile more, 20 times per month, when compared to those living in newer residences (Berrigan and Troiano, 2002). The non-specific walking associations existed for residents in urban and suburban neighborhoods, but not for those in rural areas and for other types of physical activity. Surprisingly, no discernable differences were shown in walking behavior between those dwelling in residences built pre-1946 and 1946–1973. Nevertheless, a relationship may have been evident if transport-related physical activity was specifically examined. In contrast, one study showed that residents in a newer neighborhood development demonstrated higher walking levels in comparison to residents in an older neighborhood (Leslie et al., *in press*). The anomaly could have been linked to differences in public



transport accessibility. Based on the presented evidence, it still remains to be determined if localized urban design is more influential than residential age (Table 1).

The mean age of a developed area (an informal proxy measure of sprawl) has also been associated with household non-motorized travel. Residents of older subdivisions make less automobile and more non-motorized trips than those in newer subdivisions. For example, Friedman et al. (1994) compared Bay Area Transportation Survey travel data from pre- and post-World War II neighborhoods in San Francisco. Post-War suburban residents engaged in almost two more auto driver trips per day, and walked less than pre-War neighborhood residents (8% versus 15%, respectively). Comparison groups however were not adjusted by potential confounders and all data were self-report. To support this relationship further, three years of self-reported health and localized county sprawl have been investigated, with lower sprawl values indicating greater residential sprawl. Residents in areas one standard deviation above the mean county sprawl walked 14 min more for leisure each month compared to residents living in localities one standard deviation below. A reverse trend was shown with BMI, detailing a 0.085 kg/m<sup>2</sup> reduction with each standard deviation increase (Ewing et al., 2003). Leisure time walking behavior was the only variable investigated in the study, although other research has linked urban sprawl to TPA behavior (Table 1).

Studies repeatedly show that mixed land use diversity is the urban design variable most likely to affect the walkability of neighborhoods, primarily by influencing the accessibility and convenience of locations (Leslie et al., in press, Saelens et al., 2003a, Giles-Corti and Donovan, 2002b, Handy and Clifton, 2001). An Australian study detailed those who reported better access, mixed land use, density, and connectivity, resided in more walkable neighborhoods and were more physically active (Table 1). On a cautionary note, the low walkability neighborhood contained hillier topography and the residents reported reduced access to public transport (Leslie et al., in press). Nevertheless, residents' neighborhood walkability differences are estimated to be between 15–30 min (Sallis et al., 2004) and 70 min (Saelens et al., 2003a) per week, with the latter value based on a small pilot study. In practical terms, residents in high walkability neighborhoods accumulate current physical activity recommendations (30 min of moderate intensity activity on most days) at least one additional day per week.

### 3. Traffic calming

Modifying traffic patterns through calming mechanisms may be a logical way to influence physical activity levels. Traffic calming measures such as speed humps, traffic circles, and pedestrian refuges have merit as self-regulating automotive speed designs, and may provide opportunistic occurrences for non-motorized travel such as utilizing road closure thoroughfares and pedestrian crossings. Although traffic calming may increase activity opportunities, it is unknown what effect the devices have on modifying LTPA and TPA levels. It has been shown that traffic calming reduces pedestrian injuries, where the risk of injury or death for child pedestrians were significantly higher for traffic volume (OR = 14.30; 95%CI = 6.98–29.20) and high density curb parking (OR = 8.12; 95%CI = 3.32–19.90) in a case-control study (Roberts et al., 1995). Increases in pedestrian injuries were evident in streets that had greater than 10% curb space allocated for parking and 250 automobiles traveling the road per hour. The curb parking variable requires further

Table 1  
Environmental variable studies associated with neighborhood differences

Reference	Number Age Gender	Environmental variables	Setting	Physical activity behavior	Statistical adjustment	Significant associations
Berrigan and Troiano (2002)	<i>N</i> = 14,827 Adults <i>M</i> = 7117	Age of residence	Local neighborhood	Walking Leisure time physical activity	A, E, I, L, R, S	Age of residence was associated with urban walking frequency and all demographic variables apart from gender
Ewing et al. (2003)	<i>N</i> = 206,992 Adults <i>M</i> = unknown	Urban sprawl	Census tracts	Walking	A, E, R, S, SP, SS	Risk of increased BMI and hypertension, and decreased walking were associated with increased county sprawl
Friedman et al. (1994)	<i>N</i> = 7091 Adults <i>M</i> = unknown	Number of trips per household Travel mode per trip	Census tracts	Transport-related physical activity	None	Post-World War II suburbs were associated with residents making more automobile trips Pre-War suburbs were associated with residents using alternative transport modes
Leslie et al. (in press)	<i>N</i> = 87 Adults <i>M</i> = 23	Residential density Land use mix diversity Land use mix access Street connectivity Walking infrastructure Neighborhood aesthetics Traffic safety Level of crime	Local neighborhood	Walking	None	High walkability neighborhoods were associated with higher residential density, street connectivity, and land use mix
Saelens et al. (2003a, 2003b)	<i>N</i> = 107 Adults <i>M</i> = 50	Land use diversity Residential density Street connectivity Walking/cycling facilities Neighborhood aesthetics Traffic safety Level of crime	Local neighborhood	Walking and cycling	A, E	Those reporting mixed land use diversity, higher density, street connectivity, aesthetics, and safety were more likely to reside in high walkability neighborhoods

Statistical adjustment key: A = age, E = education, I = income, L = activity limitations, R = race/ethnicity, S = sex, SES = socioeconomic status, SS = smoking status, SP = sprawl.

Table 2  
Environmental variable studies with at risk populations

Reference	Number Age Gender	Environmental variables	Setting	Physical activity behavior	Statistical adjustment	Significant associations
Balfour and Kaplan (2002)	<i>N</i> = 883 Older adults <i>M</i> = 383	Traffic safety Loud noise Level of crime Presence of litter Presence of lighting Public transport accessibility	Local neighborhood	Overall and lower extremity functional loss	A, BRF, E, H, I, R, S	Residents that reported multiple neighborhood problems were associated with increased risk of overall and lower extremity functional loss Excessive noise, inadequate street lighting, and heavy traffic were associated with an increased risk of functional loss in residents
Estabrooks et al. (2003)	<i>N</i> = 133,046 Adults <i>M</i> = unknown	Availability of user pays physical activity facilities Availability of free physical activity facilities	Census tract	Facility accessibility	None	Availability of free physical activity facilities was positively associated with SES increases
Giles-Corti and Donovan (2002a, 2002b)	<i>N</i> = 1803 Adults <i>M</i> = 532	Spatial access to individual facilities Perceptions of the physical environment Use of facilities	Census tract	Walking Leisure time physical activity	A, E, I, NC, O, S	Time spent walking for transport was associated with low SES Sufficient physical activity, spatial access to facilities, facility use, and vigorous activity were associated with increases in SES
Langlois et al. (1997)	<i>N</i> = 1249 Older adults <i>M</i> = 560	Difficulty crossing the street Crossing controlled intersections in designated time	Local neighborhood	Walking	A, HO, MH, S, V	Low walking speed, required daily assistance, history of strokes, fractures, or diabetes, were associated with increased risk of difficulty in crossing the street
Roberts et al. (1997)	<i>N</i> = 13,423 Children <i>M</i> = unknown	Number of streets crossed	Environment between home and school	Walking and cycling	SCE	Increase in numbers of streets crossed was associated with increased age of child Increased household car ownership was associated with a reduced likelihood of a child walking to school

						Number of streets crossed by a child was inversely associated with household car ownership
Ross (2000)	<i>N</i> = 2482 Adults <i>M</i> = 1015	Number of days walked per week Vigorous activity participation	Census tract	Walking Leisure time physical activity	A, E, I, MS, R, S	Residents of low SES neighborhoods and neighborhoods with a high proportion of residents with college degrees were more likely to regularly walk
Takano et al. (2002)	<i>N</i> = 3001 Older adults <i>M</i> = 1312	Space near residence for a stroll Local park accessibility Tree-lined residential street Automobile and factory noise Level of crime Hours of sunlight Residential garden Public transport accessibility Communication with neighbors Preference to live in the community	Local neighborhood	Walking	A, L, MS, S, SES	Five year survival was associated with adequate neighborhood walking space, neighborhood parks and tree-lined streets, and preference to live in the community
Timperio et al. (2004)	<i>N</i> = 291 5–6 year old children <i>M</i> = 150 <i>N</i> = 919 10–12 year old children <i>M</i> = 424	Appropriate distance for child to walk Traffic safety Stranger danger Child and parental (proxy) perceptions of the neighborhood	Local neighborhood	Walking and cycling	SCE, SES	Heavy traffic, single car ownership, dog ownership, and adequate public transport were associated with increased walking and cycling Negative parental perceptions, lack of crossings, and proximal parks were associated with decreased walking and cycling

Statistical adjustment key: A = age, BRF = behavioral risk factors, E = education, H = health status, HO = housing, I = income, L = activity limitations, MH = mental health status, MS = marital status, NC = number of children (under 18 years old), O = occupation, R = race/ethnicity, S = sex, SCE = school clustering effects, SES = socioeconomic status, V = vision.

investigation however, as other research suggests that automobiles parked on the road increases the perception of pedestrian safety from street traffic (Frank et al., 2003).

#### 4. At risk populations

Interaction with the built environment is a key component of LTPA and TPA for children. Despite this, the opportunities presented are largely dependent on socioeconomic status (SES). Not surprisingly, Roberts et al. (1997) detailed a positive relationship between the number of streets crossed and chronological age, and a negative association between household vehicle ownership and reduced walking. Unfortunately, a more comprehensive understanding of children's travel behavior could not be determined as accompanied and unaccompanied child trips were not ascertained. Timperio et al. (2004) also supported the relationship between household automobile ownership and walking behavior in children. However, the findings were based on a low response rate (36%) and questionable research methodology, resulting in variable test-retest reliability measures (Table 2). Parental SES also influences residential location with many parents choosing to move to the suburbs on the premise of providing play areas and safe environments for children. As a consequence, unsupervised child active transport occurrences may be restricted because of inter-destination suburban distances (Sallis et al., 2004) and associated parental traffic concerns (Roberts, 1993), with travel modes of children strongly influenced by parental perceptions (Timperio et al., 2004). Perceived parental safety of the environment has also been related to reluctance of allowing children to play freely outside (Frank et al., 2003), where active childhood outdoor pursuits may be replaced with 'safer' sedentary activities where children can be monitored.

Many older adults also face health risks due to inactive lifestyles. The elderly take fewer trips overall by any transport mode, and their travel is largely dependent on automobiles (Federal Highway Administration and Bureau of Transportation Statistics, 1997, Land Transport Safety Authority, 2000). High suburban automobile speeds and incomplete sidewalks convey the perception that it is unsafe for elderly to use the local environment for walking (Lavery et al., 1996). For example, 99% of adult pedestrians aged 72 years or older could not cross electronically controlled street crossings in the allocated time, and 11% reported general difficulties crossing the road (Langlois et al., 1997). The findings were based on the time it took participants to walk 8 m down a corridor from a standing start. The test however, was not environment specific and potentially underestimated walking speeds.

