Public open space attributes in relation to children's independent mobility experience in urban neighbourhoods in Auckland, New Zealand

Moushumi Chaudhury

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Primary Supervisor: Associate Professor Melody Smith

Secondary Supervisor: Associate Professor Hannah Badland

Tertiary Supervisor: Professor Erica Hinckson

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List of abbreviations

Abbreviation	Definition
AUTEC	Auckland University of Technology Ethics Committee
CATI	Computer Aided Telephone Interviews
GIS	Geographical Information System
GPS	Global Positioning System
n	Sample size
NDAI	Neighbourhood Destination Accessibility Index
NDAI-C	Neighbourhood Destination Accessibility Index - Child
NH	Neighbourhood
NZ-POST	New Zealand-Public Open Space Tool
MUHEC	Massey University Human Ethics Committee
PCA	Principal Component Analysis
POST	Public Open Space Tool
POSAI	Public Open Space Attributable Index

SPSS	Statistical Package for the Social Sciences
UAHPEC	University of Auckland Human Participants Ethnics Committee

Glossary and key concepts

Active travel/transport

Active travel (i.e., walking and cycling for transport) has the potential to contribute significantly towards overall physical activity levels. Active travel can occur in a variety of settings, such as traveling to and from school, home and various other destinations in the neighbourhood (Oliver et al., 2015a).

In this study, active travel encompassed children travelling by a number of non-motorised travel modes, such as walking, cycling, scootering, skateboarding or any similar transport where human energy was spent in order to get from one place to another. Active travel to a destination without adult accompaniment corresponds to the concept of children's independent mobility (detailed below). Briefly, defined as the freedom of those aged under 18 years to move around in public spaces without adult supervision (Hillman et al., 1990)

Affordances

Affordances was theorised by Gibson (1979/1986) as a concept to explain how the individual experiences and interacts with their environment. Affordances include properties of both the environment and the acting individual. They are unique and differ for individuals and specific groups of people. Affordances provides an ideal foundation from which to explore the interplay between public open space and children's behaviours (e.g., through children's perceptions and interpretation of the environment), and to explore factors that may lead to actualizing these affordances.

Actualised affordances

Kyttä distinguished affordances in terms of being potential or actualised. Potential affordances relates to the infinite number of possible affordances of an environment or object (Kyttä, 2003) and are different for each individual or group of people (Storli and Hagen, 2010). There are several different levels of actualised affordances: perceived, utilised, and shaped (Kyttä, 2002, Kyttä, 2003). Kyttä (2003) expanded this original concept to include emotional, social, and socio-cultural opportunities and restrictions that an environment can offer. Actualised affordance are what the individual perceives and are revealed through actions of the individual (Kyttä, 2004). For example in the context of children's independent mobility, once the potential affordances are interpreted as inviting opportunities for children's independent mobility and are experienced through action, they are known as actualised affordances (Aziz and Said, 2015, Heft, 1988, Kyttä, 2003, Kyttä, 2004).

Children's independent mobility

Children's independent mobility is defined as the ability to freely roam and actively travel (i.e., walking, cycling, scootering, skate boarding) around the local neighbourhood without adult accompaniment (Hillman et al., 1990) but can be in accompaniment of siblings and friends (Mikkelsen and Christensen, 2009).

'True' independent mobility as applied in this thesis implies the individual (child) roaming independently without adult supervision.

Parental licence for freedom

Parental licence is conceptualised as parents allowing children the freedom to do certain activities without the presence of an adult. The seminal study by Hillman et al. (1990)

devised a set of behavioural indicators related to the risks children are exposed to in the local environment. These were whether children were allowed to do the following activities *'on their own':* (1) cross main roads, (2) go to leisure places, (3) return home from school, (4) go out after dark, (5) cycle on main roads, and (6) use local buses. The higher the number of parental licences a child held, the higher that child's level of independent mobility.

Public open space

Public open space encompasses a variety of spaces within the built environment. A number of definitions exist (Koohsari et al., 2015). These terms include (1) green space (e.g., public parks and planted areas), (2) blue space (e.g., water ways, rivers and coast), and (3) grey space (e.g. civic squares, streets and transport corridors) (Regional Public Health, 2010).

In the context of this thesis, the focus is broadly on 'green spaces.' There was a slight variation in how public open spaces were defined to reflect the qualitative studies (Chapter 3 and 4) and quantitative, experiential study (Chapter 5). In Chapters 3 and 4, public open space was defined as freely accessible parks, reserves and greenspaces (including those containing wetlands) studies). In Chapter 5, public open spaces reflects the types of green spaces that children talked about during the go-along interviews, and were not specifically delimited as in the previous chapters.

Nomenclature

Term/symbol	Definition
CI	Confidence interval
ICC	Intraclass Correlation
IRR	Inter-rater Reliability
n	Number of cases in a subsample
N	Total number of cases
OR	Odds Ratio
%	Percentage
p	p-value, statistical significance
SD	Standard Deviation
R	Correlation Coefficient

List of publications arising from doctoral thesis

Peer-reviewed book chapter publication

Chaudhury, Moushumi., Melody Oliver, Hannah M. Badland, and Suzanne Mavoa. 2015. "Public Open Spaces, Children's Independent Mobility." In *Play, Recreation, Health and Well Being, Geographies of Children and Young People 9*, edited by B. Evans and Horton J, 1-21. Singapore: Springer Science (Appendix A).

Peer-reviewed journal publications

Chaudhury, Moushumi., Melody Oliver, Hannah M. Badland, and Karen Witten. 2016. "Using the Public Open Space Attributable Index tool to assess children's public open space use and access by independent mobility." *Children's Geographies*. doi: 10.1080/14733285.2016.1214684 (Appendix B).

Manuscripts under review in peer reviewed journals

Chaudhury, Moushumi., Melody Oliver, Hannah M. Badland, Nick Garrett, and Karen Witten. *In review*. "Conceptualisation of a Public Open Space Attributable Index" *Journal of Landscape and Urban Planning*.

Chaudhury, Moushumi., Melody Oliver, Hannah M. Badland, Nick Garrett, Erica Hinckson, and Penelope Carroll. *Accepted for publication*. "Children's independence and affordances experienced in the context of public open spaces: A study of diverse inner-city and suburban neighbourhoods in Auckland, New Zealand." *Children's Geographies*. doi:10.1080/14733285.2017.1390546.

Peer reviewed conference presentations

Chaudhury, Moushumi., Melody Oliver, Hannah M. Badland, and Karen Witten. "Using
the Public Open Space Attributable Index tool (POSAI) to assess children's
public open space use and access by independent mobility." Forthcoming.
Poster to be presented at the Active Living Research conference 2017, Florida,
USA 26 Feb- 1March 2017.

Chaudhury, Moushumi., Melody Oliver, Hannah M. Badland, Nick Garrett, Erica
Hinckson, and Penelope Carroll. "Children's independence and affordances
experienced in the context of public open spaces: A study of diverse inner-city
and suburban neighbourhoods in Auckland, New Zealand." Forthcoming.
Paper to be presented at the Active Living Research conference 2017, Florida,
USA 26 Feb- 1 March 2017

Research chapter contributions

The academic contributions and specific role of the student for these research chapters
were as follows:

Chapter 2:   *Literature Review: Children's independent mobility and the importance of*
              public open spaces

              Moushumi Chaudhury (80%: lead author), Melody Oliver (7.5%),
              Hannah M Badland (7.5%), Suzanne Mavoa (5%)

Chapter 3:   *Conceptualisation of a Public Open Space Attributable Index (POSAI) of*
              Environmental Quality and Quantity

Moushumi Chaudhury (80%: Lead author, 80% data analysis), Nick

Garrett 20% data analysis), Melody Oliver (7.5%), Hannah Badland

(7.5%), Phil Donovan (2.5%) Karen Witten (2.5%)

Chapter 4:   *Using the Public Open Space Attributable Index tool to assess children's*

public open space use and access by independent mobility

Moushumi Chaudhury (85%: Lead author, 100% data analysis), Melody

Oliver (5%), Hannah Badland (5%) Nick Garrett (5%) Karen Witten

(5%)

Chapter 5:   *Children's independence and affordances experienced in the context of*

public open spaces: A study of diverse inner-city and suburban

neighbourhoods in Auckland, New Zealand.

Moushumi Chaudhury (90%: Lead author, 100% data analysis), Erica

Hinckson (3.3 %), Hannah Badland (3.3 %), Melody Oliver (3.3 %).

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Chapter 5:   *Children's independence and affordances experienced in the context of public open spaces: A study of diverse inner-city and suburban neighbourhoods in Auckland, New Zealand.*

Moushumi Chaudhury (90%: Lead author, 100% data analysis), Erica Hinckson (3.3 %), Hannah Badland (3.3 %), Melody Oliver (3.3 %).

Co-author agreement

Assoc. Prof Melody Smith (nee Oliver)

Phil Donovan

Assoc. Prof Hannah Badland

Prof Karen Witten

Dr Nick Garrett

Prof Erica Hinckson

Dr Suzanne Mavoa

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.

Chapter 2 has been published as a peer-reviewed book chapter. Chapters 3–5 have been published or submitted (and are under review) for consideration as separate papers for publication in international peer-reviewed journals. Each of these publications was conceived by the candidate, who was also the main contributor and principal author. All co-authors have approved the inclusion of the papers they were involved in as chapters for this thesis. Individual contributions for these chapters are outlined in the introduction (Chapter 1).

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28 July 2017

Ethical approval

Auckland University of Technology Ethics Committee granted ethical approval for the Kids in the City research project in Chapters 3 to 4 as follows:

AUTEC 07/126, 18 October 2010   (Appendix C)

MUHEC 10/091, 16 August 2010   (Appendix D)

UAHPEC, 15 October 2010   (Appendix E)

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"Be grateful for all the obstacles in your life. They have strengthened you, as you continue with your journey"

Unknown

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Thesis abstract

Children's experiences in the outdoor environment are important for their healthy development: physically, socially, spiritually, emotionally, intellectually, and cognitively. Emerging research shows that children who engage in outdoor physical activity and travel to destinations using active modes (i.e., walking, cycling) accumulate higher levels of physical activity than those who do not. Children's independent mobility (the ability to freely roam and actively move around their neighbourhood without adult supervision) is not only an important component of active travel and overall physical activity accumulation, it is an integral part of a child's 'growing up' experience in their local neighbourhood environment. Yet, evidence suggests children's independent mobility has declined radically over the last 40 years.

Public open space, defined in this thesis as freely accessible parks, reserves and greenspaces, are recognised as potentially important settings to promote physical activity, active travel, and independent mobility in children. This is through provision of spaces and purpose-built infrastructure (e.g., playgrounds) for play, and when located near to home, as settings to travel to actively and independently. However, simply locating public open spaces in neighbourhoods does not guarantee their use. Design, quality, population-appropriateness of infrastructure, and maintenance of the public open spaces appear to increase the appeal to usage of public open space.

Despite the growing literature on children's independent mobility and public open space, little is known of factors associated with children's independent mobility to neighbourhood public open spaces. With that in mind the overarching aim of this thesis is to explore associations between neighbourhood public open spaces and children's independent mobility in a sample of children living in socio-demographically and

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geographically diverse neighbourhoods in Auckland, New Zealand. This thesis supports an adapted socio-ecological systems model to link children's independent mobility with public open space visitation in the neighbourhood environment.

Extending the body of knowledge, this thesis presents a number of novel contributions regarding public open space visitation and children's independent mobility. A review of the literature indicated that different public open space attributes may influence their use and how children access them (Chapter 2). The review concluded that a greater understanding of public open space related to children's behaviours could be gained by using a public open space measure that incorporated both quality and quantity. To address this gap, a proof of concept tool, the Public Open Space Attributable Index (POSAI), was developed that integrated and simultaneously accounted for public open space quality (assessed using an environmental audit of key attributes) and quantity (the size of public open space, generated using Geographic Systems (GIS) spatial data) (Chapter 3). In total, 88 public open spaces were audited using the POSAI in geographically and socio-economically diverse school neighbourhoods in Auckland, New Zealand.

Extending on this work, neighbourhood POSAI scores were examined in relation to public open space visitation and independent mobility in 240 children aged 9-12 years (Chapter 4). Data were sourced from children's travel dairies and parent telephone interviews. Overall, children made 68 trips to a public open space over a seven-day period; 35 of these were independently mobile. Novel findings showed higher POSAI scores and child ethnicity were related to making any trips to a public open space. Relationships for independent trips to public open spaces differed by ethnicity and parental licence for freedom.

In the final study (Chapter 5), data were drawn from 'go-along' walking and home-based interviews (*N*=140), to gain an in-depth understanding of children's meaningful public open space experiences. Children were positioned as key informants and co-producers of knowledge who reported their viewpoints. The main outcomes indicated that public open spaces, specifically parks, were preferred locations for children to engage in various forms of play. Public open spaces were also important destinations for participating in other adventurous and social activities in company with friends and siblings. Parental restrictions were the greatest influence on whether a child could make independent trips to the public open space. New themes around new migrant experiences and use of technology for surveillance arose from this investigation. In light of these findings, policy and planning efforts should be directed towards engaging different groups in the community (i.e., children, adult care givers, new migrant populations) with policy makers and urban planners towards creating a child friendly neighbourhood infrastructure.