A link has been established between self-defined neighborhood problems and functional loss in older populations (Table 2). One cohort study examined self-reported functional deterioration over a year and associated perceived neighborhood problems. Those who reported multiple neighborhood problems were more at risk of overall physical (OR = 2.23; 95%CI = 1.01–4.60) and lower extremity (OR = 3.12; 95%CI = 1.15–8.51) functional losses than elderly who reported no, or one neighborhood problem (Balfour and Kaplan, 2002). Inadequate street lighting was the greatest single neighborhood variable associated with functional loss, followed by excessive noise. Interestingly, limited accessibility to public transport was associated with elevated risk of functional deterioration, suggesting that accessibility and localized mobility may be critical to sustaining functional independence in older adults. Regardless of SES and baseline functional capacity, positive associations also exist between



longevity and favorable attitudes toward the community, walkable green spaces, and quality of residential streets (Takano et al., 2002).

The most pronounced urban design and transport differences exist around SES. A geographical information systems (GIS)-based study compared physical activity facilities with census tracts, indicating SES variances with facility accessibility. Significant unadjusted group differences existed regarding accessibility to free structured facilities, with low and medium SES tracts having less number of facility sites ( $4.5 \pm 2.3$  and  $4.9 \pm 2.6$ , respectively) in comparison to high SES census tracts ( $8.4 \pm 3.5$ ). The amount of user pay facilities however, were similar for all groups ( $3.1 \pm 1.5$ ) (Estabrooks et al., 2003). This is concerning, as low SES groups are least likely to have disposable income and are most at risk to suffer from chronic illnesses associated with physical inactivity.

In contrast, Australian researchers detailed residents in low SES census areas had better network access to facilities, including sidewalks, but were less likely to use them for LTPA. After adjusting for various confounding factors, significant associations were shown with low SES residents reporting increased walking for transport in comparison to their high SES counterparts, but were more likely to be classified as inactive (Giles-Corti and Donovan, 2002b). Caution should be applied when interpreting these data as the sample consisted predominantly of women, and was based on socio-economic extremities (Table 2). On the other hand, a multi-level analysis associated a higher level of leisure time walking in low SES groups with enhanced perceptions of convenience. This was purported as a potential normalization effect of the local environment, although potential confounders, such as automobile accessibility and public transport data, were not investigated (Ross, 2000).

## 5. Non-motorized transport

Recognized travel mode considerations include distance, modal speeds, costs, and convenience, although modal user characteristics warrant further investigation. Inter-destination design features such as density, accessibility, mixed land use, and street connectivity are also mitigating factors for engagement in non-motorized transport. A review of trip-chaining analyses of people in three European countries detailed commuting to education or work were the main bicycle traveling motives. As expected, the extent of bicycle network development was positively associated with bicycle use (Martens, *in press*). Other analyses indicate that cycling and walking in Europe were safer than other non-European industrialized countries. Specific urban design fundamentals linked to reduced European injury levels included traffic calming, automobile restrictions, extensive traffic education policies surrounding non-motorized transportation, and pedestrian and cyclist sensitive designs. Incorporating these design features and policies into future initiatives may be useful to encourage cycling, particularly in many non-European industrialized countries where cycling levels are low across all age groups (Goldsmith, 1992, Land Transport Safety Authority, 2000).

In non-European countries, potential causes of low cycling rates may be because of the lack of cycle corridors leading to practical destinations and residential proximity to cycle trails. To support this finding, Australian inner city residents who used and resided 1.5 km away from a cycle trail were more likely to use a cycle trail approximately one hour extra per person per week

( $p = 0.04$ ) than suburban users who lived between 1.5 and 5 km away from it (Merom et al., 2003). The cohort study also indicated that males and younger adults (18–34 years old) were more likely to have used the trail at least once (Table 3). Aside from accessibility and connectivity, negative correlates of bicycle use include heavy intersection traffic and the presence of steep hills (Troped et al., 2001). These last findings however, may not have been based on sufficient participant variability, as the cross-sectional sample was predominantly white and well educated. In the study, unadjusted significant positive relationships were shown with light traffic and mixed land use diversity, but were not evident in the adjusted models. Based on the presented information in Table 3, it appears that environmental variables are not strongly related to recreational cycling behavior.

Walking is the most common and preferred form of physical activity for the general population, and is the principle reason why numerous physical activity reviews that have focused on the behavior. Walking popularity likely stems from its accessibility, negligible equipment specialization, and acceptability as a form of exercise for various sub-populations (Siegel et al., 1995). Although it may be the most pursued form of physical activity, only a small portion of Australians engage in adequate walking for health benefits (Giles-Corti and Donovan, 2003). The study detailed one significant relationship between self-reported walking behavior and access to public open space. This is somewhat of an anomaly as an extensive body of research has reported significant relationships with the other study variables investigated. It is likely however, that research findings for walking are culturally specific. For example, Indian travelers without vehicles were simulated to engage in walking distances between 1.3 and 2.5 km, with distance discrepancies based on economic positions (Thamizh Arasan et al., 1996). In contrast, a cross-sectional study with limited statistical analysis, demonstrated that 8% of Americans did not think it was acceptable to walk any distance for transport (Rafferty et al., 2004). Rafferty et al. (2004) cited the three most common barriers associated with walking for transport were time inconveniences, poor weather, and substandard health. Conversely, trip distances were the most defining barrier when travel modes were limited (Thamizh Arasan et al., 1996).

## 6. Measurement tools

Public health researchers have predominantly been concerned with tracking activity changes, instead of measuring the contextual environment, whereas transport and urban design practitioners have spent little time focusing on non-motorized activity levels (Sallis et al., 2004). In order to ensure mutually beneficial research, urban design, transport, and physical activity objectives need to be integrated into comprehensive studies. In the first instance, measurement strategies need to be incorporated at a cross-sectional level with practitioners seeking to develop cohort studies that track behavior in differing environments. Table 4 outlines pertinent studies that have incorporated some of these measures in the study designs.

### 6.1. Audit tools

Audit tools show promise for collaborative approaches as they are relatively easy to use and can incorporate a large number of variables. Sallis et al. (1997) developed a 43-point scale that examined physical activity at home, in the neighborhood, and on frequently traveled routes.

Table 3  
Environmental variable studies associated with non-motorized transport

Reference	Number Age Gender	Environmental variables	Setting	Physical activity behavior	Statistical adjustment	Significant associations
Giles-Corti and Donovan (2003)	<i>N</i> = 1773 Adults <i>M</i> = 564	Presence of sidewalks Presence of trees Presence of sidewalks Land use diversity Access to river Access to public open space Access to beach Access to golf club Quiet surrounding roads Street lighting Dog ownership	Local neighborhood	Walking	A, E, I, NC, S	Access to public open space was associated with increased walking.
Merom et al. (2003)	<i>N</i> = 450 Adults <i>M</i> = 248	Recall of trail promotional campaign message Bicycle trail use	Suburb	Cycling	A, AR, MS, R	Inner city cyclists, males, trail launch, and recollection of baseline message were associated with increased cycling. Minimum daily temperature and rainy days were negatively associated with cycling.
Rafferty et al. (2004)	<i>N</i> = 3808 Adults <i>M</i> = 1512	Distance walked for transport	State-wide	Walking for transport	A, R, S	Men and African-Americans were more likely to walk for transport. Warmer seasons were associated with increases in walking for transport.
Troped et al. (2001)	<i>N</i> = 413 Adults <i>M</i> = 164	Presence of sidewalks Topography Level of crime Land use mix diversity Street lights Distance to trails Scenery Traffic safety Unattended dogs	County	Cycling for transport and recreation	A, SE, SO	Pleasant scenery, presence of street lights, neighborhood sidewalks, and no hills were associated with increased cycling for transport. Increased distance to trails was negatively associated with cycling for transport.

Statistical adjustment key: A = age, AR = residential area, E = education, I = income, MS = marital status, NC = number of children (under 18 years old), R = race/ethnicity, S = sex, SE = self-efficacy, SO = social support, TS = transit service.



Table 4  
Environmental variable studies that have utilized measurement tools

Reference	Number Age Gender	Environmental variable	Setting	Physical activity behavior	Statistical adjustment	Significant association with main outcome variables
Boarnet and Sarmiento (1998)	<i>N</i> = 769 Adults <i>M</i> = 377	Residential density Land use mix Street connectivity	Local neighborhood	Trips	None	Women were more likely to engage in non-work trips. Children and elderly were least likely to make non-work trips.
Cervero and Radisch (1996)	<i>N</i> = 1460 Adults <i>M</i> = unreported	Mixed land use diversity Modal travel use Street network length	Census tracts	Transport related physical activity	I, TS	Neo-traditional neighborhood residents were more likely to engage in non-motorized, non-work trips and make less daily automotive trips than suburban residents. Residents in mixed use, compact areas were more likely to access public transport by walking and cycling than residents in more sprawling areas.
De Bourdeaudhuij et al. (2003)	<i>N</i> = 521 Adults <i>M</i> = 270	Side walk quality Activity facilities Home activity equipment Residential density Land use mix diversity Land use mix access Street connectivity Walking/cycling facilities Aesthetics Traffic safety Level of crime Public transport accessibility	Local neighborhood	Physical activity	None	Increased quality of sidewalks was positively associated with an increased likelihood of minutes walking and moderate intensity physical activity for men. Enhanced accessibility to shops, public transport, and facilities were associated with increased minutes walking and moderate intensity physical activity for women. Vigorous activity was positively associated with proximity of activity facilities and home activity equipment.

Humpel et al. (2004a, 2004b)	N = 800 Adults M = 402	Residing in coastal versus non-coastal locations  Accessibility Convenience Traffic safety Aesthetics	Local neighborhood	Walking	A, E	Men residing in a coastal location who held positive perceptions of their neighborhood were more likely to engage in neighborhood walking than non-coastal men. Reduced accessibility to services was associated with an increase in neighborhood walking for women.
King et al. (2003)	N = 149 Older adults M = 0	Proximity to park Proximity to trail Land mix diversity Aesthetics Traffic safety Level of crime	Community	Walking Leisure time physical activity	None	Those who lived within walking distance of a trail, retail store, or park were more likely to have higher pedometer scores than those who did not live within walking distance. Neighborhood walkability scores increased as the number of destinations accessible by walking from home intensified.
Sallis et al. (1997)	N = 110 Adults M = 27	Home physical activity equipment Physical activity facilities Presence of sidewalks Hilly landscape Enjoyable scenery Level of crime	Local neighborhood	Physical activity	A, E, FA, HE, I, S	Presence of home equipment was associated with an increased likelihood of physical activity.
Wendel-vos et al. (2004)	N = 11541 Adults M = 5353	Neighborhood green space Neighborhood recreational space	300–500 m radius around respondent's home	Walking and cycling	A, E, S	Size of sports ground was associated with an increased likelihood in general bicycling in the 500 m radius. Size of parks was associated with an increased likelihood in bicycling for transport in the 300 m radius.

Statistical adjustment key: A = age, E = education, FA = facilities, HE = home equipment, I = income, S = sex, TS = transit service.