CHAPTER 1

Introduction

Background:

Context

Children's independent mobility is defined as the ability to freely roam and actively move around the local neighbourhood without adult supervision (Hillman et al., 1990). Children's independent mobility can contribute to physical activity accumulation (Schoeppe et al., 2012, Oliver et al., 2015a). Engaging in recommended levels of physical activity (Sport and Recreation New Zealand, 2008) has important health and development benefits for children, including improved musculoskeletal health, aerobic fitness, weight management, mental health, and well-being (Banks et al., 2012, Strong et al., 2005). Insufficient activity accumulation in children has been implicated in the rise of childhood obesity (Kopelman et al., 2007) and has been identified as a significant risk factor in the development of both paediatric and adult onset of chronic diseases (Strong et al., 2005). In addition to the contribution to physical activity, independent mobility provides opportunities for development of practical skills and spatial skills including the ability to navigate risky situations in the outdoor environment (Kyttä, 2004). Despite these benefits, there has been a global decline in children's independent mobility over the last 40 years (Hillman et al., 1990, Fyhri et al., 2011, Shaw et al., 2015).

As shown in Figure 1, features of the built environment are important for supporting active living, and in turn can impact children's independent mobility. Children's territorial range and diversity of outdoor behaviours (e.g., play and physical activity) are

influenced by varied built environment attributes and social factors (Islam et al., 2016).

Previous research, both qualitative and quantitative, has highlighted that certain

attributes in the built environment impact greatly on (Ding et al., 2011, Badland et al.,

2015a), in particular, perceived neighbourhood safety (Rudner, 2012, Pooley et al.,

2005a, Foster et al., 2010), increased motorised traffic (Hillman et al., 1990, Zwerts et

al., 2010), and different public open space attributes (Francis et al., 2012, Gidlow et al.,

2012). Public open space features that may be relevant for children's independent

mobility include distribution, accessibility, aesthetics, size and quality; and presence of

green space/greenery (Giles-Corti et al., 2005a, Witten et al., 2008, Foster et al., 2010,

Owen et al., 2004).

Conceptual frameworks and theoretical concepts for children's independent mobility

This thesis draws from an adapted systems model to investigate links between

children's independent mobility and public open space visitation (Figure 1). Badland et

al's (2015b) model, which was based on Bronfenbrenner's (1994) conceptual

framework of a socio-ecological model, illustrates the complexity and

interdependencies of children's independent mobility. The model proposed by Badland

and colleagues may provide a useful structure for how to best develop and monitor

interventions to help alleviate the declining rates of children's independent mobility.

Socio-ecological models account for complex 'layers' and can be used to consider a

child's development with the context of the system of relationships that form his or her

environment (Bronfenbrenner, 1994, Stokols, 1996). Conceptual framework models are

increasingly adopted in public health research for theorising relationships between

factors in complex systems (Macmillan et al., 2014, Egger et al., 2003, Sallis et al.,

2002). In exploring conceptual frameworks to understand causal pathways for

children's independent mobility and physical activity, several framework models have

been proposed (Martin and Wood, 2014, Oliver and Schofield, 2010, Pont et al., 2013).

These three frameworks follow a linear causal pathway and do not incorporate the

interdependencies between the various levels as suggested by the Badland model.
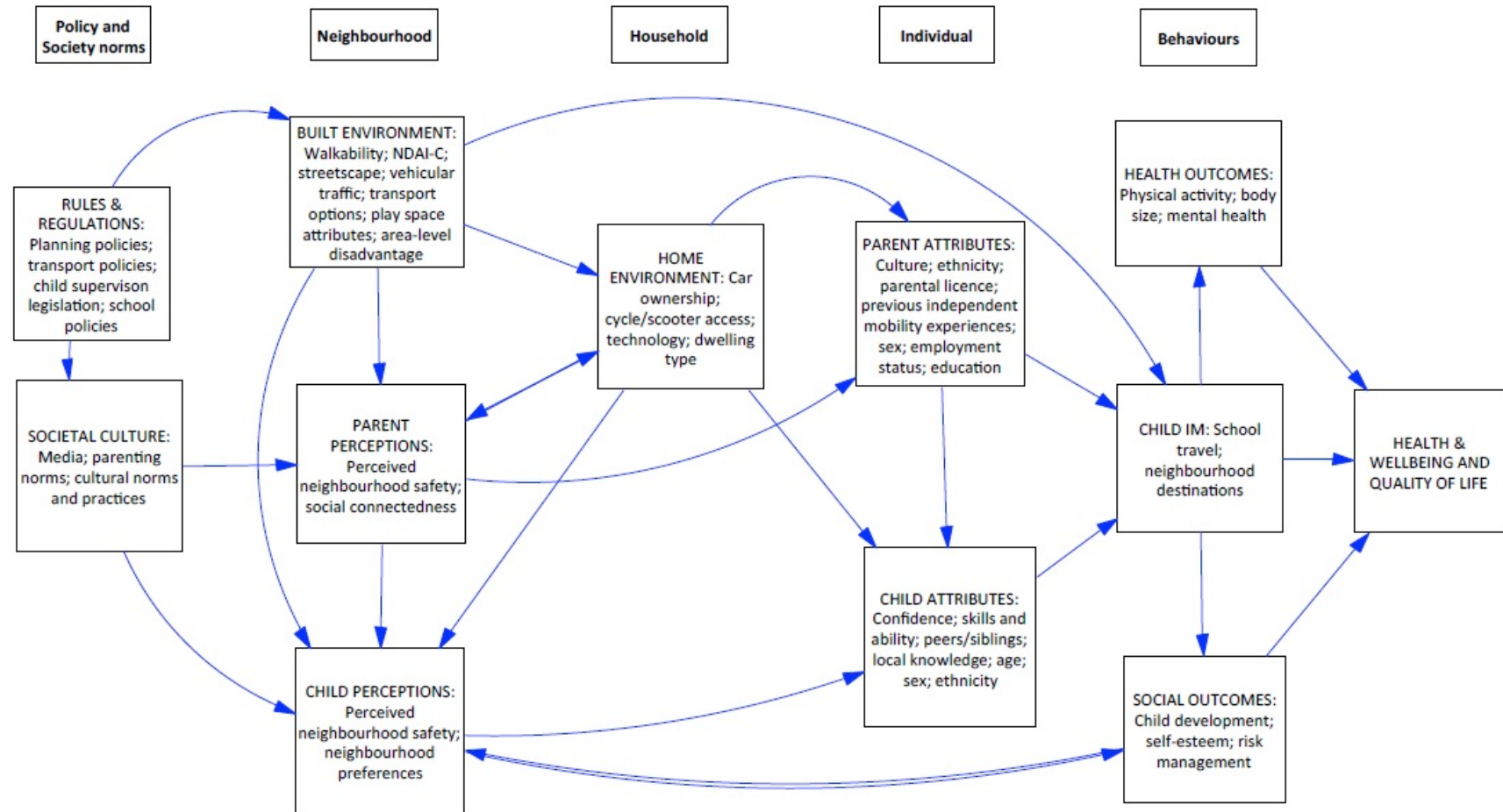
Figure 1. Conceptual model development for children's independent mobility. Permission to reprint by Badland et al. (2015b)

Definition of public open space and importance for children's health

Public open space encompasses a variety of spaces within the built environment. A number of definitions exist (Koohsari et al., 2015). Carmona (2010) described public open space as *"managed open space, typically green and available and open to all, even if temporally controlled."* Terms such as green space (e.g., public parks and planted areas), blue space (e.g., water ways, rivers and coast), and grey space (e.g. civic squares, streets and transport corridors) are commonly used to describe public open spaces (Regional Public Health, 2010). Essentially, public open spaces are easily accessible spaces for all age groups and may have multiple uses by multiple users, including sport and recreational opportunities. In the context of this thesis, public open spaces were defined as freely accessible parks, reserves, and greenspaces.

Public open spaces are recognised as potentially important settings to promote physical activity behaviours. Such spaces and purpose-built infrastructure (e.g., playgrounds) encourage play, and when located near to home, encourage active and independent travel (i.e., walking and cycling) (Cohen et al., 2006, Floyd et al., 2011, Edwards et al., 2015, Veitch et al., 2012).

The Auckland, New Zealand context

In New Zealand, the proportion of the population living in urbanised areas is already over 87%, with projections to reach over 90% by 2050 (United Nations, 2008). In terms of ethnicity, the five largest ethnic groups in New Zealand are (in order of prevalence): New Zealand European, indigenous Māori, Chinese, Samoan, and Indian. In the context of this thesis and the New Zealand setting, the ethnicities discussed include European, Māori,

Pacific Islanders (including subgroups Samoan, Tongan, Niuean, Cook Island Māori), Asians (including Chinese, Korean, Filipino) and Indian.

Auckland is the most populated city in New Zealand, In 2012 the estimated population of Auckland was 1.4 million people (34% of total New Zealand population), of which 300,000 were children (Auckland Council, 2012a). All population projections anticipate ongoing growth and it is estimated that there will be a further 100,000 children living in Auckland by 2040 (Auckland Council, 2016). Auckland's main population in the 1980s were primarily descendants of earlier European settlers, indigenous Māori and migrants from the Pacific islands. Since the enactment of the Immigration Act 1987 there has been a shift in ethnic diversity in Auckland. It is now one of the most ethnically diverse cities in New Zealand, with over 180 ethnicities represented in its population. The 2013 Census data reports the rapid growing population of migrants who originate from Asian countries such as China, India, Korea, and the Philippines (Friesen, 2015).

Study context

New Zealand has mimicked international trends in the declines in children's independent mobility and active travel to school and non-school destinations (Quigg and Freeman, 2008, Witten et al., 2013, Mitchell et al., 2007). National transport data have shown the time children spent in active travel has almost halved from 130 to 72 minutes per week over the last 20 years. In addition motorised transport to school has increased from 31% to 58% over this time period (Ministry of Transport, 2012, Ministry of Transport, 2015). At present no national survey data exists that has assessed children's independent mobility, however the reduced prevalence of active travel may be indicative of declining trends for independent mobility amongst New Zealand children.

This research focuses specifically on the surrounding environs of schools as neighbourhood community hubs in Auckland, New Zealand (Sanjeevan et al., 2012, Black, 2008). In New Zealand, school zoning has been applied for public schools, whereby a public school has a catchment area generated around the school. Those children that live within this catchment, termed being 'in-zone', are guaranteed a place at this school (Freeman, 2010). Accordingly, school zones (Ministry of Education, 2011) were employed as the geographical boundary for the thesis defined 'school neighbourhood catchment' (detailed in Chapter 3). School neighbourhood catchments were chosen as the likely areas, outside of the home environment, in which children would spend most time and as such may play an important role in children's independent mobility (Badland et al., 2015a). Moreover, children that do reside within the zones are likely to live within walking or cycling distance away between home to school. The use of school neighbourhood catchments is not commonly applied in this area of research and is explored in detail in Chapter 3.

Children in eight public primary schools (Years 5 - 6) and one public intermediate school (Years 7-8) in socio-demographically and geographically diverse neighbourhoods in Auckland participated in this study. Schools in New Zealand are ascribed a decile rating which indicates the school's socio-economic status (decile 1 = lowest socio-economic status; 10 = highest socio-economic status). Further detail on school deciles is provided in the methods section in Chapter 3.

Thesis methodology

First, this section details the two cross sectional projects that comprised the Kids in the City study. Second, it details the additional data collected by the PhD candidate specific to this thesis. Finally, the PhD candidate's contributions to the Kids in the City study are detailed.

Background on the Kids in the City study design

This thesis has grown out of a broader body of work, arising from two separate projects: (1) Children's mobility and physical activity in higher density urban neighbourhoods, which focused on six schools in suburban neighbourhoods across Auckland (funded by the Health Research Council of New Zealand), and (2) Inner-City Kids (funded by a Royal Society of New Zealand Marsden Fund grant), which focused on schools in three inner-city neighbourhoods. Both projects had slightly different objectives but similar data collection protocols, which are detailed below. Together these studies comprise the Kids in the City study. Overall The Kids in the City study involved eight primary schools (Years 5-6; aged 8-11) and one intermediate school (Years 7-8; aged 10-12), across socio-economically and geographically diverse suburban and inner-city neighbourhoods in Auckland, New Zealand.

The Kids in the City study involved investigators from three universities in Auckland, New Zealand; AUT University, Massey University and The University of Auckland. Ethical approval was granted by the respective research institutes (AUTEC 07/126; MUHEC 10/091; and UAHPEC) as detailed in Appendix C, Appendix D and Appendix E respectively.

The aim of this study was to understand how the design and density of urban neighbourhoods in higher deprivation areas could influence the independent mobility and physical activity of

resident children (8-11 years of age). The main objective was to understand children's

perceptions and experiences of neighbourhood spaces and the opportunities and constraints

they face moving between the activities of daily life.

Project 1: Children's mobility and physical activity in higher density suburban neighbourhoods

The aim of this study was to understand how the design and density of urban neighbourhoods in higher deprivation areas could influence the independent mobility and physical activity of resident children (8-11 years of age). The main objective was to understand children's perceptions and experiences of neighbourhood spaces and the opportunities and constraints they face moving between the activities of daily life.

School selection and consent

Selection of study localities was undertaken in consultation with local government and Housing New Zealand Corporation (national government housing provider). The suburban schools were selected based on socioeconomic and urban design characteristics of their surrounding neighbourhoods (student catchment areas). A strategy for pairing schools with a similar decile rating but different built environments in terms of their walkability was implemented. Four suburban schools were rated decile 1 by the Ministry of Education (lowest socio-economic status areas), and two were deciles 4-5 (representing medium-income neighbourhoods). Consents were obtained from the Principals, Board of Trustees and classroom teachers, permitting the children to be involved in the research project.

Participant recruitment:

The study comprised 161 children aged 8-11 years and their parents/caregivers. The sample size estimate was derived by generating data for six hypothetical neighbourhoods using New Zealand accelerometer data (personal communication R. Maddison with principal investigator of the Kids in the City study, Professor Karen Witten); and defining a significant neighbourhood effect of physical activity intensity value at least 1.6 times greater in the neighbourhood with the highest compared to the lowest physical activity intensity value

(Oliver et al., 2011). It should be noted that at the time of this project (2010) the sample size estimates were generated on hypothetical data as there was no existing research that could be drawn from. Similarly, with respect to children's independent mobility there was no information to be drawn from as this project was the first to try to quantify children's independent mobility through travel diaries. Data were collected between 2011 and 2012.

Participant selection criteria:

There were no selection exclusion criteria in recruitment of the children; all children in the participating classes from Years 5 and 6 of the selected schools were invited to participate in all quantitative and experiential components of the study. This included any children that may have recently moved to the neighbourhood. A total of 161 children participated in the quantitative component of the study, of which 100 children participated in the experiential go-along interviews (discussed below), Chapter 5.

Participant consent

There were multiple stages to the consent process; parent consent and child assent were required for the child to participate in the school-based data collection and go-along interviews (including recording of walking interviews) and separate parent consent was required to participate in the individual telephone interview. At any point the child/parent could withdraw from the study.

Project 2: Inner-City Kids

Data collection for this study commenced in 2012. The aim of this project was to understand opportunities and constraints on play and independent activity for children living in medium and high density housing in inner city Auckland. Data were collected with 94 children from three inner-city schools in Auckland.

School selection and consent

The inner-city primary schools in Auckland's central business district were approached. Schools were rated as deciles 5 and 8, indicating mid and higher socio-economic status at the neighbourhood level. School consent was provided from Principals, Board of Trustees and participating classroom teachers.

Participant recruitment:

Participants were recruited from two primary schools (Years 5-6; aged eight to 11) and one intermediate school (Years 7-8; aged 11-13). All children that wished to participate in the quantitative component of the study (see below data collection) could do so (n=93). Of these, 40 children (20 boys and 20 girls) were invited to participate in the go-along interviews based on their residential dwelling type.

Participant selection criteria

There were no exclusion selection criteria in recruitment of the children for the quantitative data collection. The selection criteria for the go-along and home interviews was that participants were residents of apartment blocks in the Auckland central business district or city fringe. Half of the invited go-along sample lived in medium density (n=20; multi-unit terraces/apartments of two to four storeys), and half in high-density (n=20; over four storeys) apartments. There was no exclusion criteria for those children that may have recently moved to the neighbourhood.

Participant consent

Parental consent and child assent were required in order to participate, as detailed in project 1 (above).

Sample size and saturation

The prevailing concept of sample size in qualitative studies is saturation (Malterud et al., 2016). Saturation is not about the numbers per se (size) but the depth of information gathered from the participants (Burmeister and Aitken, 2012). Sample sizes for qualitative studies are generally much smaller than those used in quantitative studies (Mason, 2010). Mason's (2010) article on sample size in qualitative interview studies, analysed 560 PhD studies that had used qualitative approaches and qualitative interviews as the method of data collection. The results showed that the mean sample size was 31. Guest et al. (2006) noted that data saturation may be attained by as little as six interviews depending on the sample size of the population. In this study the PhD candidate analysed all 140 (suburban =100; inner city= 40) go-along interviews that were collected, this exceeded the recommended amount required to reach saturation. As was mentioned in thesis methodologies in Chapter 1, the differences in sample size between the two areas was dependent on specific criteria's of the two projects. The imbalance in sample size though did not impact on the depth of information obtained from the inner-city sample.

As both the studies had different aims and objectives, high decile neighbourhoods were not selected in project 1, however higher decile schools were located close to the inner city neighbourhoods in project 2. This selection provided data from a range of socio-demographically and geographically diverse group of New Zealand children.

Kids in the City Data Collection Methods

Data were collected with the children across the nine schools involved in the two studies outlined above. Key methods relevant to the thesis research and differences between the two projects are explained below.

Travel diaries

Travel diary data were used to collect data on children's independent mobility. Information included time, origin, trip destination (e.g., to and from school, parks, visiting friends etc.), mode of travel (e.g., walking, cycling, motorised vehicle, scootering), and accompaniment status (alone, with friends, siblings, with parents etc.) over a seven day period. Researchers visited child participants at their school for seven consecutive weekdays to check and confirm each weekday of data collection with the child (Oliver et al., 2011, Badland et al., 2015a). An example of the trip diary is presented in Appendix F.

Go-along walking interviews

In total, 140 children participated in go-along interviews. All children in the participating classes of the suburban schools (n = 161) were invited to participate, of which 100 children took part in the go-along walking interviews. To encourage rapport-building and ease of dialogue, these go-along interviews were conducted by trained local high school students aged 16-18 years and of the same sex as the participant where possible. For the inner-city sample (n = 40), it was determined by senior members of the research team that interviews were best conducted by a senior academic researcher and that a total of 40 interviews were needed. The decision for senior researchers to undertake the interviews was based on preliminary analysis of the data collected in the suburban schools. It was identified that limited probing for themes occurred in the student-led interviews, and the research team were interested to see if additional themes arose with more intensive discussion with participants. The sample size determination was a decision based on saturation of themes relating to children's independent mobility in their neighbourhood environment from suburban neighbourhoods. Participants for the qualitative component of the inner-city neighbourhoods were selected based on children who lived in apartment blocks and invited specifically for

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inner-city go-along and home based interviews. Critical reflection on the impact of these differential approaches on study findings is provided in Chapter 6.

These interviews started from the child's home and discussions were based around frequently visited places (e.g., food outlets, community centres, sports facilities, library, church, parks etc.) in the local neighbourhood. What defined a 'neighbourhood' depended on the child and where they took the researcher on the self-directed walk. This could be several streets, lasting 20 minutes to several hours across a larger area. On average interviews were 40 minutes long.

The interviews were semi structured, questions were based on likes and dislikes and children's perceptions and experiences in these places (e.g. play opportunities), social and physical activity engagement, safety, mobility (alone, with peers and adults), and family rules and restrictions (Appendix G).

Interviews were recorded (a discreet microphone was used to ensure adequate sound quality of recordings for transcription purposes). Children were provided with a digital camera to take photos along their journey that become a focus of conversation.

Home-based interviews

Home based interviews were only conducted only in the Inner-City Kids study. The reasons for home-based interview were two-fold: Firstly, a lack of in-depth interview data from the use of youth researchers in the suburban sample indicated a need for additional protocols with the goal of garnering additional insights; and secondly, to capture more in-depth information about neighbourhood experiences, (i.e., extending beyond the conversations stimulated through the go-along walk).

All the transcripts from both interview techniques were transcribed by professional transcribers. The senior researchers and PhD candidate read all the transcripts for data analysis. As experienced transcribers were employed, it was considered unnecessary to conduct formal checks between transcribed notes and audio recordings. Analysis, for the purpose of this study, was conducted by the PhD candidate. In both instances, for the purpose of the thesis research question, only public open spaces were analysed and discussed (Chapter 5).

Parent computer aided telephone interviews (CATI)

Parents of participating children were telephoned at the completion of data collection at the schools and a 75 item computer-aided interview (CATI) was administered by a trained interviewer (Appendix H). The survey drew from existing questionnaires and included child, parent and household demographics; perceptions of neighbourhood physical and social environments (Sampson et al., 1999); children's mode of accompaniment of travel to and from school and independent mobility to other settings, play locations, parent neighbourhood safety concerns and perceptions of the importance of their child's independent mobility and interactions with friends (Oliver et al., 2011). CATI interviews lasted between 15 to 20 minutes and were conducted in the parent's language preference of English, Samoan, Tongan, or Chinese.

Built environment: Geographic information systems (GIS) variables

Objective measures of the built environment were generated in ArcInfo 9.3 (ERSI Inc., Redlands, CA) these included:

The Neighbourhood Destination Accessibility Index (NDAI)

The NDAI is a GIS derived composite measure that uses eight domains of neighbourhood destination (i.e., education, transport, recreation, social and cultural, food retail, financial, health and other retail) (Witten et al., 2011).

Walkability

A GIS-derived measure of neighbourhood walkability, the walkability index (Leslie et al., 2007) comprises street connectivity, dwelling density, and land-use mix.

Variables generated by the student

'Neighbourhood': School neighbourhood catchment

There were two steps involved in creating the 'school neighbourhood catchment' (Chapters 3-4). Firstly neighbourhoods were generated from established geographic school zones (Ministry of Education, 2011). Where school zones were not implemented (two schools), a Euclidean buffer of 1200 m was generated and applied from the school's x, y coordinates. 1200 m was the overall median buffer values for the schools with catchment zones available. This is detailed in the methods section of Chapter 3 (page 67). Secondly, public open space area that intercepted these boundaries were identified, as a child does not visit 'half a park.' Neighbourhood size (m^2) was calculated using GIS Software ArcInfo 9.1 (ESRI, Redlands, CA), Figure 5 (page 76) illustrates the geographic location of the eight school neighbourhood catchments.

For the most part, health researchers conceptualise the neighbourhood environment as a residential neighbourhood, and have examined whether variations in environmental attributes at the neighbourhood level predict differences in the health-related behaviours or outcomes. In doing so, residential neighbourhood boundaries have come to be used as proxies for exposure to the local environment (Mavoa, 2015). Census areas and circular buffers, such as Euclidean or road network boundary (e.g. 500m, 800 m 1200m scales) are commonly used to delineate neighbourhood boundaries. The use of residential neighbourhood buffers is based on the hypothesis that a majority of activity behaviour occurs within a boundary around a person's residence, which may not necessarily be the case. While the use of school neighbourhood catchment is presently an uncommon method, there is rationale for this approach. For example within the New Zealand context, a high proportion of the primary school aged children live within the school catchment and are guaranteed a place at their local school, as per the Ministry of Education regulations (Ministry of Education, 2011). By using the school neighbourhood catchment as the spatial buffer, built environment exposures can be measured for children living in a defined area. Given the overall mean size of the school neighbourhood catchment was 1200 m in this study, this distance is deemed within an acceptable walkable distance for children to actively travel and be independently mobile (Chillón et al., 2015, D'Haese et al., 2011). Previous research suggests that for children aged 10-12 years, walkable distance range from 0.25 km to 1.6 km walk (Harten and Olds, 2004, Timperio et al., 2006, McDonald and Aalborg, 2009) and within the context of journeys to school, shorter distances have been associated with higher rates of active travel to school (Panter et al., 2008, Pont et al., 2009). Similarly in previous work from the Kids in the City study, findings showed that distance to school was associated with significantly less active trips made in the weekend as well as on weekdays, suggesting that the school may be an

important destination for active travel and independent mobility outside school hours (Oliver et al., 2016).

Public open space identification and auditing

The selection criteria for public open space included freely accessible parks, reserves, and greenspaces (including those containing wetlands, and grass verges). Public open spaces were identified using google maps; details of this process can be found in Chapter 3 (pages 69-70). The total area (m^2) of each public open space identified was calculated in ArcGIS.

Auditing of the public open spaces across the neighbourhoods was conducted by the student and a research assistant. The initial intent was for the research assistant to conduct duplicate assessments across the entire dataset. However, when conducting preliminary intraclass correlation coefficients (ICC) between raters, it was determined sufficient reliability existed between raters and no further duplicate assessments were required (Appendix I).

Public open spaces were audited using the adapted New Zealand Public Open Space Audit Tool (NZ-POST); this had previously been validated and tested in the New Zealand setting (Badland et al., 2010). This tool was adapted from the original Public Open Space Audit Tool (POST) (Giles-Corti et al., 2005a), which was tested in the Australian setting. The modifications of the NZ-POST included removal of the following items: size of water feature, evidence of grass watering, accessibility for dogs, and types of surrounding roads, as these questions were thought to be irrelevant to the New Zealand setting, or because of ambiguity (e.g., dogs could encourage or discourage use of public open space) (Badland et al., 2010).

Gaps in the literature

This thesis addresses the specific gaps identified in the literature (detailed on page 20) with respect to public open space attributes and associations with children's independent mobility. This was achieved by firstly creating and testing an integrated proof of concept tool. Secondly by examining the associations between public open space visitation and children's independent mobility across socio-economically and geographically diverse neighbourhoods. Lastly children's experiences and perceptions of neighbourhood public open space were explored in order to understand public open space affordances for children's independent mobility.

Thesis rationale

Statement of the problem

Within the last decade research on associations between built environment attributes and health outcomes and behaviours has grown (Christian et al., 2015a, Hunter et al., 2015, Giles-Corti et al., 2005a, Bedimo-Rung et al., 2005, Kaczynski et al., 2008). Children's independent mobility, a behaviour which is vital for children's healthy development, has shown substantial declines over recent decades (Shaw et al., 2015, Fyhri et al., 2011, Schoeppe et al., 2015b). This may, in part, be attributed to factors in the neighbourhood built environment (Villanueva et al., 2013b). Despite the growing interest in this field, much is still unknown, particularly with regard to simultaneous measurement of public open space quantity and quality attributes in relation to children's independent mobility, and child-reported public open space experiences in the context of understanding independent mobility.

Statement of the purpose

The overarching question of this thesis is: What are the associations between public open space attributes and children's independent mobility experiences in a sample of children living in socio-demographically and geographically diverse neighbourhoods in Auckland, New Zealand? This was explored through a series of studies. The specific objectives of the research were (see Figure 2):

1. To conduct an in-depth literature review on public open space and children's independent mobility in the built environment (Chapter 2).

2. To develop a proof of concept tool, the Public Open Space Attributable Index (POSAI) that integrated measures of public open space quality and quantity (Chapter 3).

3. To examine associations between public open space (using POSAI) and children's visitation, and independent mobility, to public open spaces (Chapter 4).