Although adequate test-retest reliability existed (0.68–0.89) and construct validity was supported, the only significant association once confounders were adjusted for, existed between home physical activity equipment and strength exercise (Sallis et al., 1997). Environmental characteristics measured by the Neighborhood Environment Walkability Scale (NEWS) also showed moderate to high test-retest reliabilities (0.58–0.80) in a predominantly Caucasian sample (Table 1). Those who reported higher density, land-use mix, connectivity, safety, and aesthetics, accumulated more physical activity as measured by accelerometers. High walkability residents also reported more TPA for errands than those in low walkability localities (85.2% versus 59.6%), although there were no differences in reported vigorous activity (Saelens et al., 2003a).

NEWS has also been used in two Australian studies. Significant adjusted relationships were shown with men who held more positive neighborhood perceptions and women who perceived greater accessibility were most likely to engage in neighborhood walking (Humpel et al., 2004a). NEWS also detected differences between high and low walkable neighborhoods, showing the greatest neighborhood variability for mixed land use diversity and least group differences for adequate street connectivity (Leslie et al., in press). Pikora et al. (2002) has also developed a simple, reliable audit tool to measure the local physical environment. The Systematic Pedestrian and Environmental Scan (SPACES) defined a neighborhood as a 400 m radius from a respondent's residence, and assessed components of functionality, safety, aesthetics, and destinations. Both the intra- and inter-reliability of the items in the SPACES audit were generally high, aside from subjective measures of attractiveness of the streetscape and difficulty in walking (Pikora et al., 2002).

## 6.2. Geographical information systems (GIS)

GIS is an objective spatial mapping tool that analyses layers of the built environment. It is gaining popularity in the health and urban design sectors with several studies incorporating this technology to provide an in depth objective analysis of the local environment. Pikora et al. (2002) incorporated GIS into the SPACES tool to ascertain geographic features of the audited environment. Similarly, GIS databases have been employed to measure green space around a respondent's residence (300–500 m radius) in an attempt to understand physical activity influences (Wendel-vos et al., 2004). The study reported no significant findings for walking, and the cycling behaviors were dependent on the radius around the respondent's home (see Table 4), reiterating the findings from Merom et al. (2003). Potential limitations of the study were that the GIS variables measured were restricted and the participants resided in exceptionally hilly terrain. Troped et al. (2001) also utilized GIS in a cycling study, showing a negative relationship between bicycle use and environmental variables (Troped et al., 2001) (Table 3).

GIS has also been used at a simulation level to model neighborhood pedestrian network connectivity (Randall and Baetz, 2001; Aultman-Hall et al., 1997). Modeling neighborhoods prior to development show promise for conceptualizing the urban environment relative to physical activity behaviors. Although several physical activity studies (both real and simulated) have used GIS, further attention is still required, including vigilant selection of information overlays to detect determinants of neighborhood level physical activity. The objectivity and level of detail of the tool

remains unsurpassed and many GIS uses remain untapped. Despite this, the cost and expertise required limits GIS uses to large, collaborative studies.

### 6.3. Self-report tools

Numerous physical activity questionnaires exist and have been used extensively in environmental research. The International Physical Activity Questionnaires (IPAQ) have been successfully used in environmental studies (Humpel et al., 2004b, De Bourdeaudhuij et al., 2003), and may show the most utility for international physical activity comparisons (Shephard, 2003). The IPAQ measure has shown acceptable international psychometric performance, reporting  $r = 0.80$  for reliability and  $r = 0.30$  for validity (criterion measure accelerometers) in adults (Craig et al., 2003). In one study, minutes spent walking were significantly correlated to environmental variables, although walking for transport or recreation could not be differentiated (Table 4). However, the IPAQ explained only minimal variance between reported physical activity and environmental correlates (De Bourdeaudhuij et al., 2003).

A common criticism of the short format seven-day IPAQ is that it is not sensitive enough to detect TPA (Humpel et al., 2004b, De Bourdeaudhuij et al., 2003). However, the long-form IPAQ scores higher activity level prevalence than other questionnaires, as it effectively accounts for transport, occupational, and recreational physical activity. Therefore, higher recommended activity guidelines may need to be devised if IPAQ is to be used systematically as a surveillance tool. On a cautionary note, the long form survey is lengthy and repetitive, making it costly for routine surveillance. Two studies have also found the IPAQ telephone protocol to over-report physical activity levels (Rutten et al., 2003, Rzewnicki et al., 2003).

Travel diaries have been used to form the basis of aggregate trip data. Current methods of self-report travel diary data appear to capture home-based travel better than work-based travel, potentially because work-related trips are underreported when trip chaining occurs (linking several travel modes to access one destination) (Fisher et al., 2004). Boarnet and Sarmiento (1998) used two-day travel diaries to estimate the number of residential non-work trips through regression modeling techniques. A complex non-significant relationship existed between socio-demographic and land use characteristics near the person's place of residence for non-work trips, and no relationship was established with work-related travel (Boarnet and Sarmiento, 1998). Limitations were that the sample was biased towards highly educated, white people, and the measured area was too confined to capture many non-work trips. Other research has also utilized travel diaries, with participants recording their three main transport trips from the previous day (Cervero and Radisch, 1996). Although the response rate was low (18%), a substantial amount of information was gathered, including travel means, origin and destination information, and trip length and time. Matched-pair non-work travel appeared to be more elastic than work-related travel and was strongly linked to household vehicle ownership.

### 6.4. Motion sensors

Motion sensors, such as pedometers and accelerometers are objective physical activity monitors that record ambulatory activity, and have been successfully implemented in environmental studies. King et al. (2003) found a positive association between women with higher pedometer step

counts and living within walking distances of a park, walking trail, or specific shops ( $p < 0.01$ ). Unadjusted findings demonstrated older women perceived that 20 min was an acceptable walking time to access destinations, and were more likely to walk when multiple destinations were present. Other research detailed a relationship between accelerometer measured minutes of physical activity, walkability of a neighborhood, and obesity prevalence. The relationship between residents' weight status and neighborhood walkability was weakened once other covariates were included (Saelens et al., 2003a).

Tudor-Locke et al. (2003) used accelerometers with children to understand energy expenditure differences between different travel modes to school. Annual energy expenditure differences between walking and being driven to school equated to 8840 calories for boys and 6640 calories for girls (Tudor-Locke et al., 2003). Similar findings for children were reported elsewhere (Cooper et al., 2003). In both cases, urban design variables were not measured, as the objectives were to establish energy expenditure associated with school related travel. Although physical activity studies often seek to incorporate motion sensors, limitations do exist. These include the lack of measurement sensitivity to certain types of body movements (such as cycling), and the cost of both the unit and attaching the sensors to the participants. Nevertheless, motion sensors show promise in urban design studies as they are portable, non-invasive, and easy to use.

Infrared sensors are common automated measurement devices used in transport research, but are limited in the field of physical activity. The sensors are vulnerable to reliability and validity issues regarding non-motorized travel modes, including only being able to measure one person at a time, disturbances by environmental conditions, inability to distinguish between modal activity and individuals, and inconsistencies in open spaces (Granner and Sharpe, 2004). A study comparing infra-red beam counters (IRBC) with direct observation in five parks demonstrated that the IRBC overestimated people using walking paths by 14–78% and underestimated pedestrian volume count by approximately 20% (Milat et al., 2002). Presently, infrared sensor applications are limited for measuring physical activity in an urban setting.

## 7. Limitations

Understanding the association between the built environment and physical activity behavior is a challenging task, but one that is gaining momentum. Australian (Humpel et al., 2004b, Owen et al., in press, McCormack et al., 2004, Pikora et al., 2003, Giles-Corti et al., 2003) and United States (Ewing et al., 2003, Brownson et al., 2004, Cervero and Duncan, 2003, Frank, 2004, Sallis et al., 2002, 2004) researchers are leading the way in built environment and physical activity research, however more detailed international perspectives are needed. The 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. A problem facing researchers in the area of urban design, transport, and physical activity is sampling and measurement inconsistencies between studies, making inter-study comparisons often impossible. This is evident in the presented tables where contradicting information is shown. Furthermore, the present review is confined to existing academic publications, and a paucity of research has been highlighted around trip chaining, traffic calming, and a comprehensive understanding of how the environment impacts on travel mode choices.

## 8. Future directions

An opportunity exists to combine and develop ecological models that may increase the understanding of transport and physical activity behaviors. Further investigation is needed first however, to understand perceived and real environmental barriers for different user groups, particularly low SES groups and those with limited vehicular accessibility. Urban and health planners need to prioritize settings that are most specific for these user-groups. Facility site selection and traffic calming mechanisms also need careful consideration to maximize population health outcomes. Parental environmental and safety concerns need to be targeted to encourage the sustainability of child non-motorized transport, and prospective research needs to investigate if travel modes utilized as a child track into adulthood.

This review supports the different urban design features that are conducive to discrete physical activity behaviors. However, we now need to understand which urban investments will maximize physical activity behaviors. Based on the presented evidence it appears that TPA shows the most promise in activity sustainability, but limited information is available regarding this behavior and much work remains in this field. Future prospective designs need to determine if individuals select their neighborhood, or if the relationship is reversed because of individual, social, economic, and logistical restrictions. This is a comment echoed by nearly all published urban design and physical activity research. Despite this, the present review goes some way to drawing together existing transport, built environment, and physical activity literature, however the complexity of the relationships need further systematic attention.

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**Appendix L: The Built Environment and Transport-related Physical  
Activity: What We Do and Do Not Know**

# The Built Environment and Transport-Related Physical Activity: What We Do and Do Not Know

Hannah M. Badland and Grant M. Schofield

*Background:* Leisure time physical activities have been a priority in recent years for many health practitioners, with transport-related physical activity (TPA) largely ignored. The urban environment has altered in the last few decades, increasing the reliance on automobiles. Simultaneously we have seen increases in obesity and other non-communicable diseases related to sedentary lifestyles. *Methods:* Information was sourced from major health databases. The remainder of the literature was directed from citations in articles accessed from the initial search. *Results:* Clear health benefits result from regular TPA engagement, with opportunities closely linked to accessible urban design infrastructure. 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. *Conclusions:* Existing evidence necessitates TPA research and promotion should be public health and urban design priorities. Collaborative research needs to incorporate prospective study designs to understand TPA behavior.