4. To gain an in-depth understanding of the meaningful experiences of individual children, drawing from the concept of environmental affordance (Chapter 5)

Significance of the research

During the thesis a method was developed to integrate, for the first time, both quality and quantity attributes into one measurement tool for public open spaces. The POSAI integrated public open space environmental quality and size (quantity) into one measurement tool by building on the New Zealand-Public Open Space Tool (NZ-POST) (Badland et al., 2010), and adding a GIS derived measure of public open space quantity. It is speculated that the POSAI may be useful for planners and policy makers to prioritise areas for intervention and facilitate changes in areas of greatest need.

Adding to the limited data available, the second stage was the application of the POSAI tool to examine public open space visitation and children's independent mobility across socio-economically and geographically diverse neighbourhoods. Finally, the study sought to explore independent mobility and public open space experiences from children's perspectives, to elucidate findings from earlier chapters and gain new insights. This work is carried out within an adapted socio-ecological framework for children's independent mobility which recognises the multiple factors associated with children's independent mobility and public open space.

Thesis delimitations

Parameters specific to this body of work are as follows:

1. A number of definitions exist to describe public open space. In this thesis public open spaces were defined as freely accessible parks, reserves and greenspaces (including those containing wetlands). There are a number of public spaces which children regularly frequent that do not fit into the thesis definition of public open space (e.g., shopping centres, local shops, food outlets, libraries, streets) and thus were excluded using this definition (Chapters 3-5).

2. Data for children attending the intermediate (junior high) school were excluded in Chapters 3 and 4. It is likely that this group's independent mobility behaviours and parental licences are different from primary school aged children.

Thesis overview

Thesis structure

The thesis comprises six chapters designed to address the overarching thesis question, that is to explore associations between neighbourhood public open spaces and children's independent mobility, and the key objectives outlined in Figure 2.

Chapter 1
- **Title:** Introduction

Objective # 1:
In-depth literature review on public open space and children's independent mobility in the built environment.

Chapter 2
- **Title:** Public Open Space, Children's independent mobility: Literature review

Chapter 3
- **Title:** Conceptualisation of a Public Open Space attributable Index (POSAI)

Objective # 2:
To develop a proof of concept tool, the Public Open Space Attributable Index (POSAI) that integrated measures of public open space quality and quantity.

Quantitative Research

Chapter 4
- **Title:** Using the POSAI tool to assess children's public open space and use and access by independent mobility

Objective # 3:
To examine associations between public open space (using the POSAI) and children's visitation, and independent mobility, public open spaces.

Qualitative Research

Chapter 5
- **Title:** Children's independence and affordances in the context of public open space: A study of diverse inner city and suburban neighbourhoods in Auckland, New Zealand

Objective # 4:
To gain an in-depth understanding of the meaningful experiences of individual children, drawing from the concept of environmental affordance.

Chapter 6
- **Title:** Discussion and conclusion

Figure 2. Overview of thesis structure, aims and objectives

Chapter 2 was published as a chapter in a peer-reviewed edited book and Chapters 3 to 5 are published or are under review in peer-reviewed academic journals. There is, unavoidably, some repetition of information in sections (introduction, term definitions, and methods). Each

chapter is prefaced with a summary of the research gap to be addressed and synthesises the research undertaken in the previous section to ensure the thesis is structured and coherent.

Candidate contributions

The candidate's specific contributions to the wider Kids in the City study were as follows:

1. Identified the public open spaces in the nine study school neighbourhoods.

2. Audited the public open spaces manually (total public open spaces N= 197, n= 88 for eight neighbourhoods).

3. Data cleaning – raw data were entered into Microsoft Excel with a 10% random selection of NZ-POST scores checked for accuracy.

4. Data analysis – Microsoft Excel was used to calculate total and sum NZ-POST scores, SPSS to derive new variables, run the principal component analysis (PCA) and regression models.

5. Creation of the relevant public open space variables and data in SPSS and Microsoft Excel databases.

POSAI data were used from this thesis (Chapters 3 and 4). Data sourced from travel diaries, parent computer aided telephone interviews (CATI) and child go-along and home interviews from the larger Kids in the City research study were used in Chapters 4 and 5, after being subjected to secondary data analysis by the candidate.

CHAPTER 2

Literature review

Preface

Children's independent mobility, the freedom to roam without adult accompaniment, may comprise an important component of active travel and overall physical activity accumulation. Yet, evidence suggests children's independent mobility has declined radically in recent decades. Public open space environments such as parks and playgrounds with purpose-built infrastructure provide settings to promote children's independent mobility, and when located near to home, they are sites children can travel to actively and independently. In Chapter 2, a comprehensive overview of children's independent mobility and a synthesis of public open space literature within the context of children's activity and independent mobility is provided to set the foundation for this thesis.

The manuscript resulting from this chapter has been peer reviewed and published as a book chapter in Play, Recreation, Health and Well Being, Geographies of Children and Young People 9. Since the publication of this Chapter as a book chapter in 2015, the literature has been updated to include recent research.

Introduction

Definition of independent mobility

The term independent mobility was conceptualised by Hillman and colleagues in the early 1990s, as the freedom to move around to destinations outside the home by active travel (e.g., walking and cycling) and engaging in outdoor play without an accompanying adult (Hillman et al., 1990, O'Brien et al., 2000). van Vliet (1983) described these destinations as the 'fourth environment'; the setting outside the home, including playgrounds and child-orientated institutions. Broadly, the investigation of children's independent mobility has fallen into three categories: studies of parental licence for children's independent mobility, accompaniment status, and 'true' independent mobility. Parental licence is conceptualised as parents allowing children the freedom to do certain activities without the presence of an adult. The seminal study by Hillman et al. (1990) devised a set of behavioural indicators related to the risks children are exposed to in the local environment. The authors examined the licences and parental proxy reports which allowed children to be able to, *'on their own',* cross roads, go to leisure places, return home from school, go out after dark and also what forms of transport they were approved to use independently of parents (i.e., walking, cycling, cycling on roads, buses). Hillman refined this to 'six licences' which establish the level of a child's independent mobility. The higher the number of parental licences a child held, the higher that child's level of independent mobility. Generally, children's independent mobility increased as children aged.

A child's accompaniment status when travelling ranges from being with a parent, another adult, a sibling, a peer or alone with 'true' independent mobility (Hillman et al., 1990, O'Brien et al., 2000). Mikkelsen and Christensen (2009) suggested a more theoretical

perspective was needed to fully understand children's independent mobility. They identified that children navigating environments 'on their own' and 'alone' accurately described the behaviour, but without conceptual underpinnings. Mikkelsen and Christensen's findings suggested that the concept of children's independent mobility should not focus solely on the presence or not of adults, but should be broadened to include 'invisible actors', such as peers, friends, pets, and other animals. In particular, they found Danish suburban children reported companionship with other children en route to and from school and around their neighbourhood, whilst mobility of rural children principally involved the family, pets, and animals.

The terms 'independent' and 'mobile' have been interpreted in a variety of ways in health research to describe how these relate in childhood. Mikkelsen and Christensen (2009), argued that 'independent' implies freedom of control/not dependent (on people or things). However, a definition which focuses on a power struggle between child and parent, dependence, or physical distance between parent and child at any given time is not always workable. For example, a child attending an adult-controlled after school club, but engaging in outdoor play with no direct adult supervision during this time is considered to be independently mobile based on Mikkelsen's construct. Pooley et al. (2005a), characterised 'mobility' into three levels. Level one encompassed practical functions including those undertaken on a temporary basis such as journeys to school, shopping and visiting friends. Level two included everyday mobility as a social function including interaction/development of social networks, friendships and local communities. Level three incorporated mobility as a cultural function to construct personal identity. More recently, the use of telecommunication technology, such as mobile phones, has allowed parents to monitor their independently mobile children. This is

an additional factor to consider when defining children's independent mobility (Mikkelsen and Christensen, 2009).

While it is evident from the literature that no precise definition of children's independent mobility exists, it must be noted that children's independent mobility is fundamentally a social construct and therefore any useful definition must reflect on-going societal changes.

In order to capture diversity of mobility patterns, a combination of 'true independent mobility and accompaniment by siblings and peers during active travel behaviour' has been adopted as the definition of children's independent mobility in this chapter. Therefore, by definition, whenever a child undertakes active travel unaccompanied by an adult to school or other destinations during leisure time in the neighbourhood environment the child is independently mobile.

Trends in children's independent mobility and active travel

Historical context

Setting the scene in this global phenomenon was the seminal work by Hillman et al. (1990), in 'One False Move' they investigated children's independent mobility in England and Germany in 1971 and 1990. The samples drawn from these two countries were deemed geographically and socially compatible in a number of ways including residential density, range of urban and rural environments and car ownership. In 2010 the study was revisited 39 years later, drawing on the same geographic areas (Shaw et al., 2013). The comparative findings are discussed below in the subsection, 'Comparative trend over time data on children's independent mobility and active travel' (page 34).

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O'Brien et al. (2000), replicated Hillman's work, with questions pertaining to the six parental

licences, in the Childhood, Urban Space and Citizenship project with English primary (10-11

years of age) and secondary (13-14 years of age) school children in the late 1990s. Along

with Hillman's findings in the 1990 report, this study revealed a decrease in children's

independent mobility. There are limitations when interpreting the results of these three

studies. The measurement of children's independent mobility was limited to parent report of

licences to travel to school unaccompanied, and independent mobility to other destinations

was not considered. The use of parental licence was also a subjective proxy measure of

children's independent mobility and thus was not an assessment of children's actual

behaviours to a range of destinations.

Through in-depth oral life history interviews, Pooley et al. (2005b), compared children's

journeys to school in urban areas in England since the 1940s. For 10-11 year olds born in the

oldest cohort (1932-41), 40% travelled to school alone, compared with 9% of 10-11 year olds

in the youngest cohort (born in 1990-1991). Figure 3 shows this decline in children's

independent mobility over the period 1940 - 2000.
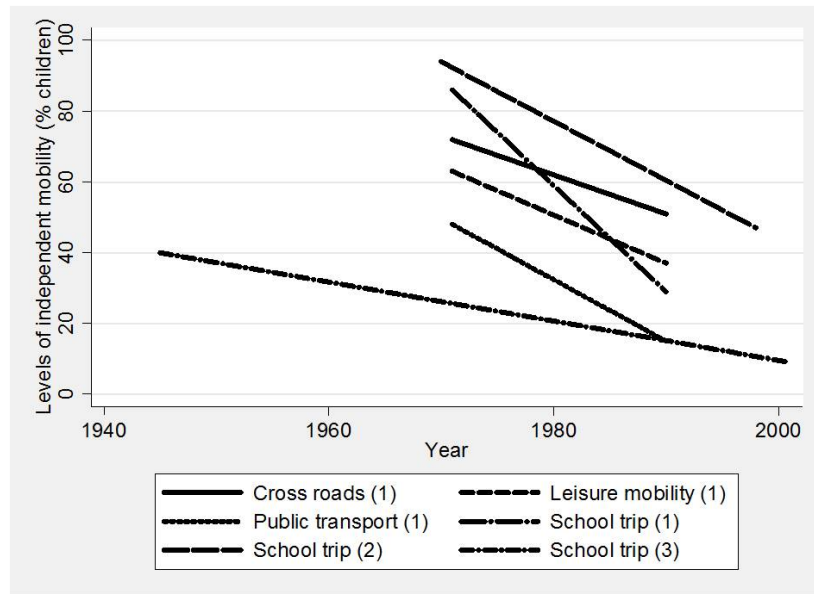
Figure 3. Prevalence of independent mobility in children (% children over years 1940- 2000) (Badland and Oliver, 2012)

Notes: Cross roads = allowed to cross roads on own, Leisure mobility = independent mobility during leisure time, Public transport = allowed to use public transport on own, School trip = independent mobility to school. (1) Hillman (1990); (2) O'Brien (2000); (3) Pooley (2005). Figure 3 reprinted with permission; Badland and Oliver (2012).

Current trends of children's independent mobility

Globally, children's engagement in independent mobility has radically declined over time with research spanning over four decades (Hillman et al., 1990, Shaw et al., 2013, Shaw et al., 2015, Prezza et al., 2001). Particularly over the last decade, children's independent mobility studies have attracted a lot of interest worldwide and similar trends have been reported in other countries, including, Australia, Denmark, Finland, Italy, New Zealand, Norway, and the United Kingdom (Fyhri et al., 2011, Witten et al., 2013, Johansson et al., 2010, Carver et al., 2013b, Shaw et al., 2013, Cordovil et al., 2015). Interestingly, studies

from Finland and other Scandinavian countries have reported children engage in higher levels of independent mobility than children from other European countries, even though a decline has been observed over time (Kyttä, 2004).

Another comparative study between Australia and England (Carver et al., 2013b) showed that when examining differences by school year, Australian primary school children appeared to have more mobility licences granted, and therefore more independent mobility compared with their English counterparts. However it was identified that Australian children at each school stage were around 1 year older than English children at the same stage. When stratifying by age of the child, the most significant differences were found among 10-12 year olds. At this age, the English children had significant higher rates of parental licence for independent mobility than their Australian counterparts. Present findings from this study emphasised that age and school stage, together are important correlates of children's independent mobility. This reflects what we already know from some of the earlier research demonstrating independent mobility increases with age (Prezza et al., 2001, Hillman et al., 1990, Matthews, 1992). There is some evidence that children's autonomy coincides with the transition from primary to secondary school, when school location, peer groups, and parental licences may alter (Valentine, 1997).

The largest study in this field to date included data on children's independent mobility from 16 countries including Australia, Brazil, Denmark, England, Finland, France, Germany, Ireland, Israel, Italy, Japan, Norway, Portugal, South Africa, Sri Lanka and Sweden (Shaw et al., 2015). International comparisons showed that independent mobility varied widely across all the countries. Finland (Kyttä et al., 2015), Germany, Norway, and Japan (Drianda and Kinoshita, 2011) reported higher rates of independent mobility whilst Portuguese children

(Cordovil et al., 2015) had some of the lowest rates when comparing aggregate rank scores of children's independent mobility (Shaw et al., 2015). However only aggregated ranked scores of children's independent mobility were provided in the report (Shaw et al., 2015).

Current trends of children's active travel

If children's independent mobility decreases, their active travel tends to decrease, and consequently their overall physical activity reduces (Schoeppe et al., 2012, Oliver et al., 2016, Faulkner et al., 2009). Active travel is defined as walking, scootering, or cycling to destinations. Active school travel promotes overall health (Lubans et al., 2011), it provides children with habitual activity opportunities throughout the day (Loprinzi et al., 2012), and can be seen as an incidental source of daily physical activity (Race et al., 2017). There is a large body of evidence reporting the significant contribution of active transport to or from school (Cooper et al., 2005, Salmon et al., 2007, Yang et al., 2017) and other non-school travel destinations (Mackett et al., 2005, Oliver et al., 2016, Smith et al., 2012) in overall children's physical activity.

The overall decline in active transport (Fyhri et al., 2011, Schoeppe et al., 2012) and active travel to school has been observed in many countries globally (Lu et al., 2014, Schoeppe et al., 2012, Yang et al., 2017). Most of these studies were conducted in developed countries (e.g., Europe, Australia and USA). However the magnitude of decline and the underlying drivers may differ by country (Yang et al., 2017). For example data from Asian developing countries such as China, Vietnam and Philippines (Tudor-Locke et al., 2007, Trang et al., 2012, Cui et al., 2011) have previously reported higher prevalence of active travel to school compared with research arising from developed countries (van der Ploeg et al., 2008, McDonald et al., 2011).

Active transport has been targeted as a way of increasing energy expenditure in children and combatting rising levels of obesity in children (Harten and Olds, 2004). There are other positive health and social benefits too, including mental health benefits, cognitive development, increased self-esteem, improved behaviour and relationship building (Jan, 2011). The decline in active transport is particularly well documented in relation to trips to school. The shift away from active travel to school may be explained by, for example, parents' negative perception of the neighbourhood, including concerns of stranger danger and traffic safety; the increasing distances to schools, and time pressures (Oliver and Schofield, 2010). While globally on the decline, it should be acknowledged that children's active travel practices do vary by country and geographic region.

Active travel to school has been shown to be an important source of physical activity in young children (Schoeppe et al., 2012, Roth et al., 2012). A few studies have shown that it contributes to as much as 30% or more towards the child's daily physical activity (Voss et al., 2015, van Sluijs et al., 2009, Cooper et al., 2010). Walking is free and convenient and has been described as a "near perfect exercise." Cooper et al. (2005), used accelerometry with Danish primary school aged children to study walking, cycling and motorised transport to school. The authors found walking to school was associated with higher levels of overall physical activity compared with motorised transport. Cycling was also associated with higher levels of physical activity, but only amongst boys.

Distance or trip duration of journeys, such as home to school, are the main influences on whether a child undertakes active or passive transport modes (Oliver and Schofield, 2010). Several studies have shown the negative relationships between distance to school and children's active travel and independent mobility behaviours (Oliver et al., 2014, Lin et al.,

2017 (*in press*), Fyhri and Hjorthol, 2009). These studies reported children who lived closer to school engaged in more independent trips. Furthermore, distinct differences can be found for walking and cycling; distance to location has greater impact for children who walk (Schlossberg et al., 2006), while increased trip duration may affect cycling more than walking (Ewing et al., 2004). Findings from studies in the early 2000s from the United Kingdom and Australia reported that distance to school was the main factor affecting the likelihood that a trip would be active (Harten and Olds, 2004, Black et al., 2001). In Harten and Olds (2004) study of Australian children aged 11-12 years, trip data were collected on two school days and one non-school day. They reported that children made an average of one active trip per day, with median trip length of 0.63 km and the mean total distance per child per day being 0.61 km. In the Black et al. (2001) study of English children aged 5-10 years, 50% of the trips to school were by active commute up to a distance of 2.0 km. Urban planning literature suggests that key destinations should be within 400-450 metres (approximately five minutes walking) of residential areas, and within 800 metres of public transport. In their 2004 study of 275 younger English children (year one, aged 5 years), Metcalf et al. (2004) reported the median time taken to walk to school was 6 minutes and the median distance actively travelled in accompaniment was 0.7 km.

More recent studies are finding similar results. Wong et al. (2011), identified that of 17 studies dated between 1960–2010, 15 reported negative associations between distance to school by either walking or cycling to school, or both. No study reported a positive association between distance to school and active transport. McDonald (2007) reported a negative association with active school travel when the trips were short, (i.e., less than 1.6 km); no associations were found for trips greater than 1.6 km. Promotion of active travel

modes, such as walking and cycling with peers or independently in the built environment, has greater likelihood of success if school catchment area is explicitly considered (Black et al., 2001). A handful of studies have measured children's independent mobility in the form of children's (unsupervised) active travel to various destinations (Page et al., 2009, Wen et al., 2009) and one study has looked at unsupervised outdoor play as an indicator of children's independent mobility (Floyd et al., 2011). Schoeppe et al. (2012) recently reviewed the associations between children's independent mobility and active travel. The authors' systematic review reported a vast majority of active travel studies focussed on children's transport behaviour (active/motorised) to and from school. The review noted that only five studies examined active transport to non-school locations, suggesting a gap in research that needs to be addressed.

Comparative trend over time data on children's independent mobility and active travel

To date, only four studies exist that provide comparative data in children's independent mobility over time (Hillman et al., 1990, Shaw et al., 2013, Kyttä et al., 2015, Schoeppe et al., 2015b). The first two studies detail Hillman et al. (1990) initial work on children's independent mobility in the 70's between English and German children, and the comparative study revisited 39 years later by Shaw et al. (2013). As discussed above, Hillman's work was based on six parental licences which were given to children aged between 7-15 years (juniors aged 7-11 years; seniors aged 11-15). In 1971, 86% of parents of English primary-school aged children reported that their children were allowed to travel home from school alone. By 1990 this had declined to 35% by 1990 and by 2010, the proportion of children allowed to travel home from school independently had further reduced to 25%. On a closer examination by age, this reduction was largely due to a decrease in parental licences given to 7-8 year olds

to travel from home to school alone. In 1971, 80% of parents allowed children in this age group to travel alone to school, but by 1990 this had declined to 19% and in 2010 to 6%. In that same year the German cohort reported greater freedom than their English counterparts across all six licences for independent travel.

The second study to review degrees of children's independent mobility was conducted by a Finnish research group lead by Kyttä et al. (2015), and covered a two decade period from 1990 to 2011, comparing five different settlement types in Finland (inner-city, suburban, large town, small town, rural village). The major findings of the study mirrored those from Shaw et al. (2013) whereby independent mobility had decreased significant during a 20 year span. Independent mobility was noticeably lower in the small town and rural village settings than the inner-city settlements.

The final study by Schoeppe et al. (2015b) investigated changes in Australian children's independent mobility levels using data drawn from five cross sectional studies conducted between 1991 and 2012. Both parental and child survey data were used to assess parental licences and actual independent mobility behaviour in children aged 8-13 years. Unsurprisingly, the findings reported declines from 1991 to 2012 across the six licences including being allowed to travel independently from school to home (declining from 68% to 31%), from home to school (from 61% to 32%), or on buses (31% to 9%).

Many of the accounts of children's independent mobility, and more recently, walkability, have have been developed by researchers across a number of disciplines by objectively examining distances or destinations walked to, and maps illustrating spatial ranges. However from the perspective of the health geographer, for example, who exalts the practice of

walking in itself, could further contribute to the understanding of movement activities, through different forms of embodiment and relationship to health places, experiences, agency and culture (Christian et al., 2012).

In terms of active travel, a number of trend over time data, have captured the decline in active travel. For example, Centers of Disease Control and Prevention (CDC) data from the USA (Centers of Disease Control and Prevention, 2005, Centers of Disease Control and Prevention, 2002), although not directly comparable to those presented by Fyhri et al. (2011), it is clear that active travel, particularly walking and cycling to school, is on the decline and in contrast transport by vehicular modes has become a predominant form of personal mobility (van der Ploeg et al., 2008).Furthermore, a national survey of USA youth has shown a steep decline from 1969 to 2001 (41% to 13%) in children's active commuting to school, whilst motorised transport (by car) to school has increased in this period from 17% to 55% (Shaw et al., 2013, McDonald, 2008b). Following on from Hillman's earlier work (1990), active transport from home to school amongst English children decreased between 1971 to 2010 (86% to 25%) (Shaw et al., 2013).

Theoretical and conceptual frameworks that inform children's independent mobility and public open space research

In order to better understand associations between neighbourhood public open spaces and children's independent mobility this thesis drew upon an adapted multi-level socio-ecological framework specific to children's independent mobility (Badland et al., 2015b) and then specifically focusses on the public open space-person interaction, applying Gibson's ecological perspective affordances (1979/1986).

Socio-ecological model

There is no published specific behavioural model that provides a theoretical framework for emerging research in this area (Mikkelsen and Christensen, 2009). One of the most common models used in health promotion research, is Stokol's (1996) socio-ecological model which looks at health behaviour. The model developed out of the work of a number of prominent researchers (Glanz et al. (2008), pp. 468-469). The core concept of a socio-ecological model is that behaviour has multiple levels of influences, including individual, social environment, physical environment and policy. Bronfenbrenner's work on Ecological Systems Theory (1979), which identifies five levels of the environment that can influence child's development and the world around them. Bronfenbrenner divided the person's environment into five different levels: microsystem, mesosystem, exosystem, macrosystem, and the chronosystem.

Bronfenbrenner saw the influences on behaviour as a series of layers, where each layer had a resulting impact on the next level (Bronfenbrenner, 1994). All levels of the socio-ecological model impact on the behaviour of the individual (Stokols, 1996). As Stokol explains, the socio-ecological approach integrates person-focussed efforts to modify health behaviours with environment-focussed interventions. While the components remain the same, the socio-ecological model needs to be tailored to suit particular behaviours and population groups within each level. Figure 4 illustrates the basic socio-ecological model linking the individual with their social, physical, and political environments.
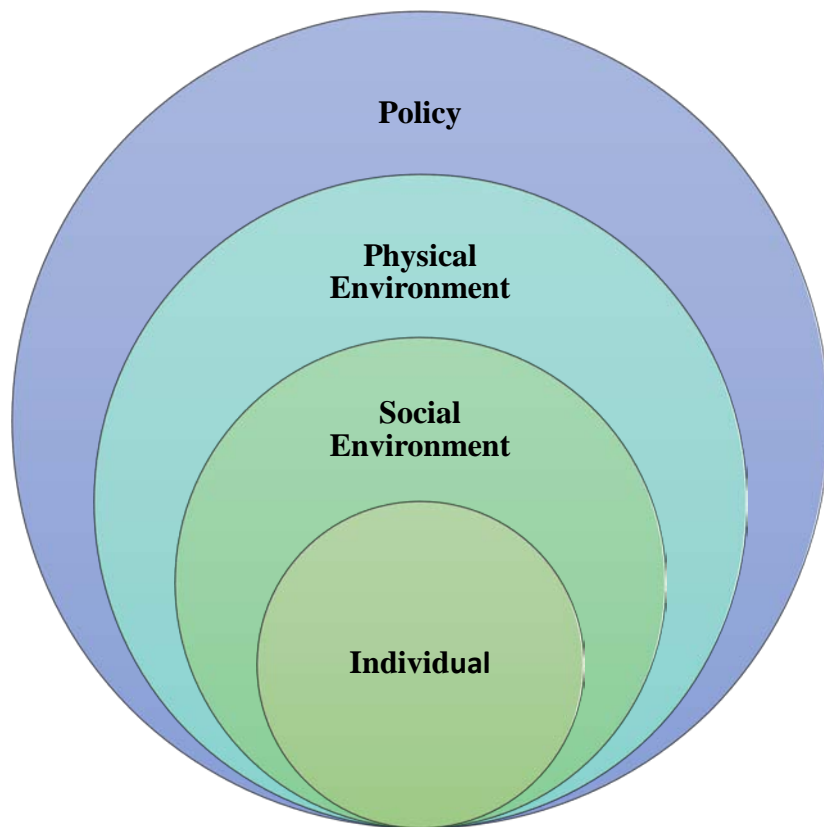
Figure 4. Illustration of model made up of the individual, social environment, physical environment and policy components

Because of the lack of a theoretical framework for children's independent mobility, Badland and colleagues more recently developed a conceptual multi-level framework to understand the multiple influences on the behaviour as illustrated in Figure 1 (Badland et al., 2015b). Figure 1 highlights the relationships within the conceptual framework, for example children's independent mobility behaviour may be influenced by factors associated within the built environment, which in turn are influenced by environmental policies and social norms, and these relationships may be causational or bi-directional.

The focus on children's independent mobility by many social science researchers, over the last three decades, has concentrated mainly within the urban neighbourhood setting. The use of conceptual-methodological frameworks from transport geography and environmental psychology has facilitated research exploring children's and young people's everyday walking in diverse contexts, including walking routines, behaviour and patterns. Together with new terminologies and the development of a number of techniques and technologies researchers have contributed to understanding children and young people's geographies (Trapp et al., 2012).