*Key Words:* urban design, transport, physical activity

## The Case for Transport-Related Physical Activity

Vehicle congestion, traffic accidents, and pedestrian fatalities have been the primary concerns for urban designers and transport researchers for many decades,<sup>1</sup> whereas public health officials have examined the relationship between the built environment and health status, namely respiratory health,<sup>2</sup> cardiovascular disease,<sup>3, 4</sup> and social capital.<sup>5</sup> Although these problems are worthy of attention, the burden of disease and subsequent mortality rate from physical inactivity is alarmingly high,<sup>6, 7</sup> and health practitioners are becoming increasingly concerned at the low physical activity levels within developed and developing countries, and resulting co-morbidities.<sup>6</sup> It is estimated that non-communicable diseases account for 60% of all deaths, and 47% of global burden of disease. These figures are expected to rise to 73% and 60%, respectively, by 2020,<sup>8</sup> in part because of the changing environment that supports sedentary lifestyles.<sup>9</sup> Increasingly, evidence is linking

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community design and the built environment to physical activity levels. Several recent comprehensive reviews<sup>10,11,12,13</sup> have identified aspects of urban design associated with activity behaviors. Following on from these, two inclusive reviews have specifically documented correlates of transport-related physical activity (TPA), both from health<sup>14</sup> and urban design<sup>15</sup> perspectives. The latter reviews pointedly demonstrate that TPA should become a public health priority, with the Task Force on Community Preventive Services<sup>16</sup> and the World Health Organization<sup>8</sup> further recommending environmental and policy approaches to increase physical activity levels. Accordingly, the US national health surveillance survey (Behavioral Risk Factor Surveillance Systems [BRFSS]) has been incorporating transport-related questions from 2001 onwards.<sup>17</sup> Although this is a worthy initiative, the current BRFSS survey cannot track TPA as the frequency and duration are not recorded independent to leisure time physical activity (LTPA). Despite this, the present review strengthens the case for focusing on TPA behavior by addressing pertinent urban design variables, travel behavior, and associated health outcomes.

## Current Transport Trends

Industrialized countries are becoming increasingly reliant on automotive travel. As cities become more sprawling and less connected, few realistic alternatives other than private automobile use are available.<sup>1,18</sup> Motorized travel now replaces many TPA journeys, existing as the main form of transport in many industrialized countries,<sup>19</sup> and ownership is increasing rapidly in developing nations, such as China.<sup>20</sup> Despite this trend, preliminary findings from the Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality (SMARTRAQ) survey detailed 40% of all current motorized trips in the area could reasonably be substituted with TPA travel. The survey reasoned replaceable journeys were for food, school transport, shopping, and entertainment.<sup>21</sup> Indeed, the World Health Organization suggests that transport policies should focus on promoting walking and cycling for trip distances less than 5 km.<sup>8</sup> Although non-motorized travel occurrences are reducing,<sup>22</sup> TPA promotion might be a realistic approach to accumulate physical activity, largely because of the combined and vested interest from transport and health sectors. Government organizations in industrialized countries are now beginning to understand the economic, social, and health impacts of automotive dependency.<sup>23</sup> TPA offers promise as a sustainable option, as it fulfils the dual purpose of physical activity and transport, while becoming a habitual transportation mode. Aside from being readily accessible for the majority of the population, cycling and walking are multifunctional modes of TPA, incorporating substantial health and transport benefits while causing no pollution. Each mode is cost efficient, both from an energy and infrastructure viewpoint when compared to relative automobile costs,<sup>8</sup> and is complementary to other travel modes. This is evident in transit, where a review using data sourced from the Netherlands, Germany, and the United Kingdom, indicated people would cycle up to 5 km to access transit facilities.<sup>24</sup> The acceptance of non-motorized travel as an acceptable transport mode varies by country, and is particularly evident when comparing travel-related cycling levels between non-European and northern European industrialized nations.<sup>22,24,25</sup> Travel differences also exist between first world countries and developing nations. In

China, 94% of adults regularly commuted to work via physical activity,<sup>26</sup> whereas 8% of United States adults perceived that it was unreasonable to walk for transport at all, and 45% would only walk between 0.25 and 1 mile for TPA.<sup>17</sup> Similarly, only 7% of Australians walked regularly for transport.<sup>27</sup> Those that had irregular or no access to an automobile were significantly more likely to walk for TPA.<sup>28</sup> Despite these findings, no comparative physical activity data were taken between TPA and LTPA engagers, and to our knowledge, no research has investigated physical activity differences between TPA and LTPA behaviors. Aside from a paucity of comparative data, TPA research has not been a focus for public health or transport researchers. There are several reasons for this. First, TPA modes are viewed as low-technical investments, which make up only a modest share in total traffic.<sup>1</sup> Second, as with any physical activity intervention, the individual exertion required might deter participants. Although this could be the case, the potentially shorter distances associated with commuting and participating in purposive activity, in conjunction with self-selected intensity, could act as incentives to engage in the behavior. Third, measurement issues are associated with TPA. Trips might be hard to measure, partly because they can exist as part of a trip-chain. Lastly, TPA behavior is dependent on existing localized built environment infrastructure and destination access. Although only limited non-motorized travel studies exist,<sup>14</sup> urban planners are acknowledging the importance of TPA as a means to reduce traffic congestion and pollution when traveling short distances,<sup>23,29</sup> while physical activity practitioners' view the behavior as a mechanism to increase habitual activity and improve population health outcomes.

## Transport-Related Physical Activity and Health

Aside from improving the cost-benefit ratio of travel, TPA could provide comparable health benefits when weighed against LTPA. Potential reasons include accumulation of small, regular doses of physical activity with individuals using TPA as a form of transport for traveling to and from destinations, doubling the physical activity exposure. Documented health outcomes associated with TPA include reduced body-mass index (BMI),<sup>30</sup> improved blood lipid profile,<sup>31,32</sup> lowered hypertension,<sup>26,33</sup> and all-cause mortality<sup>34</sup> in a variety of different populations. Indeed, those who partake in TPA often report little or no LTPA, but often convey superior health statuses when compared LTPA engagers. For example, men who actively commuted to work showed a weight reduction ( $r = -0.0075$ ,  $P = 0.07$ ), whereas those who only engaged in moderate intensity LTPA detailed no significant body mass diminutions ( $r = -0.0564$ ,  $P = 0.70$ ). On a cautionary note, no incremental correlations were presented regarding TPA intensity and duration with body mass.<sup>30</sup> A more recent study detailed Chinese adults who recorded the lowest blood pressure, engaged daily in 31 to 60 min of TPA, or TPA combined with LTPA, and men who completed 1 to 30 min of TPA daily were less likely to be overweight (OR = 0.70; 95% CI = 0.49 to 0.99) than those who engaged in the same duration of LTPA (OR = 0.89; 95% CI = 0.70 to 1.13).<sup>26</sup> Another study ( $N = 3708$ ) reported significant inverse associations with serum lipids and TPA, but not with LTPA.<sup>32</sup> A prospective study has also demonstrated reduced all-cause mortality for those who cycled to work (RR = 0.72; 95% CI = 0.57 to 0.91), even after controlling for LTPA, BMI, blood



lipid profile, smoking, and blood pressure.<sup>34</sup> A caveat of these findings, however, are that some potential confounders, such as activity frequency and duration, and total energy expenditure, were not controlled for in the aforementioned studies.

### Correlational Studies

Walking has been associated with health benefits.<sup>6</sup> A Japanese study tracked men ( $N = 6017$ ) in sedentary occupations for 59,784 person-years. Those who walked for 11 to 20 min ( $RR = 0.88$ ; 95%  $CI = 0.75$  to  $1.04$ ) and  $\geq 21$  min ( $RR = 0.71$ ; 95%  $CI = 0.52$  to  $0.97$ ) to work had a reduced relative risk of developing hypertension ( $\geq 160/95$  mm Hg). In practical terms, 1 case of hypertension was prevented for every 26.3 men who walked more than 20 min to work. No significant relationship was evident between LTPA and TPA.<sup>33</sup> This relationship, however, might be different for children. Using accelerometers as a criterion measure, those who walked to school accumulated significantly more step counts/min ( $712.0 \pm 206.7$ ) than children who were driven to school ( $629.9 \pm 207.2$ ). Boys who engaged in TPA were also more active after school and in the evening than boys who commuted by car. This relationship was not evident in girls.<sup>35</sup> As well as showing associations with chronic diseases and overall activity accumulation, an inverse relationship has been demonstrated between TPA and weight. Adults who habitually expended at least 10 MET h/wk actively commuting to work, but did not necessarily report vigorous exercise, demonstrated a reduction in body mass.<sup>30</sup> Consequently, researchers are now trying to ascertain a relationship between physical activity, obesity, and the built environment. This association is being addressed in the SMARTRAQ study. The multi-disciplinary study is the first to establish BMI and physical activity patterns within a household travel survey. Preliminary data show significant relationships with lower obesity rates with more compact, dense, mixed use, and transit-accessible neighborhoods and decreased time spent in an automobile and kilometers walked.<sup>21</sup> Other research documented Chinese people who own automobiles were 80% ( $P < 0.05$ ) more likely to be obese than individuals who did not. Men who acquired an automobile over an 8-y time period, on average, were also 1.8 kg heavier ( $P < 0.05$ ) than those who only had access to non-motorized transport. Chinese women reported a 0.4 kg increase also, but the relationship was not significant once adjusted for confounders.<sup>20</sup>

### Intervention Studies

TPA interventions have proved difficult to implement, largely because the success of the study is dependent on local urban infrastructure and individual adherence.<sup>14</sup> To our knowledge, no interventions to increase local shopping TPA exist, and only two TPA worksite commuting studies have been identified in the literature.<sup>31, 36</sup> A 10-wk Finnish intervention to increase TPA levels ( $N = 68$ ) for inactive employees yielded encouraging findings. Post mean walking and cycling trip distances were 3.4 km and 9.7 km, respectively, and approximately 85% of participants commuted to and from the workplace via TPA daily. No post-intervention adherence data were obtained, however. Positive physiological changes included improved blood lipid profiles,  $VO_{2max}$ , heart rate, and blood lactate.<sup>31</sup> Mutrie et al.<sup>36</sup> conducted a randomized controlled trial using the transtheoretical model of behavior change to encourage walking to and from work ( $N = 295$ ). At the conclusion, the intervention

group increased walking to work more than the control (OR = 1.93; 95% CI = 1.06 to 3.52). A promising finding was that 25% of the initial inactive intervention group remained physically active 1 y post-intervention.<sup>36</sup> To summarize, despite the lack of intervention data, existing evidence clearly demonstrates TPA is a viable tool to improve population health outcomes. Numerous cross-sectional studies show the importance of TPA as a valuable way to accumulate physical activity and the limited intervention studies show promise. Despite these benefits, it is imperative that we understand travel behavior before developing TPA interventions.

## Travel Behavior

To promote TPA modes, it is necessary to understand why and how individuals choose travel. TPA might not be primarily engaged in for health benefits, but instead reflect convenience, time, and other urban design factors relative to other travel modes. Based on this premise, individuals could tend to engage in whichever transport mode will be the most convenient to access destinations, and it is likely that time constraints and expediency might be influential in this contemporaneous environment. Urban designers, rather than public health practitioners, could have the greatest influence on TPA travel. Practically, to increase TPA levels in the built environment, urban design convenience factors, such as street design, residential and employment density, and mixed land use, need to be maximized to enhance the utility of TPA, making it a realistic alternative to other modes.

## Transport, Urban Design, and Physical Activity

Evidence supports that built environment modifications are a logical way to influence population-level behavior. For individuals to realistically engage in TPA, the environment needs to support convenient and efficient travel through urban design fundamentals. The association between the built environment and physical activity has long been recognized,<sup>37</sup> however, the collaboration of transport, urban planning, and health professionals is a relatively new phenomenon.<sup>14, 15</sup> Pertinent urban design variables are discussed in greater detail below.