Societal changes

The deterioration of children's relationship with urban space, and decline in independent mobility, may be in part attributed to environmental, social, and cultural transformations that have taken place over the last few decades (Alparone and Pacilli, 2012). A number of societal changes have likely influenced children's independent mobility, including changes in family structure, greater use of structured childcare, increasing number of dual-income and working households, families living further away from schools, and places of employment and increased and multiple car ownership per household (Fyhri et al., 2011, Cordovil et al., 2015). As well, parental (O'Brien et al., 2000, Prezza et al., 2005, Santos et al., 2013) and children's (Hume et al., 2005) perceptions of safety in neighbourhoods, risks, including stranger danger (Rudner, 2012, Foster et al., 2014), outdoor play (Wen et al., 2009, Veitch et al., 2006, Ahern et al., 2017) and increased road traffic (Hillman et al., 1990, Zwerts et al., 2010, Ahern et al., 2017) are contributing factors to influencing children's independent mobility.

Fyhri et al. (2011), examined datasets from national travel surveys and surveys of active travel and children's independent mobility in the United Kingdom, Norway, Denmark and

Finland. Not all data sources were directly comparable between the countries; however, the same patterns were found in all four countries. Data from the United Kingdom sample showed that parental accompaniment for school travel increased amongst children aged 7-11 years from 78% in 2002 to 86% in 2008 (Department of Transport, 2009). In the same age group, traffic danger (58%), fear of assault/molestation (29%), convenience (21%), and distance to school (22%) were the leading four reasons given by adults for accompanying their children to school. In Norway, parents taking the same route to the workplace as their child's route to school was main reason children were driven to school by car (58%), followed by concerns of traffic safety (21%) and the car being the fastest travel mode (18%). In the Danish and Finnish studies the main parental concerns for accompanying children to school were road traffic and fear of molestation from adults (Fotel, 2007).

Associations between children's independent mobility and physical activity

Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure (Strong et al., 2005). This behaviour is not limited to sport and exercise, and includes any activity that raises the heart rate. There are significant health benefits for children who participate in the current national guidelines for physical activity, that is, 60 minutes of moderate-to-vigorous physical activity daily (Ministry of Health, 2017). Being sufficiently physically active is important for children. It is associated with a wide range of health benefits which include improved muscular and bone strength and aerobic fitness, reduced risk of adiposity, motor skills, healthy weight and protection against chronic diseases later in life (e.g., chronic diseases such as cardiovascular disease, obesity, type 2 diabetes, high blood pressure and some cancers) as well as improved mental health (Strong et al., 2005, Banks et al., 2012, Biddle et al., 2004, Janz et al., 2010). Whilst morbidity and

premature mortality increases into adulthood and older age, exposure to risks through inactivity begins in childhood. The benefits of different types of physical activity differ across life stages and engaging in physical activity from childhood tend to track this behaviour into adult life (Telama, 2009).

The time children spend outdoors is consistently and positively correlated with physical activity accumulation (Wen et al., 2009); and engaging in behaviours such as independent mobility and active travel provides opportunities to be accumulate the daily recommendations of physical activity. Therefore reductions in active travel and in children's independent mobility may be contributors to the decline in physical activity levels (Page et al., 2009). At present there is still minimal research that has explored the health benefits of children's independent mobility and accumulation of physical activity (Schoeppe et al., 2014a, Schoeppe et al., 2012). In trying to answer this question, a recent Australian study of 375 children (aged 8-13 years) investigated associations between children's independent mobility and light, moderate-to-vigorous, and total physical activity (Schoeppe et al., 2014a). Key findings from this study suggested independent travel (walking, cycling, using public transport) to school and non-school destinations was not related to higher levels of physical activity compared to adult-accompanied travel. Secondly, children that frequently engaged independent outdoor play ($\geq$ 3 days per week), had higher daily physical activity levels, predominantly at light intensity. These findings were contrary to previous studies (Page et al., 2009, Wen et al., 2009) possibly because the previous research did not examine physical activity intensities (e.g., light, moderate-to-vigorous) as an outcome, but instead assessed overall physical activity or physical activity dimensions (e.g., walking, outdoor play).

Another plausible reason could be that leisure time activities children pursue at non-school destinations will likely also influence their physical activity levels (Dunton et al., 2012).

Children's independent mobility associations with health and social outcomes

The benefits of children's independent mobility are two-fold. First, a child who is independently mobile will likely engage in non-formalised physical activity, which is important for achieving daily physical activity requirements (World Health Organization, 2010). This has been discussed in earlier sections. Secondly, children's independent mobility has an important role in fostering children's physical, social, emotional, cognitive and spatial development (Kyttä, 2004, Aziz and Said, 2015). Children who are independently mobile have opportunities to develop life-long skills including contributing to community social capital, social connectedness, and making calculated judgements to safely navigate risky situations, such as crossing busy roads or encountering strangers (Rudner, 2012).

Children's independent mobility and the neighbourhood built environment

At the physical environment level, the design of the neighbourhood built environment can have an impact on children's, habitual physical activity, by influencing (both facilitating and constraining) active commuting, neighbourhood play (McGrath et al., 2016, Tucker et al., 2009) and independent mobility opportunities. The built environment refers to man-made features in a city and are characterised by the 6Ds in literature. These are, density, diversity, design (i.e., amenities, site and street design, safety), distance, destination accessibility and demand management (Cervero and Kockelman, 1997, Ewing and Cervero, 2001, Cervero et al., 2009, Ewing and Cervero, 2010). Each of these are measured further by a number of indicators. Detailed description of all the indictors for each can be found in Cervero et al.

(2009). Building on this work Giles-Corti et al. (2016), identified eight integrated interventions that are needed to create cities that promote health. The authors further differentiate between urban and transport planning and design policies that determine regional and local outcomes. Details of the urban and transport planning and design features for regional and local urban design can be found elsewhere (Giles-Corti et al., 2016).

Emerging literature has examined the effects of neighbourhood built environments on children's independent mobility, with substantial effort made by researchers to identify the characteristics of the built environment that affect children's independent mobility. Many of these studies investigated a range of built environment factors and their associations with children's independent mobility which include availability, proximity of destinations, land use diversity, density, and street connectivity (Villanueva et al., 2012, Loebach and Gilliland, 2016, Villanueva et al., 2013a, Kyttä, 2004, Islam et al., 2016, De Meester et al., 2014).

For changes to be implemented by policy makers, and urban professionals, evidence that specific built environment elements contribute to active behaviours are warranted. Over the last decade, a number of reviews have examined the relationship between the built environment and children's physical activity, including active travel and independent mobility (Bates and Stone, 2015, Davison and Lawson, 2006, Ding et al., 2011, McGrath et al., 2015, Panter et al., 2008, Sharmin and Kamruzzaman, 2017). Attributes in the urban built environment may explain some of the changes documented in children's independent mobility behaviour. Sharmin and Kamruzzaman (2017) conducted a meta-analysis of research published on associations between the built environment and children's independent mobility between 1980 and 2016. A total of thirteen associations between the built environment and children's independent mobility were identified. Four built environment

factors had positive associations with independent mobility (i.e., cul-de-sac street network, proportion of residential land, proportion of commercial land, and residential location type). Conversely, eight built environment variables had negative associations with independent mobility (vehicular street width, road density, intersection density, major road proportion, land-use mix, availability of recreational facilities, residential density, and distance to destination) and one had a neutral association (traffic volume).

Some of the earliest work on environmental features on public open space locations in the neighbourhood environment, by Giles-Corti et al. (2005a) reported that distribution, accessibility, aesthetics and quality of destinations such as public open space; presence of green space/greenery and size of public open space such as parks were associated with children's independent mobility. Several studies report that the shorter distance to school from place of residence was associated with increased likelihood of active travel (Oliver et al., 2014, Yang et al., 2017). Other features known to influence independent mobility are perceived neighbourhood safety (Rudner, 2012, Pooley et al., 2005a) and increased motorised traffic (Hillman et al., 1990, Zwerts et al., 2010). More walkable neighbourhoods (i.e., those with higher street connectivity, residential densities and mixed uses), have positive associations with walking activity among adults, however often with improved street connectivity comes more exposure to vehicular traffic and the need to make more frequent intersection crossings, which may not be conducive for active travel behaviour in children.

Evidence suggests that neighbourhoods with parks, play areas, recreational facilities, pedestrian infrastructure and sporting venues facilitate higher active travel among children (Pont et al., 2009) and support children's independent mobility. One Australian study found

that perception of unsafe road environments were negatively associated with walking and cycling among 10-12 year olds (Timperio et al., 2004).

Importance of public open space for children

Public space and public open spaces are commonly defined to include parks, green spaces, plazas, sidewalks, shopping malls, community centres and schoolyards. In Chapter 1, the definition of public open spaces; green, blue, and grey spaces was described. Some of the more subjective definitions of what constitutes a public space or public open space within the built environment literature overlap with this. Furthermore, public open spaces can include land space areas for playgrounds and 'blue space' areas of water including rivers, canals, lakes, and reservoirs. Crucially, public open spaces are spaces freely accessible to all, and may have multiple uses by multiple users, including sport and recreational opportunities. In contrast private green space includes private backyards/gardens, communal grounds of apartment buildings, and corporate campuses (Wolch et al., 2014). In this thesis, the research focused on public open spaces defined as 'parks and green space that can be freely accessed by the public' (Badland et al., 2010).

There is growing recognition that natural or green public open space environments can benefit the health of urban populations (Vries and Herzele, 2011). They are recognised as important settings in which to promote physical activity engagement (Timperio et al., 2008, Besenyi et al., 2016), psychological well-being and the general public heath of urban residents (Wolch et al., 2014) in the neighbourhood. Purpose built infrastructure (e.g., playgrounds) promote specific use and also operate as potential active travel destinations, and thoroughfares. Public open spaces may also confer health and well-being benefits by fostering social connectedness, communication skills and friendship development (Sugiyama

et al., 2008, Lachowycz and Jones, 2013). Evidence also suggests that children's body mass index is lower when they have access to more green space (Lachowycz and Jones, 2011).

The multidimensional physical characteristics of the neighbourhood may contribute to various forms of activity engagement among children in their immediate environment. The relationship between child and neighbourhood environment needs to be further explored to add to the existing body of knowledge about what contributes to, or hinders, children's independent mobility.

Public open space use by children

Urban public open spaces are seen as particularly important places for children (Villanueva et al., 2016, Baek et al., 2015, Zamani, 2016, Carter and Horwitz, 2014). These spaces provide areas for social contact with others, freedom for play, and to be away from urban traffic and pollution (Greenspace Scotland, 2008), as well as destinations to actively travel to, and once there, engage in physical activity (Besenyi et al., 2016, Edwards et al., 2015, Prezza et al., 2005, Veitch et al., 2008). A number of studies have looked at neighbourhood public open spaces, to garner what opportunities that they may provide children to engage in physical activity (Blanck et al., 2012, Ferdinand et al., 2012, Veitch et al., 2014). Presently minimal research has been published examining children's' independent trips made to public open spaces and the association with frequency of park visitation (Veitch et al., 2014). However, simply providing green space in a neighbourhood is not enough; attention to characteristics such as the space's design and qualities is crucial for optimum benefit for all groups (Villanueva et al., 2013c, McCormack et al., 2011, Baek et al., 2015). Access to good quality green space has positive associations with physical and mental health well-being (Francis et al., 2012). Conversely, poor access and increasing distance (from residence) to urban green

public open spaces have been associated with a wide range of behavioural problems in children (Markevych et al., 2014, Louv, 2005). In fact Louv (2005) coined the term 'nature deficit disorder' to linking the lack of access and daily nature exposure to children's lives. Access to appropriate facilities for physical activity and active play has been previously identified as a key determinant of activity participation (Sallis et al., 1993, McCormack et al., 2011), and public open spaces need to be flexible to accommodate a diverse community and populations (Cabe Space, 2004). What is not as clear is how public open space availability, safety, and accessibility are conducive to children's independent mobility and children's active play. For example, safety features of a public open space have been identified as important contributors to their use. Lighting, presence of dog fouling, visible graffiti, vandalism, evidence of drug and alcohol use, unclean public toilets and unmaintained areas all contribute to a perceived lack of safety, which reduces the use of public open space by children and adolescents (Cabe Space, 2004, McCormack et al., 2011, Day and Wager, 2010, Valentine and McKendrck, 1997).

Availability and quality of public open space are used widely in health research to determine relationships between the physical environment, physical activity and health. Availability and access to parks close to home are associated with higher levels of physical activity in youth (Cohen et al., 2006). The quality of the space (e.g. whether it is safe, has toilet facilities, drinking water, adequate lighting and pathways) influences how it is used by children (Veitch et al., 2006, Sallis et al., 1997, McCormack et al., 2011, Day and Wager, 2010). Crawford et al. (2008) examined features of public open space in contrasting socio-economic neighbourhoods. The authors found the spaces in the disadvantaged areas had more amenities (e.g., toilets, drinking fountains), and better shading from trees, walking and cycling paths

and lighting than public open spaces in the more advantaged areas. Similar results have been reported elsewhere (Giles-Corti et al., 2003). Park proximity, size, and features have been minimally investigated in relation to children's access to them (Kaczynski and Henderson, 2007).

A number of studies over the last decade document that the proximity of a park from children's life spaces such as a home and school influences how children may use the park (Baek et al., 2015, Roemmich et al., 2007, Roemmich et al., 2006, Kaczynski and Henderson, 2007). A recent American study found that when distance between home and nearest park decreased by 100m, there was a positive association in park use by children (Dunton et al., 2014). Similar findings were reported for Australian children and adolescents aged 12-15 (Edwards et al., 2014). The authors reported young people living within 800m of a park were more likely to use that park, and those that did were more likely to achieve recommended levels of physical activity (Edwards et al., 2014).

Shifting the focus to size and types of public open spaces, a recent Australian study examined the relationship between context-specific measures of the physical and social environment and children's independent mobility to a variety of destinations, including parks (Christian et al., 2015a). The authors hypothesized that larger parks have more variety of attributes (e.g., sporting facilities, amenities, walking paths, lighting) and thus children were more likely to travel independently to these larger parks to access these amenities when compared with smaller parks. Their findings suggested that access to both small and large sized local neighbourhood parks was important for encouraging children's independent mobility. To date, adult and adolescent physical activity behaviours have been the focus in research investigating associations between park size and use (Kaczynski and Henderson, 2007, Giles-

Corti et al., 2005a) (Edwards et al., 2015, Edwards et al., 2014, Danis et al., 2014, Floyd et al., 2011), and understanding of this relationship in children is limited.

Most public open space studies have focused on the influence these spaces have on physical activity and active play. This candidate considers attention needs to be given to how these spaces influence children's independent mobility, an important contributor for daily physical activity. To date, very few studies have attempted to relate environmental attributes to children's independent mobility in specific locations, such as public open space. Further research is warranted to guide urban planners and developers on the importance of local public open spaces for children's independent mobility and physical activity.

How have public open spaces been measured?

A number of direct observational methods have been employed in health research to code attributes of physical activity environments, and a summary of these can be found in Sallis (2009). The chapter discusses observational tools used to measure physical activity behaviour in specific settings (e.g., schools, stairways) and the auditing of specific environments.

Largely, direct observation tools have been used to audit public open spaces (parks and green space). Audit tool examples include the Bedimo-Rung Assessment Tool, the Environmental Assessment of Public Recreation Spaces Tool, the Community Park Audit Tool, and the Public Open Space Tool (POST) (Giles-Corti et al., 2005a). These inventories all vary in length and type of environmental information collected. Other tools collect data objectively on both individual and environmental levels, for example the System of Observing Play and Leisure Activity in Youth and System for Observing Play and Recreation in Communities. Details of these tools and resources can be found elsewhere (Active Living Research, 2014).

Taylor et al. (2011), measured the quality of public open spaces using a remote-assessment approach, Google Earth Pro. The study assessed the correlation between remote assessment of quality of public open spaces using Google Earth and direct observation using a shortened version of the POST. Fifty parks were assessed by the remote method and scores were compared with some of the parks using POST. The key strengths of the remote method were the speed at which audits could be completed and the facilitation of a larger number of environmental audits without the need of in-person visits. The limitations of this remote-assessment method were that some items could not be accurately scored due to obstructed view or poor resolution, particularly the space's aesthetic features. Additionally, satellite imagery data of some areas may not be current and therefore does not always capture redevelopment that has occurred. The advantages of direct observation audits are that they are user-friendly tools to measure different environmental characteristics, with no participant bias, and they are easy to conduct. The disadvantages include the cost and need to train auditors and, depending on the length of audit, the greater time taken to collect the data.

What is the relationship with children's independent mobility, active travel and public open space?

A majority of the studies of children's independent mobility focus on the home to school journey (Schoeppe et al., 2012), with research in the last few years examining children's independent mobility to other destinations, for example public open space (e.g., parks), visiting friends, or local shops (Fyhri et al., 2011, Carver et al., 2013a, Carroll et al., 2015, Witten et al., 2015, Christian et al., 2015a). In this section, the focus is thesis defined public open spaces (i.e., parks, green space, school grounds and playgrounds within these vicinities) within the neighbourhood built environment. In order to establish factors affecting youth physical activity, it is important to study places in which children engage in physical activity

and active play within the built environment (Giles-Corti et al., 2005b, Ellaway et al., 2007).

Play areas are potentially important areas for children's mental, social, and physical health

and for social contact with other children (Ellaway et al., 2007). There is limited data on the

relationship between children's independent mobility and public open space as the majority

of children's independent mobility studies have investigated physical activity in school

locations (including active travel to school), neighbourhood streets, and parks (Grow et al.,

2008). However, Giles-Corti and King (2009) suggest most individuals obtain physical

activity from various contexts, such as walking and cycling and free play.

Past research of children aged 10-12 years reported that the absence of nearby parks and

sports venues was related to a decrease in walking and cycling trips (Timperio et al., 2004).

Children who lived close to a larger sized park with a water feature and/or whose parents

reported greater satisfaction with park quality, spent less time engaged in sedentary activities

(i.e., computer/e-games and watching television) (Veitch et al., 2011). Similarly, Grow et al.

(2008) reported that, regardless of age, those living closer to a larger public park or public

open space were likely to be more active.

It is also possible that sex differences exist for utilising public open spaces. Some studies

have indicated that boys tend to roam more freely and independently in public open spaces in

their neighbourhoods than girls (Page et al., 2009, Villanueva et al., 2012, Wen et al., 2009).

Villanueva et al. (2012) examined how far children travelled from home within the

neighbourhood and results from parental perceptions reported that boys were more able to

safely negotiate traffic conditions than girls. When Page et al. (2009) investigated

independent mobility in English children aged 10-11 years, boys were more independently

mobile and visited a range of destinations in their local and wider neighbourhood compared to girls.

What is the relationship with public open space and area-level disadvantage?

The relationship between individual and environmental characteristics influencing health and health related behaviours is well established in the literature (Strategic Review of Health Inequalities in England, 2010). Poorer health outcomes in individuals, including children (with higher rates of chronic disease, and associated risk factors such as obesity (Diez-Roux, 2001) have been reported for those living in disadvantaged neighbourhoods. This is true for total and coronary heart disease mortality (Diez-Roux et al., 1997), coronary heart disease prevalence and risk factors (Smith et al., 1998), and depression (Yen and Kaplan, 1999). Macintyre (2007) described this as "deprivation amplification." These variations in health are explained as compositional (individual-level) and contextual (area-level) (Macintyre, 2007, Diez-Roux, 2001). Deprivation amplification is a concept that describes a pattern where health-promoting amenities, for example public open space, are less common in disadvantaged areas (Macintyre et al., 2008). The concept is linked to the established notion of environmental justice research, which initially was concerned with environmental harm (e.g., pollution and hazardous substances) being located in low socio-economic communities. In recent years the research has expanded to include exploration of the inequitable distribution of health promoting features of the built environment such as public open space such as parks and green open space (Wolch et al., 2014).

A growing body of research from a range of disciplines (including public health, geography and urban planning) has examined the distribution of public open space provision by

neighbourhood socio-economic status, or park access and ethnicity. Findings from these studies show mixed results. Some studies report that more disadvantaged communities have better provision of public open space and recreational facilities than less disadvantaged areas (Vaughan et al., 2013, Wen et al., 2013, Boone et al., 2009, Engelberg et al., 2016, Cutts et al., 2009). Conversely, other research suggests that communities in more disadvantaged neighbourhoods have poorer green space availability than less disadvantaged neighbourhoods (Harris et al., 2015, Estabrooks et al., 2003, Dai, 2011). A few studies did not detect any significant differences between neighbourhood disadvantage and number of parks (Hughey et al., 2016, Timperio et al., 2007). However Hughey et al. (2016) reported that more disadvantaged neighbourhoods were about two times more likely to have park incivilities (e.g., vandalism, excessive litter) than less disadvantaged neighbourhoods.

Several studies within the New Zealand context have shown that socio-economically deprived urban communities have better access to parks (Pearce et al., 2008, Badland et al., 2010). Nevertheless, access, location and quality are important attributes for determining public open space use within a neighbourhood. In contrast, Richardson et al. (2010) suggest that, in New Zealand, the availability of public green space may not be as an important determinant of health as has been found elsewhere. Possible explanations for this difference in New Zealand maybe (1) the lack of variation in exposure of green space compared to other countries (Maas et al., 2008), (2) public open spaces may be less important for heath, as private gardens tend to be larger in New Zealand, at least compared with the UK (Loram et al., 2007, Freeman et al., 2015). Thirdly aquatic blue space areas, (e.g., beaches) maybe of greater importance for health in New Zealand, an earlier survey reported a high proportion (65%) of the population lived within 5km of the sea (Statistics New Zealand, 2008).

The Strategic Review of Health Inequalities in England 2009 Marmot Report advocated that there should be green space within four minutes of every family home (2010). Using international data, the report found a significant lack of green spaces and play spaces for children in disadvantaged neighbourhoods. Other empirical research suggests that the relationship between area-level disadvantage and public open space access varies nationally.

Studies of the locations of children's outdoor playgrounds have found more playground facilities, and improved accessibility to these facilities, in the poorer areas in both Scotland and the USA (Cradock et al., 2005, Ellaway et al., 2007). However, in Australia, Crawford et al. (2008) found no difference in the number of playgrounds and recreational facilities in affluent and disadvantaged neighbourhoods and that most of their participants (aged 8-9 years) lived within about 300 meters of a public open space. Veitch et al. (2008) addressed the importance of park proximity to home within Australian neighbourhoods. They reported that children living in low socio-economic outer-urban neighbourhoods had to travel a greater distance to access local parks for active free play compared with children in higher socio-economic areas. These studies highlight the conflicting findings presented thus far.

Researchers have also looked at the quality of parks and playgrounds (safety and availability by area-level disadvantage) for children's play (Cradock et al., 2005, Ellaway et al., 2001, Ellaway et al., 2007, Curtice et al., 2005). Ellaway et al. (2001) reported that those living in the poorer neighbourhoods of Glasgow were more likely to report a lack of safe places for children to play. Similarly in 2005 a Scotland-wide study found 45% of people living in deprived areas, compared to 4% of those living in affluent areas, reported a problem with the availability of safe places for children to play (Curtice et al., 2005). Cradock et al. (2005) found that in Boston, USA, young people from poorer areas lived closer to playground

facilities than those in more advantaged areas, however the playground equipment in those poorer areas was unsafe and poorly maintained.

The quality of public open space for influencing children's use is also important. Badland et al. (2010) analysed public open spaces in 12 urban neighbourhoods in New Zealand and found no difference in quality by area-level deprivation, however the public open space safety score was greater in more disadvantaged areas compared with less disadvantaged areas. That is, public open spaces located in more deprived neighbourhoods were more likely to have better safety infrastructure and higher number of activities available than those in the less deprived areas. It is to be noted that this study did not investigate the association between public open space quality and individuals' use of the public open space.

A 2007 Scottish study investigated the provision and distribution of outdoor play areas for children in relation to area disadvantage. The results of the study indicated more play areas existed in disadvantaged areas compared with less disadvantaged areas (Ellaway et al., 2007). Similar findings were reported in a Danish study (Karsten, 2002), however this particular study did not assess the quality and use of the playgrounds.

While it is not yet clear whether quality, quantity, or a measure of both is most important to promote public open space use, several studies have started to investigate these associations with various health outcomes. One Australian study explored the relationship between quality and quantity of public open space attributes and mental health among adults. The authors found that the quality of public open spaces within a neighbourhood was more important than quantity (Francis et al., 2012). This warrants further investigation; indeed the relationship of

quality and quantity of public open space by neighbourhood disadvantage among children has not been examined to date.

New Zealand Context: Active travel and children's independent mobility trends and associations with public open space

This section will focus on current literature in the context of New Zealand for children's independent mobility, active travel, and public open space. Following global trends, a majority of New Zealand children walked or biked to school in previous decades whereas today's children are mostly driven to school (Ministry of Transport, 2015). Quigg and Freeman (2008) suggest that it may not be that children who are choosing not to walk, but that other aspects of family life that affect their choice. For example reasons may include multiple children in a household attending different schools, or driving because school is on the way to a parent's workplace. It has been suggested that children's lives in New Zealand have become characterised by significantly lower levels of freedom to walk, cycle and play outdoors especially in public places such as parks and on the street (Freeman and Kearns, 2015).

Most of the research in this area has focussed on the journey from home to school (Mitchell et al., 2007, Collins and Kearns, 2001, Duncan et al., 2008). Over the last 20 years in New Zealand, the time children spent in active travel has almost halved from 130 to 72 minutes per week. During this same period children that travel by car to school has increased from 31% to 58% (Ministry of Transport, 2012, Ministry of Transport, 2015). Though New Zealand national surveys have not assessed children's independent mobility, the reduced prevalence of active travel may be indicative of declining independent mobility trends for New Zealand children. Evidence suggests that compared with previous generations, children

are less likely to travel unaccompanied through neighbourhood environments to local destinations (e.g., parks) during their leisure time (Witten et al., 2013, Karsten, 2005).

In qualitative research exploring social narratives around active travel in the Auckland context, parents reported high levels of chauffeuring their children to activities (Bean et al., 2008). This is in conjunction with the upsurge of weekly formalised extra-curricular activities (Freeman and Quigg, 2009) (i.e., after school and weekends), which may be located in the wider city environment beyond the intermediate neighbourhood. These factors potentially remove opportunities for freedom to roam and play in the local neighbourhood.

Ethnicity and associations with children's independent mobility and active travel

Limited literature exists regarding ethnic differences in children's independent mobility. Several studies have looked at children's independent mobility by country, but these have not investigated within-country differences by ethnic groups (Fyhri et al., 2011). Other studies have looked at differences within settlement types (e.g., rural, urban, suburban, large town and small town) within a country (Rudner et al., 2012). To the author's knowledge, the New Zealand based Kids in the City study (Oliver et al., 2011) is the first study that has examined ethnic differences in independent mobility across socio-economically different urban neighbourhoods (Witten et al., 2015, Chaudhury et al., 2016, Lin et al., 2017 (*in press*), Carroll et al., 2015, Witten et al., 2013). Findings have revealed, from the parents' perspective, New Zealand European, Māori, Samoan and other Pacific parents, stranger danger was the most common concern for allowing their children to go out alone. Conversely, for Asian and Indian parents, traffic danger was their main concern for limiting independently mobility for their children.