### Street Design

Post-World War II, suburbanization commenced resulting in incorporation of unconnected street networks (cul-de-sacs) and reduced number of intersections, thereby replacing the finer-grained traditional grid design.<sup>22</sup> This increases the network distance to destinations and often makes non-motorized travel unrealistic. Accordingly, almost three times as much TPA activity occurs within urban settings, largely because of reduced connectivity within suburban neighborhoods.<sup>38</sup> For example, in the San Francisco Bay area, twice as many non-motorized trips were taken by TPA in the urban setting (19% versus 10%), and automobile use was 32% higher in suburban areas.<sup>39</sup> This reinforces the underlying assumption that finer neighborhood grains increase TPA travel.<sup>41</sup> Street design extends to cycling and walking paths. Well-connected bicycle networks exist in many northern European countries, providing practical links to destinations.<sup>25</sup> The high ratio of separate scenic cycling corridors in non-European industrialized countries, however, indi-

cates that the behavior has not become integrated in the transport system.<sup>42</sup> This has been reiterated at an international conference where cycling was viewed as a recreational activity, and its acceptance as a commuter vehicle in daily use was missing in many Westernized countries.<sup>43</sup> Despite this, a positive relationship exists between miles of bicycle pathways and percentage of cycle commuters in the US.<sup>44</sup> States that detailed higher cycle commuting levels reported more miles of cycle pathways leading to specific destinations.

### Density

The critical mass of population density influences transport in various ways. High-density areas have greater concentrations of trip-ends, thereby lessening trip length and distances through minimizing travel outside the localized area.<sup>45</sup> Substantial population density also ensures transit is financially feasible.<sup>46</sup> US cities typically have low density (14 people/hectare) and use buses and trains for 8% of travel, whereas Asian cities have 168 residents per hectare and utilize those transport modes for 30% of all trips.<sup>46</sup> Moreover, higher densities increase traffic congestion and make car parking prohibitive by increasing cost and restricting accessibility.<sup>47</sup> Density also shows an exponential association to TPA and transit,<sup>48,49</sup> and an inverse relationship with vehicle ownership,<sup>50</sup> and commuting use.<sup>51</sup> Specifically, employees with one automobile per household were more likely to use it for commuting purposes if they lived in a low-density neighborhood ( $r = 0.78$ ) versus an area with medium to high densification ( $r = 0.29$ ).<sup>51</sup>

### Mixed Land Use

Mixing residential and commercial properties within a localized area reduces distances to facilities, thereby increasing the perception of convenience.<sup>51</sup> Residents in high mixed use areas reported more time walking for errands than those residing in neighborhoods with limited mix land use,<sup>52,53</sup> and living within walking distances of shops ( $P < 0.01$ ) has also been positively associated with higher pedometer step counts.<sup>54</sup> Handy and Clifton<sup>55</sup> examined mixed land use and TPA in 6 neighborhoods. Traditional neighborhoods (pre-1950) averaged 215 stores within a 0.5 mile radius compared to 48 shops for the late modern areas (post-1970). Typically, 50% of trips to the shops from the traditional localities were walked, in comparison to 3% in the late modern neighborhoods.<sup>55</sup>

As well as engaging in more TPA, those who live in neighborhoods with increased land use mix are at reduced risk of being overweight or obese.<sup>21</sup> Frank et al.<sup>21</sup> detailed that for each quartile increase in land mix, there was a reduced likelihood (12.2%) of residents being classified as obese (OR = 0.88; 95% CI = 0.84 to 0.92). The study did not show a significant relationship between weight status and density. Cervero<sup>51</sup> also detailed that the presence of local shops might operate as a better predictor of TPA engagement than population density.

### Modal Choice

Choosing travel modes appears to be based on a complex relationship of socio-demographic characteristics and localized urban design. Transit use is primarily a product of trip destination density, mixed land use, and density. Specifically,



previous research has shown residents in traditional neighborhoods were more likely to carpool (9% versus 7%, respectively), engage in transit and TPA modes (19% versus 10%, respectively), and were less likely to travel to work from home by an automobile (69% versus 83%, respectively) when compared to residents of suburban neighborhoods.<sup>39</sup> Another study also reported a similar relationship with use of public transport. After controlling for confounders, those living in higher density, increased mixed land use neighborhoods reported increased use of rail stations for work purposes. A positive relationship was also evident with transit use and size of employment center.<sup>56</sup>

## Future Directions

Although substantial health benefits from TPA exist, there are many areas that require further research. Currently, much of the research is directed towards understanding how the built environment influences general physical activity. Future TPA initiatives should aim to identify locality and demographic differences, perceptions, environmental barriers, and trip origin and destination information. Comparisons of those who do and do not engage in TPA could also help to understand non-motorized travel by revealing key components of the behavior. Valid and reliable TPA measuring and tracking tools, such as questionnaires, accelerometers, and geographic information systems, need to be developed and incorporated into existing regular surveys to ascertain population level TPA data and health outcomes. Further work also needs to separate TPA from total activity before prospective study designs can be implemented. As such, much work remains to be conducted before TPA can be understood comprehensively.

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**Appendix M: Perceptions of Replacing Car Journeys with Non-motorized  
Travel: Exploring Relationships in a Cross-sectional Adult Population**





## Perceptions of replacing car journeys with non-motorized travel: Exploring relationships in a cross-sectional adult population sample

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### Abstract

**Objective.** Transport-related physical activity (TPA) has dramatically declined in the last 50 years. The purpose of this study is to establish the relationship between sociodemographics, overall physical activity levels, and TPA travel mode (walking and cycling), with the perception of replacing car journeys by means of non-motorized travel.

**Methods.** A nationally representative sample mail out survey ( $n = 7,894$ ) identified physical activity levels, perceptions of using non-motorized transport modes, and sociodemographics for a New Zealand adult sample.

**Results.** Overall, 21% of respondents strongly agreed that they could replace car journeys with TPA on at least 2 days per week. Respondents who reported higher activity levels were more likely to strongly agree with replacing car journeys than sedentary respondents. Personal income and education level were negatively associated with recognition of replacing car journeys. Respondents who recognized they could replace car journeys reported the highest prevalence for considering walking or cycling short distances.

**Conclusion.** Only a small percentage of people perceive they can replace car journeys with TPA. Current physical activity levels and socioeconomic status variables are associated with perceptions of replacing car journeys with TPA.

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**Keywords:** Transport-related physical activity; Car journey replacement; Travel behavior; Cycling; Walking

### Introduction

Despite the increasing importance of promoting a physically active lifestyle, activity levels are declining in many developed countries (World Health Organization, 2004) and can be partially attributable to dramatic increases in car dependency for traveling short distances (Frank et al., 2004). As such, there is considerable capacity to increase physical activity through substituting short car journeys with transport-related physical activity (TPA) (World Health Organization, 2004). Cycling and walking for transport are cost efficient, both from an energy and infrastructure viewpoint when compared to automobile costs (World Health Organization, 2004), and show substantial health benefits (Hu et al., 2002) (Hu et al., 2001) (Bo Anderson et al., 2000). Little is currently known, however, about the target

population segment for TPA-based interventions. Consequently, the aim of this study is to establish the relationship between sociodemographics, overall physical activity levels, and consideration of alternative non-motorized travel modes (walking and cycling), with the perception of replacing car journeys by means of TPA in adults.

### Methods

#### Questionnaire design and implementation

The survey instrument (Obstacles to Action Survey; OTA) was implemented in June and July 2003. The primary purpose of the OTA was to examine the barriers and motivators for physical activity engagement in adults. The OTA was conducted as a population level survey with case weights applied (adjusting for age, gender, ethnicity, and region) (Sullivan et al., 2003), and a sample of 14,000 households was randomly selected from the New Zealand electoral roll and sent the survey. The adult ( $\geq 16$  years of age) with the first birthday after June 1 in each household was invited to complete and return the questionnaire by mail. Overall, 7,894 surveys were eligible for the present analysis.

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Participants self-reported current physical activity levels (all purposes), consideration of walking/cycling short distances, perception of replacing car journeys with TPA, and sociodemographics. A full copy of the questionnaire is available online at [http://www.sparc.org.nz/research/pdfs/OTA\\_questionnaire.pdf](http://www.sparc.org.nz/research/pdfs/OTA_questionnaire.pdf). Participants provided informed consent and the host institution ethics committee approved the study retrospectively. The presented data are a secondary analysis of the OTA data set.

#### Physical activity measures

Participants recorded frequency of, and minutes engaged in, physical activity for all purposes for the 7 days preceding the survey. Vigorous intensity activity contribution was equated with moderate intensity activity by doubling the respondent's reported time participating in the former activities. Respondents were

classified into physical activity groups based on their adjusted activity levels. 'Sedentary' participants recorded no physical activity; 'insufficiently active' respondents reported <150 min, or <5 sessions, of physical activity; 'sufficiently active' participants recorded ≥150 min, and ≥5 sessions, of physical activity; and 'sufficiently active with additional vigorous activity' incorporated 'sufficiently active' requirements combined with both vigorous and moderate intensity sessions.

#### Non-motorized travel measures

Participants reported on a pre-defined question relating to car journey replacement; 'most weeks I could replace car trips by walking or cycling on at least 2 days (without too much difficulty)'. Responses were drawn from a 5-point Likert scale (1=strongly disagree to 5=strongly agree). 'Strongly disagree' and 'strongly agree' classes were used for statistical comparisons.

Table 1

Descriptive statistics of strongly disagreeing and strongly agreeing with replacing car journeys with TPA, and binary logistic regression analyses (unadjusted and mutually adjusted) for strongly agreeing with perceiving replacing car journeys with TPA in a New Zealand population representative adult sample surveyed in 2003

Variable	n <sup>a</sup>	Strongly disagree with replacing car journeys with TPA (%)	Strongly agree with replacing car journeys with TPA (%)	Categorization within strongly agree with replacing car journeys with TPA (%)	OR	95% CI	P value	Mutually adjusted OR	95% CI	P value
Gender										
Male	3,789	24.6	19.2	45.0	1.00	Referent		1.00	Referent	
Female	4,105	25.4	21.7	55.0	1.20	1.05–1.37	<0.01	1.15	0.98–1.35	0.08
Ethnicity										
Maori+Pacific	1,129	19.4	29.0	20.2	0.84	0.70–1.01	0.07	0.95	0.77–1.17	0.61
Asian	458	18.3	14.3	4.1	1.38	1.18–1.61	<0.001	1.39	1.16–1.65	<0.001
New Zealand European	5,771	26.3	19.7	71.1	1.00	Referent		1.00	Referent	
Other	466	28.1	15.9	4.6	1.80	1.49–2.17	<0.001	1.79	1.45–2.22	<0.001
Education										
No high school qualification	1,437	21.9	27.5	24.5	1.00	Referent		1.00	Referent	
High school qualification	2,479	23.2	20.9	32.1	0.51	0.43–0.61	<0.001	0.65	0.52–0.80	<0.001
Trade, diploma, certificate	2,423	26.5	19.7	29.6	0.55	0.46–0.65	<0.001	0.64	0.52–0.79	<0.001
University degree	1,476	29.3	13.4	12.2	0.65	0.55–0.77	<0.001	0.72	0.59–0.89	<0.01
Annual personal income (\$NZ)										
≤20,000	3,016	20.1	23.9	45.7	1.00	Referent		1.00	Referent	
20,001–40,000	2,092	28.0	19.4	25.8	0.55	0.47–0.65	<0.001	0.62	0.51–0.75	<0.001
40,001–70,000	1,397	30.9	15.7	13.9	0.68	0.59–0.78	<0.001	0.69	0.58–0.81	<0.001
70,001–100,000	268	34.6	12.7	2.1	0.63	0.55–0.72	<0.001	0.66	0.56–0.78	<0.001
>100,000	947	23.5	21.3	12.5	0.56	0.49–0.65	<0.001	0.63	0.53–0.75	<0.001
Age group										
16–24 years	1,247	20.2	24.0	18.5	1.00	Referent		1.00	Referent	
25–39 years	2,147	28.5	20.0	27.7	0.67	0.54–0.83	<0.001	0.92	0.72–1.19	0.54
40–54 years	1,429	27.1	18.4	24.8	0.67	0.54–0.83	<0.001	0.84	0.66–1.09	0.19
55–70 years	1,303	21.9	19.4	15.7	0.62	0.50–0.76	<0.001	0.84	0.66–1.07	0.16
>70 years	924	22.7	23.2	13.2	0.60	0.49–0.74	<0.001	0.80	0.62–1.02	0.07
Town size (# residents)										
<1,000	995	38.1	15.1	9.4	0.94	0.80–1.11	0.47	0.98	0.82–1.16	0.80
1,000–29,999	1,674	20.5	24.7	25.8	0.73	0.62–0.89	<0.001	0.73	0.62–0.87	<0.001
30,000–100,000	1,571	26.0	21.5	21.1	1.00	Referent		1.00	Referent	
>100,000	3,655	23.8	19.2	43.7	0.86	0.72–1.03	0.09	0.80	0.66–0.96	0.02
Physical activity level										
Sedentary	924	32.6	12.2	7.0	1.00	Referent		1.00	Referent	
Insufficiently active	2,352	25.7	16.5	24.1	1.26	1.12–1.41	<0.001	1.41	1.19–1.67	<0.001
Sufficiently active	1,208	27.1	22.9	17.0	1.35	1.20–1.52	<0.001	1.43	1.21–1.70	<0.001
Sufficiently active including moderate and vigorous activity	3,300	21.9	24.5	49.9	1.20	1.09–1.33	<0.001	1.26	1.07–1.50	<0.01

OR=odds ratio; CI=confidence interval.

<sup>a</sup> Sample size varies because of missing responses.

Table 2

Physical activity correlates for a New Zealand population representative adult sample surveyed in 2003 that strongly disagreed or strongly agreed with perceiving replacing car journeys with TPA

Variable	n	% Strongly disagree from overall sample regarding replacing car journeys with non-motorized travel	% Within strongly agree sample regarding replacing car journeys with non-motorized travel
Consider cycling for short distances			
Never	4,555	66.3	51.8
Sometimes	2,131	21.5	24.6
Often	1,208	12.2	23.7
Consider walking 1.5 km			
Never	1,018	19.5	7.0
Sometimes	2,716	36.4	24.8
Often	4,160	44.1	68.2

Respondents recorded their perceptions of cycling and walking for trips; 'for a short journey when the weather was fine and I had nothing to carry, I would...' (referring to cycling), or 'for a journey of 1.5 kilometers, when the weather was fine and I had nothing heavy to carry, I would...' (relative to walking). The 6-point Likert scales (1=not even consider cycling/walking to 6=almost always cycle/walk) were collapsed into three groups; never (1–2), occasionally (3–4), and frequently (5–6) consider cycling/walking.

#### Statistical analyses

Binary logistic regression modeling using SPSS Version 11.5 was employed to understand the relationships between the independent sociodemographic variables with the dichotomous dependent variable for the unadjusted and mutually adjusted models. The dependent variable had two levels; strongly agree and strongly disagree, with replacing car journeys by means of walking/cycling on at least 2 days per week.

#### Results

Overall, 21% strongly agreed, 17% agreed, 17% were neutral, 17% disagreed, and 25% strongly disagreed that they could replace car journeys with walking/cycling for at least 2 days per week. Unadjusted and mutually adjusted binary logistic models revealed significant negative relationships of perceptions of car journey replacement with socioeconomic status (SES) indicators (education level, income) (Table 1). Respondents who earned more, or were more educated, were less likely to identify they could replace car journeys with TPA compared to their respective referent categories. Positive trends existed between physical activity levels and replacing car journeys with TPA. Respondents who were sufficiently active were nearly one and a half times more likely to perceive replacing car journeys with TPA than sedentary participants.

Respondents who strongly agreed with replacing car journeys, when compared to those who strongly disagreed with replacing car journeys, were more likely to recognize walking and cycling as alternative transport modes for traveling short distances (Table 2).

#### Discussion

The major finding identified in this study is that only a small portion of the population strongly perceived they could replace car journeys with TPA. Before interventions can be developed,

work needs to occur within this preceding stage to positively shift population-level perceptions of TPA. Travel mode considerations also appear to be associated with physical activity levels. Those who engage in physical activity are at least 20% more likely to perceive replacing car journeys than sedentary respondents. Future TPA strategies need to target perceptual and behavioral changes for low active groups. Furthermore, the majority of respondents identified walking as an appropriate mode for traveling short distances. Cycling appears to be a less acceptable form of transport. Because of this, promoting walking rather than cycling may have greater efficacy as an alternative mode to car dependency for traveling short distances.

As well as current physical activity levels, SES variables have a substantial influence on TPA perceptions. This study identified inverse relationships between SES predictors and perceiving replacing car journeys with TPA. Similarly, an Australian study identified that low SES residents were more likely to report walking for transport when compared to high SES respondents (OR=1.33; 95% CI, 1.25, 1.42) (Giles-Corti and Donovan, 2002). SES and TPA engagement may be mediated by automobile accessibility. Low SES households generally have lower automobile ownership (Giles-Corti and Donovan, 2002), and an inverse relationship exists with number of cars available per household and non-motorized travel (US Department Transport Bureau and Transportation Statistics, 2003).

The main limitation of the study is that actual TPA engagement is not assessed; instead, the intention of replacing car journeys with non-motorized travel modes is measured. As such, the survey construction does not allow for separate analyses of TPA engagers versus the remainder of the sample. Other limitations include that all data are self-report, non-response bias potentially exists, the analysis cannot separate those who live proximal to destinations versus those who do not, and physical activity behavior is not classified into domains. Separating transportation, leisure time, and occupational physical activity may provide a more accurate depiction of the relationship between perceptions and engagement of TPA.

#### Conclusion

Future research should focus on understanding the association between overall activity levels with TPA and examine the relationship with SES, car accessibility, and TPA. By understanding these relationships better, TPA can be targeted appropriately as a sustainable form of physical activity. Indeed, walking short distances for transport appears to be an acceptable travel mode for a large portion of the adult population. The substantial challenge now remains for the majority of the population to incorporate TPA into their lifestyle.

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**Appendix N: Test-retest Reliability of a Survey to Measure Transport-related Physical Activity in Adults**

## Test-Retest Reliability of a Survey to Measure Transport-Related Physical Act...

Hannah Badland; Grant Schofield

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## Test-Retest Reliability of a Survey to Measure Transport-Related Physical Activity in Adults

Hannah Badland and Grant Schofield

**Key words:** intraclass correlation coefficient, nonmotorized travel, public health

Physical inactivity has been undisputedly recognized as a primary contributor to numerous chronic lifestyle diseases (Department of Health, Physical Activity, Health Improvement, & Promotion, 2004). Despite the importance and benefits associated with engaging in physical activity, overall levels are declining in many Westernized countries, primarily through decreasing levels of work-related, transportation, and home environment physical activity (Brownson, Boehmer, & Luke, 2005). The emerging understanding of the influence of the built environment on physical activity levels has drawn attention to transport-related physical activity (TPA) as a possible means to improve population activity levels (Saelens, Sallis, & Frank, 2003). Among adults, preliminary TPA findings are promising, with regard to health improvements such as reduced body mass index (Wagner et al., 2001), improved blood lipid profile (Hu, Pekkarinen, Hanninen, Tian, & Guo, 2001; Vuori, Oja, & Paronen, 1994), lowered hypertension (Hayashi et al., 1999; Hu et al., 2002), and decreased risk of all-cause mortality (Andersen, Schnohr, Schroll, & Hein, 2000). As such, it is important to effectively track TPA engagement within this population. The purpose of this study, therefore, was to examine a survey to measure TPA in an adult population.

TPA is recognized as a public health priority, with the Task Force on Community Preventive Services (Kahn et al., 2002) and the World Health Organization (World Health Organization, 2004) recommending policy ap-

proaches to increase nonmotorized travel modes for short distances. Despite recognizing the benefits from nonmotorized travel, no TPA-specific survey instruments presently exist. The International Physical Activity Questionnaires (IPAQ) provide a composite score that accounts for transport, occupational, and leisure time activity (Craig et al., 2003), but the IPAQ has been criticized as not being sensitive enough to detect TPA (De Bourdeaudhuij, Sallis, & Saelens, 2003; Humpel et al., 2004). The U.S. national health surveillance tool (Behavioral Risk Factor Surveillance Systems [BRFSS]) has also been used to examine TPA trends by incorporating transport-related activity questions (Rafferty, McGee, Petersmarck, & Miller, 2004). The current BRFSS survey cannot track TPA, however, as the frequency and duration are not recorded independent of leisure time physical activity. The present research details test-retest reliability of a newly developed, telephone-administered TPA survey for adults. This instrument examines barriers, perceptions, and current travel behaviors to place of work/study and local convenience shops. Demonstrated test-retest reliability of the Active Friendly Environments-Transport-Related Physical Activity (AFE-TPA) survey is essential for researchers to ensure confidence in reliability of scores from the instrument's findings.

### Method

#### Participants

Data for this study were collected from an adult sample ( $\geq 18$  years of age) of academic and allied employees ( $N = 30$ ) at a New Zealand university. A trained interviewer attempted telephone contact with every fifth staff member (as listed in the employee roll); 75 employees were contacted and invited to participate in the study (overall response rate 40%). The interviewer explained

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that the survey would be conducted with the participant again within the next 7 days. The primary reasons for not partaking in the study were that it was conducted during work hours and involved a time commitment from the participant. A sample of 30 adults ensured that appropriate test-retest confidence limits could be generated (intraclass correlation coefficient = 0.90; 95% confidence interval = 0.82–0.94) by fulfilling the minimal acceptable criteria of intraclass correlation coefficient (ICC) values above 0.7 (Baumgartner & Chung, 2001). The host institution ethics committee approved the study, and all participants provided informed consent. All respondents completed both surveys.

#### *APE-TPA Survey Development and Implementation*

The purpose of the APE-TPA telephone-based survey was to assess perceptions, barriers, and behaviors related to TPA. The survey schedule was informed by an extensive review of urban design and physical activity literature that identified pertinent analysis variables. Content validity was ascertained through consultation with three physical activity experts within the host university and several iterations of the APE-TPA survey. Survey comprehension was informally established, with the survey being conducted on colleagues prior to the pilot testing. Other than determining the total time acceptable for generic traveling by nonmotorized modes, the APE-TPA survey was separated by traveling to the usual local convenience shops and place of work/study. Relative to place of work/study or the convenience shops, respondents reported on typical travel modes, approximate time taken to access the destination, barriers to nonmotorized travel, and perceptions of TPA accessibility. Aside from distances and times, all responses were selected from a predetermined nominal scale. No other physical activity measures were taken. A copy of the APE-TPA pilot survey is available from the lead author on request.

#### *Data Collection*

Two trained interviewers telephoned participants in January and February 2005. Calls were made to each participant within normal work hours (8.30 a.m.–5.00 p.m.) and on weekdays (Monday–Friday) over a 3-week period. Test-retest periods varied between 3 and 7 days. This variation occurred, because it was often inconvenient to conduct the survey with the participant at the prespecified time and use of different retest periods strengthened the robustness of the reliability findings.

#### *Analyses*

After determining adequate variation within the data, a one-way ICC model was chosen, as all question

differences from time 1 (*t1*) to time 2 (*t2*) were assumed to be random between the testing sessions (Looney, 2000). The ICC value cut-off ranges were 0.0–0.20 (weak agreement), 0.21–0.4 (poor agreement), 0.41–0.6 (moderate agreement), 0.61–0.8 (substantial agreement), and 0.81–1.0 (almost perfect agreement; Landis & Koch, 1977). Overall, an ICC above 0.7 was considered an acceptable measure of test-retest reliability (Baumgartner & Chung, 2001). One-way analysis of variance (ANOVA) and Levene statistics were incorporated to further determine if systematic differences existed between the testing occasions based on statistical significance (Looney, 2000). All reliability analyses were conducted with SPSS 11.5 software, and confidence intervals were set at 95%.

## **Results**

The reliability scores for each survey question are presented in Table 1. The survey yielded acceptable correlations, except for two questions that focused on the social environment (see Table 1). The items "knowing others who walk or cycle to access the convenience shop(s)" (ICC = 0.67) and "knowing others who walk or cycle to access your place of work/study" (ICC = 0.69) were below the 0.7 threshold for acceptable reliability. Aside from these, the ICC values ranged from 0.79 to 1.00, representing substantial to almost perfect agreement, with most of ICC values above 0.9. These latter data indicate that respondents reported similar answers for both testing sessions. The nonsignificant ANOVA findings ( $p > .05$ ) for all questions provided evidence that there were no systematic differences between the testing occasions. The Levene statistic was used to test for homogeneity of variance. Aside from two questions ("what is the approximate distance to your convenience shop," and "do you know people who walk or cycle to the convenience shop"), all responses were  $p > .05$ ; therefore, the responses were normally distributed. The standard deviations between *t1* and *t2* were also similar (data not presented). Data presented in Table 1 show no differences in statistical trends between place of work/study and the convenience shop. Overall, the study sample, however, was not representative of the New Zealand adult population. Participants earned a higher household income, were more educated, and represented higher Asian and Indian ethnicities compared to population data (Statistics New Zealand, 2001; see Table 2).

## **Discussion**

The present study was a preliminary investigation to determine the reliability of a survey that measures

nonmotorized travel. In most cases, the AFE-TPA survey reported almost perfect test-retest reliability. Indeed, in three cases, it showed perfect agreement. Apart from two instances, the high ICC values indicate the tool has appropriate stability over time within this population (Baumgartner & Chung, 2001). The lower ICC values and wide confidence intervals shown for the two social environment questions are consistent with previous literature (Brownson et al., 2004) and may be caused by the subjectivity surrounding the measure. The nonsignificant ANOVA findings suggest no recurring differences between  $t1$  and  $t2$  for any of the questions (Looney, 2000) and further indicate the tool's

utility. Two questions however, were not normally distributed, and caution should be applied when interpreting the respective findings.

Despite establishing test-retest reliability and content validity of the tool, criterion validity has not been ascertained, primarily because accurately separating non-motorized travel from other physical activity behaviors (leisure time and occupational activity) is problematic. To compound this, TPA is often sporadic and may exist in traveling short distances that this survey cannot detect. Although objective measures (accelerometers or pedometers) may overcome problems associated with accumulated activity, it is nearly impossible to isolate the

**Table 1.** Test-retest reliability of the Active Friendly Environments-Transport-Related Physical Activity survey in a sample of adults

	<i>n</i>	ICC	95%CI	<i>F</i>	<i>p</i>	L stat.	<i>p</i>
<b>General</b>							
How many minutes is it reasonable for you to engage in walking or cycling for transport?	30	0.88	0.74–0.94	0.36	0.55	0.83	0.37
<b>Accessing the convenience shop</b>							
What type of store is your convenience shop?	30	1.00	1.00–1.00	0.00	1.00	0.00	1.00
What is the approximate distance from home to your convenience shop?	30	0.96	0.93–0.98	1.37	0.25	4.47	0.04
How do you usually get to/from your convenience shop?	30	0.97	0.93–0.98	0.07	0.80	0.24	0.63
How long does it take you to get to your convenience shop?	30	0.87	0.72–0.94	0.00	0.97	0.15	0.70
What is the main reason that you do not walk or cycle to or from the convenience shop?	30	0.97	0.93–0.98	0.07	0.80	0.24	0.63
Do you think your convenience shop is within walking or cycling distance?	30	0.93	0.86–0.97	0.26	0.61	0.52	0.47
How often do you walk or cycle to get to/from the convenience shop?	30	0.88	0.75–0.94	0.21	0.65	0.86	0.36
You know people who walk or cycle to the convenience shop	30	0.67	0.31–0.84	1.35	0.25	5.46	0.02
You can always access car parking at, or near the convenience shop	30	1.00	1.00–1.00	0.00	1.00	0.00	1.00
Items purchased at the convenience shop are too heavy to carry home	30	0.89	0.77–0.95	0.07	0.80	0.26	0.62
<b>Accessing place of work/study</b>							
How do you usually get to/from your place of work/study?	30	0.98	0.96–0.99	0.04	0.84	0.12	0.73
How long does it take to get to your place of work/study?	30	0.97	0.93–0.98	0.04	0.85	0.06	0.81
Do you need to travel across the Auckland harbor to get to your place of work/study?	30	0.88	0.75–0.94	0.21	0.65	0.86	0.36
What is the main reason that you do not walk or cycle to/from your place of work/study?	30	1.00	1.00–1.00	0.00	1.00	0.00	1.00
Do you think your place of work/study is within walking or cycling distance?	30	0.86	0.72–0.94	0.72	0.40	2.89	0.10
How often do you walk, run, or cycle to get to/from your place of work/study?	30	0.97	0.93–0.98	0.07	0.80	0.25	0.62
You know people who walk or cycle to/from your place of work/study	30	0.69	0.34–0.85	0.10	0.76	0.38	0.54
You can always access car parking at, or near your place of work/study	30	0.79	0.57–0.90	0.34	0.56	1.40	0.24

*Note.* *n* = sample size; ICC = intraclass correlation coefficient; CI = confidence intervals; *F* = variance ratio; L stat. = Levene statistic.

domain in which the activity occurred. Subsequently, small bouts of TPA may be undetected in this survey. Nevertheless, the present AFE-TPA survey provides insight to travel behaviors. Travel diaries, however, may show promise for determining convergent validity of the AFE-TPA survey. Boarnet and Sarmiento (1998) modeled travel modes using a 2-day travel diary ( $N = 769$ ). Findings showed that the diary method was more effective for measuring nonwork trips than commuting behavior. Conversely, other travel diary research has shown that detailed work-related travel information can be gathered, despite recording only the three main trips within each day (Cervero & Radisch, 1996). Regardless of the potential for travel diaries to assess convergent validity, these measures may prompt recall bias, and researchers have noted a high rate of noncompliance (Cervero & Radisch, 1996). Furthermore, the present survey also assessed a series of attitudinal factors that may not translate into travel behavior and are, therefore, not appropriate for convergent or criterion validity testing.

**Table 2.** Demographic profile of AFE-TPA survey participants

Characteristic	<i>n</i> <sup>a</sup>	%
Gender		
Male	11	37
Female	19	63
Ethnicity		
European	18	60
Maori	6	20
Indian	4	13
Asian	2	7
Age (years)		
18–24	1	3
25–30	8	27
31–40	7	23
41–50	5	17
51–60	7	23
61–70	2	7
Highest academic qualification		
Did not finish high school	1	3
Finished high school	3	10
Apprenticeship/diploma/trade certificate	4	13
Bachelor degree	9	30
Postgraduate degree	13	43
Combined household income (\$NZD)		
< \$20 000	1	3
\$20 001–30 000	0	0
\$30 001–40 000	3	10
\$40 001–50 000	3	10
\$50 001–70 000	4	13
\$70 001–100 000	10	33
> \$100 000	8	27

<sup>a</sup>Sample sizes vary because of missing data.

In this instance, test-retest reliability may be a better measure of the instrument's utility.

When developing a survey to be used for population surveillance, aside from having acceptable stability reliability, it is important to incorporate key correlates that have been associated with the behavior, while not becoming burdensome to the participants. With this in mind, the AFE-TPA survey was developed by identifying potential TPA associations and by its ability to be administered in a 5-min time frame. After making minor adjustments identified in the pilot study (reducing the cumbersome nature of one question and combining two questions), the AFE-TPA survey is ready for use in future population studies. The intended application of the AFE-TPA survey is to incorporate it into existing telephone-based physical activity surveillance systems to appropriately track nonmotorized travel behavior, thereby providing use for transport planners and public health and physical activity representatives. Collaborative approaches have been highly recommended (Orleans, Kraft, Marx, & McGinnis, 2003) to enhance public health outcomes, and the AFE-TPA survey is integral to developing sustainable alliances with multiple sectors. There is also scope for developing the AFE-TPA survey into a self-administered questionnaire to be used on different population subgroups. This is because the AFE-TPA survey is easy to comprehend and transport, it limits use of physical activity jargon, and it does not require long recall periods.

Extensions of the AFE-TPA survey include adapting the survey from telephone-administered to mail-based and developing a similar tool to determine behavior causality. To date, this survey can be used only within a cross-sectional context to understand correlates of TPA. Other limitations are that it has not undergone convergent or criterion validity testing and may be subject to self-report and nonresponse bias. The present study was also conducted on a relatively homogenous sample, and, as such, generalizability of the AFE-TPA survey is currently limited. Future studies should also seek to incorporate other potentially pertinent measures of the built environment and TPA (such as street connectivity, degree of mixed land use, and public transit accessibility) to provide a more comprehensive assessment of the behavior.

### Implications

This study contributes to the field of physical activity by providing the first reliable survey to measure TPA in adults. The AFE-TPA survey assists with understanding perceptions, barriers, and current transport modes in an adult population. As such, there is scope to incorporate the AFE-TPA survey into existing physical activity measures to track TPA travel. Further work is now needed to establish the validity of the AFE-TPA survey and ascertain the reliability of the tool with diverse populations.

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## Authors' Notes

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**Appendix O: Objectively Measured Commute Distance: Associations with  
Actual Travel Modes and Perceptions to Place of Work or Study in  
Auckland, New Zealand**

## Objectively Measured Commute Distance: Associations with Actual Travel Modes and Perceptions to Place of Work or Study in Auckland, New Zealand

Hannah M. Badland, Grant M. Schofield,  
and Philip J. Schluter

**Background:** Little is known about the relationships between objectively measured commute distance with actual and perceived transport-related physical activity (TPA) engagement. **Methods:** A telephone survey assessed travel behaviors to place of work/study within an adult sample ( $n = 772$ ) residing in New Zealand. **Result:** Overall, 50% of respondents perceived they could, and 10% of the sample actually did, use TPA modes to commute to their occupation for distances less than 5 km. Differences between TPA perceptions and engagement existed for all distance classifications, and prevalence declined as distances increased. **Conclusions:** Differences between TPA engagement and perceptions were evident. Actual and perceived TPA engagement levels declined as commute distance increased.

**Key Words:** Geographical information systems; physical activity; transport; occupation; adults

Motorized transport is now the dominant form of travel for the majority of developed countries, contributing in part to increased traffic congestion, air pollution, and diminishing community cohesion.<sup>1</sup> Simultaneously, physical inactivity is a major public health concern for these countries.<sup>2</sup> One potential solution to minimize problems associated with automobile reliance and physical inactivity is to promote transport-related physical activity (TPA) modes for traveling short distances. Research has shown individuals who engage in TPA modes have shorter self-reported network distances to their occupation than those who commute by automobile.<sup>3</sup> Although commute distance plays a pivotal role in transport modal choice, perceptions should also be considered. An Australian study reported that time travel perception was the most common barrier to TPA/transit engagement to university for employees and students, followed by perceived commute distance.<sup>4</sup>

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This study builds the commute distance evidence by using geographical information systems (GIS) route measures, actual travel mode, and TPA perceptions in relation to accessing place of work/study for the first time using an adult regional representative sample.

## Methods

### Study Sample

The Active Friendly Environments Survey (AFES) was implemented in a representative adult sample ( $\geq 16$  y of age) of North Shore City, (Auckland, New Zealand) residents in 2005. Participants were drawn randomly from the electronic telephone white pages and contacted through computer assisted telephone interview procedures. Overall, 2000 respondents were recruited (31% response rate). Consent was provided prior to participation and the Auckland University of Technology Ethics Committee approved the study.

### AFE Travel Mode Measures

The TPA component reported typical travel modes for commuting from residence to occupation. Respondents were asked "How do you usually get to and from your place of work/study?" Answers were collapsed into three travel mode categories: motorized, TPA, and transit/combined.

### AFE TPA Perceptions

Participants reported whether they recognized they could engage in TPA modes to access their occupation from their residence by responding yes or no to the question: "Do you think that you could access your place of work/study by traveling on foot or cycling?"

### Commute Distance

Commute distances between residence and place of work/study were calculated using ArcView version 9.1 OD Cost Matrix function GIS software. Residential and place of work/study addresses were obtained directly from respondents and geocoded. The shortest street network distance between the points was calculated in kilometers (km) for every resident. Distances were collapsed into four categories.

## Statistical Analysis

Proportions and exact associated confidence intervals were made based on the binomial assumption. Crude and adjusted relative risk estimates were made using binary logistic regression analyses. Statistical comparisons were made using SPSS version 11.5 and Stata version 8.0.

## Results

Overall, 772 respondents from the sample were eligible for analysis as they resided and engaged in an occupation within North Shore City. Motorized travel was the dominant mode of transport to access place of work/study (87%;  $n = 673$ ), followed by TPA (10%;  $n = 75$ ) and transit/combined (3%;  $n = 24$ ) travel modalities. Table 1 outlines the overall respondent profile, which was similar to North Shore City census data.<sup>5</sup>

A total of 75 people engaged in TPA to access their place of work/study, and 50% ( $n = 385$ ) of all respondents perceived they could access their occupation by TPA modes. Those age 30 y and under were more likely to engage in TPA modes to commute to place of work/study when compared to other age categories, and respondents with trade qualifications were more likely to engage in motorized transport relative to other education classifications. Women were more likely to recognize they could employ TPA modes for commuting to their occupation in comparison to men.

Figure 1 outlines the relationship between commute distance with actual and perceived TPA modes for accessing place of work/study. Participants' perception and actual use of TPA both showed declines as commute distances increased. Table 2 further reveals the likelihood of an individual traveling to work by TPA modes decreasing as commute distance increases.

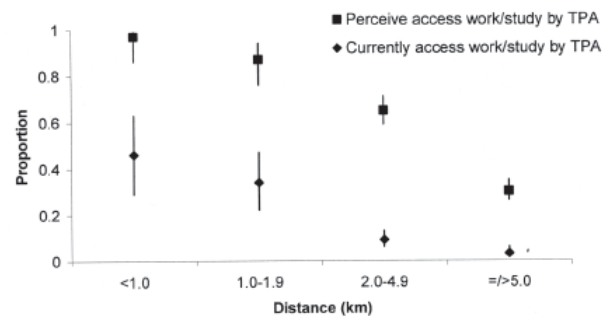
The group of importance for public health is those who do not use TPA, but perceive they can, therefore we excluded those who engaged in TPA modes for the final analysis. Perusal of Table 3 reveals a strong association between non-TPA mode respondents perceiving they could employ TPA modes to access their occupation and commute distance ( $P$ -value  $< 0.001$ ). The likelihood of these individuals perceiving they could use TPA modes to access their place of work/study decreased as commute distance increased.

## Discussion

This study confirms that individuals who lived closer to their occupation were more likely to actually, and perceive they could, engage in TPA modes to access their place of work/study. Perception prevalence levels were substantially higher than current TPA engagement. Almost all respondents (97%) identified they could use TPA modes to access their occupation for distances 1 km or less, however, less than half (46%) of this population currently employed TPA modes for this distance. Steady declines in TPA engagement and perceptions were also shown as commute distance increased. Despite the reduction in actual and perceived TPA engagement with longer distances, when the 5 km WHO TPA advocacy threshold<sup>1</sup> is applied to our findings, 47% of the adult working/studying population commuted within this distance parameter, 68% of this group perceived they could use, and 18% actually used, TPA modes for commuting purposes. As such, TPA promotion for up to 5 km appears to be a reasonable public health recommendation. These findings concur with previous research using an online survey with university staff and students ( $n = 2210$ ). Shannon et al.,<sup>4</sup> reported 30% of staff and students perceived they could replace their current motorized travel mode to university with TPA means,

Table 1 Demographic Profile of Adults Who Currently Access, and Perceive They Can Access, Place of Work/ Study by TPA Engagement

	Sample profile		Actual TPA engagement		Perceived TPA engagement		P-value
	n	(%)	n	(%)	n	(%)	
Gender							
Male	306	(40)	37	(49)	173	(45)	<0.01
Female	466	(60)	38	(51)	212	(55)	
Age (y)							
≤ 30	210	(30)	36	(51)	118	(34)	0.26
31-50	155	(22)	14	(18)	74	(21)	
51-70	194	(28)	9	(13)	95	(27)	
> 70	134	(19)	12	(17)	63	(18)	0.19
Ethnicity							
NZ European	500	(66)	53	(71)	262	(69)	0.35
Māori	36	(5)	5	(7)	18	(5)	
Pacific Island	12	(2)	3	(4)	8	(2)	
Asian	72	(10)	5	(7)	28	(7)	
Other	135	(18)	9	(12)	65	(17)	0.39
Education							
No high school	84	(11)	21	(28)	47	(12)	
High school only	169	(22)	20	(27)	82	(21)	
Trade, diploma, or certificate	204	(26)	8	(11)	93	(24)	<0.001
University degree or higher	315	(41)	26	(35)	163	(42)	
Household income (NZ\$)							
< 20,000	59	(9)	11	(18)	30	(9)	<0.05
20,000-40,000	106	(16)	11	(18)	45	(14)	
40,000-80,000	259	(39)	23	(38)	126	(38)	
80,000-120,000	161	(24)	13	(22)	85	(26)	
> 120,000	77	(12)	2	(3)	43	(13)	



**Figure 1**—Population proportions of actual and perceived access to place of work/study by TPA modes compared by commute distance.

with a strong relationship between commute distance, time travel, and travel mode evident. Our findings are consistent with other self-reported commute distance and travel modality findings.<sup>3</sup>

Although this study clearly showed the relationships between actual travel modes, perceptions of accessing place of work/study by TPA means, and commute distance, limitations were evident. These include the cross-sectional design, the small sample size, and basing perceptions and travel modalities on self-report. Measuring perceptions of TPA modes is problematic; recognition of TPA participation may not associate strongly with engagement. Nevertheless, perceptions serve to provide a rudimentary indication of TPA acceptance.

## Conclusions

There is considerable recognition of acceptability for TPA modes for distances 5 km or less. Substantial divergences, however, between travel behaviors and perceptions exist. Prospective work in this field should focus on shifting perceptions to behavior change and developing infrastructure that supports reduced commute distances.

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Table 2 Travel Mode Prevalence and Logistic Regression Models of TPA Engagement Defined by Commute Distance

Distance (km)	TPA travel		Motorized travel		Crude RR	95% CI	Adjusted RR <sup>a</sup>	95% CI
	n	(%)	n	(%)				
< 1.0	17	(23)	18	(3)	1.0	referent	1.0	referent
1.0 - 1.9	21	(28)	37	(5)	0.6	0.3 - 1.4	0.4	0.1 - 1.3
2.0 - 4.9	23	(31)	230	(34)	0.1	0.05 - 0.2	0.1	0.03 - 0.3
≥ 5.0	14	(19)	388	(58)	0.04	0.02 - 0.1	0.04	0.01 - 0.1

CI = confidence interval; km = kilometer; RR = relative risk

<sup>a</sup>RR adjusted by gender, age, ethnicity, education, and household income

Table 3 Travel Mode Prevalence and Logistic Regression Models of Perceiving Can Engage in TPA to Access Place of Work/Study Defined by Commute Distance

Distance (km)	Perceived TPA engagement				Crude RR	95% CI	Adjusted RR <sup>a</sup>	95% CI
	Yes		No					
	n	(%)	n	(%)				
< 1.0	17	(6)	1	(0)	1.0	referent	1.0	referent
1.0 - 1.9	29	(10)	8	(2)	0.2	0.02 - 1.9	0.4	0.05 - 4.3
2.0 - 4.9	137	(48)	93	(24)	0.1	0.01 - 0.7	0.1	0.02 - 1.1
≥ 5.0	103	(36)	285	(74)	0.02	0.003 - 0.2	0.04	0.02 - 0.3

CI = confidence interval; km = kilometer; RR = relative risk

<sup>a</sup>RR adjusted by gender, age, ethnicity, education, and household income

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