Ethnicity is one of the socio-demographic factors that has been associated with rates of active travel to school in the international literature, showing low income and minority groups, particularly blacks and Hispanics have higher rates of active travel to school than whites or higher income groups (Davison et al., 2008, McDonald, 2008a, Chillón et al., 2014). At present only a small number of studies have looked at child's ethnicity and active travel to destinations in the New Zealand context (Yelavich et al., 2008, Conlon, 2013). Conlon (2013) explored the factors that influenced a child's mode of transport to and from school in four cities in New Zealand, analysing the data from the Activating Communities To Improve Vitality and Equality (ACTIVE) study. Of the 71 participating children (45 European, 21 Māori, 5 Other/not stated), over half (58%) of the European children used active transport access school compared with 43% of Māori. The numbers of Māori participants were too small to examine whether these differences were statistically significant. Conversely, walking rates were lower among New Zealand European children when compared to other ethnicities (Yelavich et al., 2008). The authors reported children from lower socio-economic status backgrounds and those who attended low decile schools (deciles 2-4) were more likely to walk to school than those from higher decile schools.

Conclusion

1. Evidence of the potential health and well-being benefits public open spaces provide has increased immensely over the last decade along with an emerging research interest in public open space in the urban built environment.

2. Most public open space studies have focused on physical activity and active play. More attention needs to be given to measuring children's independent mobility, an important contributor of daily physical activity.

3. The evidence base linking public open space attributes with children's independent mobility is limited and to date very few studies have explored this relationship.

4. Multidimensional physical characteristics of the neighbourhood may contribute to various forms of activity engagement among youth in their immediate environment. The relationship between children's independent mobility and their neighbourhood environment needs further exploration.

CHAPTER 3

Conceptualisation of a Public Open Space Attributable Index (POSAI)

Preface

In Chapter 2, the findings, and gaps, in the literature on the relationship between children's independent mobility and neighbourhood public open spaces were identified. The findings suggest that attributes in the urban built environment may explain some of the changes documented in children's independent mobility behaviour and the decline over time. Features of public open spaces that may influence children's independent mobility include distribution, accessibility, aesthetics, and the quality of the destination, such as presence of green space and size. However, simply locating public open spaces in neighbourhoods does not guarantee their use. There is a body of literature which suggests attributes of public open space may influence how children use and access them. Design, quality, age-appropriateness, and maintenance of the public open space have been shown to encourage, or discourage, public open space use. However, it is currently unknown how combined attributes of public open space quality (internal attributes) and quantity (public open space size) are associated with children's independent mobility or public open space use. The objective of this chapter was to develop, for the first time, a proof of concept tool, POSAI, that integrated public open space quality and size into one measure across eight socio-demographically and geographically diverse urban neighbourhoods in Auckland, New Zealand.

The manuscript resulting from this chapter is currently in review with Landscape and Urban planning as follows:

Chaudhury, M., Oliver, M., Garrett, N., Badland, H. M., Donovan, P., & Witten, K. (*under review*). Conceptualisation of a Public Open Space Attributable Index. *Landscape and Urban planning*.

Introduction

Background

Public open spaces may attract people, across a range of age groups, to engage in activity in the natural environment, fostering social connectedness, communication skills, friendships (Francis et al., 2012, Sugiyama et al., 2008, Lachowycz and Jones, 2013); and other diverse social interactions (Hoskins, 2008). Furthermore, public open spaces are important destinations for promoting psychological health and well-being (Richardson et al., 2013, Francis et al., 2012). Public open spaces may also be important for encouraging physical activity; evidence suggests people who have access, and live closer, to public open spaces exercise more (Cohen et al., 2006) and those who regularly use parks accumulate more physical activity than people who do not (Cohen et al., 2013, Cohen et al., 2007).

A number of public open space definitions exist, and predominantly include: green spaces (e.g., public parks and planted areas), blue spaces (e.g. waterways, rivers and coast), and grey spaces (e.g. civic squares, streets, transport corridors) (Ministry of Education, 2011, Regional Public Health, 2010). In this study, public open spaces were delimited and defined as parks and green spaces that could be freely accessed by the public (Badland et al., 2010).

Most of the available research on the associations between public open space and health and wellbeing has been adult focused (Lachowycz and Jones, 2011, Kaczynski and Henderson, 2007); even though children likely utilise public open spaces differently (Davison and Lawson, 2006). In addition to public open spaces being destinations where children can engage in physical activity (Veitch et al., 2008, Bedimo-Rung et al., 2005), these spaces can provide destinations to which children can actively travel (e.g., walk, cycle), and opportunities for social interaction with other children and freedom for play. Good access to a

public open space, such as having a park close to home, has been associated with higher levels of physical activity in children (Cohen et al., 2006). Within public open space, access to appropriate child-specific facilities for physical activity (structured and unstructured) and active play has been associated with localised activity participation (Sallis et al., 1993). By way of example, the Personal and Environmental Associations with Children's Health (PEACH) project, a study of 1,307 children in the United Kingdom aged 10-11 years, found that time spent in green spaces was important for facilitating higher intensity activity, especially among boys (Wheeler et al., 2010).

Access, location and quality are important attributes for determining public open space use within neighbourhoods of different socio-economic status. Residents living in more advantaged areas may have better access to public open spaces such as parks and green spaces than residents living in lower income areas (Dahmann et al., 2010). The reverse findings are also true; those living in disadvantaged neighbourhoods have more, or at least similar, access to parks than those living in more advantaged neighbourhoods (Macintyre, 2007, Ellaway et al., 2007). In fact, Crawford et al. (2008) found public open spaces located in disadvantaged areas had better amenities (e.g., toilets, drinking fountains), better shading from trees, more walking and cycling paths, and adequate lighting compared with public open spaces located in more advantaged areas. Similar results have been reported elsewhere (Giles-Corti et al., 2003, Smoyer-Tomic et al., 2004).

A growing body of research has focused on the development and implementation of audit tools to measure either public open space qualities, such as internal attributes, or public open space quantity, such as size or number of public open spaces within a given boundary. However to date no tools exist which integrate both public open space quality and quantity

measurements, which in turn could better inform how appropriate these spaces are for children. To fill this research gap the PhD candidate developed and tested a tool which integrated observational public open space audit and area (size) data within school catchments and across school deciles. The primary aim of this study was to develop and test the utility of a proof of concept tool, POSAI, across a range of different built and socio-demographic environments. The POSAI aggregates public open space quality (public open space features), using an existing observational audit tool NZ-POST, with public open space quantity (public open space size) sourced from GIS spatial data. The exploratory data analysis of the POSAI will focus on the public open spaces around selected schools in Auckland, New Zealand.

Public open space qualities

The qualities of public open space that may influence use include design attributes, attractiveness and safety. Giles-Corti et al. (2005a) identified that among similar sized parks, those rated as being 'higher-quality' (versus 'lower quality') were more likely to attract all age groups to engage in physical activity. These findings have since been replicated in other studies examining the relationship between public open space quality and use across age groups (Sugiyama et al., 2015, Cohen et al., 2007), and particularly in children (Villanueva et al., 2013c). Concerns about safety and crime, such as poor lighting, dog fouling, graffiti, vandalism and inadequate maintenance have been identified as being negatively associated with public open space use by children (Veitch et al., 2013). In terms of public open space amenities, well-maintained toilets, drinking water facilities and pathways have been positively associated with public open space use by children.

Within the last decade considerable progress has been made in developing environment audit tools which offer an unobtrusive quantification of features that are not biased by individual resident perceptions. These tools can be categorised into four main groups: transport-related, parks and public open space (to measure quality attributes of public open space), schools, and home audits (Oliver et al., 2015b). All are primarily administered through direct observational methods. Detailed reviews of public open space audit tools exist (Sallis, 2009, Brownson et al., 2009, Oliver et al., 2016). The application of public open space audit tools is important because it allows a check list of predetermined key attributes to be identified and tested with specific populations and behaviours of interest, thereby informing evidence-based interventions (Floyd et al., 2009). A greater understanding of how selected attributes influence behaviours, and for whom, is also important for assisting urban planners and local councils to appropriately develop and maintain public open spaces.

There is currently no 'gold standard' for measuring the quality attributes of public open spaces. A number of instruments that measure parks and recreation environments have been developed for USA-based active living studies (Bedimo-Rung et al., 2006, Saelens et al., 2006, Cavnar et al., 2004, Troped et al., 2006, Lee et al., 2005). The wider international literature includes examples such as the Community Park Audit Tool (CPAT) (Kaczynski et al., 2012), the POST (Giles-Corti et al., 2005a), and the NZ-POST (Badland et al., 2010). These audit tools measure a variety of public open space attributes, including accessibility, use, activity areas, amenities, aesthetics and safety.

Public open space quantification

Public open space quantity (i.e., availability of public open space) for a given area can be calculated as the total size (area) of public open space within a given boundary or,

alternatively, the number of public open spaces located within a specified area, however the latter does not account for the proportion of area attributed to public open space. When considering accessibility, distance to closest public open space (e.g. by using either the road network distance or a Euclidean buffer) or distribution (e.g., evenly spread or clustered) of public open space within a given area may be considered. The current study focuses on the amount or proportion of public open spaces available within a given geographic area.

Previous research has shown that size of public open space may be important in the context of attracting and encouraging physical activity and active travel (Giles-Corti et al., 2005a). Larger public open spaces can host a range of facilities such as sports grounds, walking paths and playgrounds which enable multiple uses by multiple users. Using ratings of more than 500 public open spaces, Giles-Corti et al. (2005a) showed that parks of equal size tended to have more facilities present, and subsequently attracted more users.

To date, there is no standardised method for measuring public open space quantity (size). Depending on the research question, gross total public open space area for a given geographical unit may be of use, however if comparing public open space quantity across differing areas, standardisation of public open space quantity (i.e., accounting for varying geographical sizes of study areas) may be necessary to ensure comparability.

Current public open space audit tools

In general, observational audit tools offer unobtrusive quantification of public open space features that are not biased by individual resident perception and they are easy to conduct. Detailed reviews of built environment audit tools exist (Sallis, 2009, Brownson et al., 2009, Oliver et al., 2016). Although the reviews were not focused on specific tools for assessing

public open spaces, both Brownson et al. (2009) and Oliver et al. (2016) provide comprehensive reviews on the different measures and tools applied in the built environment literature for various population groups. Oliver et al. (2016) highlighted the range of measures developed and adapted for understanding the relationships between built environment features and children's behaviour (i.e., physical activity, independent mobility, active travel). Of particular relevance to the current investigation, the review concluded that a greater understanding of built environment factors related to children's behaviours could be gained by exploring the usability of a measure that incorporates both quality and public open space size. Evidence based development of an integrated measure, such as the POSAI, which simultaneously accounts for both quality and size, could contribute in this field by utilising and improving existing measures. It may also assist policy makers and land developers to deliver healthier communities by providing improved public open spaces in local neighbourhoods.

Methods

Study design

Kids in the City study

This study utilised public open space data drawn from the Kids in the City study, a cross sectional investigation conducted in Auckland, New Zealand. Detailed methods have been described in Chapter 2. In brief, the study examined the association of specific urban design attributes with child independent mobility. Data on activity behaviours (active travel and independent mobility) were obtained from the self-completed seven-day travel diary. Study design details, including the neighbourhood selection, can be found elsewhere (Oliver et al., 2011). To demonstrate the utility and validity of the POSAI tool the associations with active

travel and independent mobility were examined for the children living in the Kids in the City urban neighbourhoods (Chaudhury et al., 2016).

Public open space audits

Public open space audits were conducted manually (by the PhD candidate) using the NZ-POST. These took place between May and June 2012 and between October and November 2013. In this sub-study the school was conceptualised as the neighbourhood of interest, and 'school neighbourhood catchments' were used to define neighbourhood boundaries. Ethical approval was granted by the respective research institutes (AUTEC 07/126; MUHEC 10/091; and UAHPEC).

School and neighbourhood selection

The Kids in the City study recruited participants from schools and used school neighbourhood catchments to define school neighbourhoods. To capture adequate built and social environment variability, eight prospective co-educational primary (Years 0 – 6) and intermediate (Years 7 – 8) schools, geographically spread across the greater Auckland region, were identified by using a matrix of high/low neighbourhood walkability (Frank et al., 2010) and Neighbourhood Destination Accessibility Index (NDAI) (Witten et al., 2011) scores, built environment diversity markers and high/low school decile rating. The walkability index is a GIS-derived measure of neighbourhood walkability, comprising street connectivity (a measure of street pattern), dwelling density, land-use mix and retail floor area ratio (Leslie et al., 2007). The NDAI is a composite built environment measure that assesses access to various neighbourhood destinations using GIS and spatial datasets (Witten et al., 2011). School decile is an indicator of socio-economic status of residents within a school's neighbourhood catchment area; deciles range from 1 (the 10% of schools with the *highest*

proportion of students from low socio-economic areas) to 10 (the 10% of schools with the *lowest* proportion of students from low socio-economic areas) (Ministry of Education, 2013).

Delineating the school neighbourhood boundary

The use of school neighbourhood catchments (also known as school zones), while a relatively uncommon method of defining a neighbourhood for measuring public open space quantity, may be a meaningful measurement unit for investigation. Children spend the majority of their weekday outdoors time between home and school (Badland et al., 2015a). Therefore, using a school neighbourhood catchment will likely capture the child's route between home and school as well as other frequently accessed locations. The use of school neighbourhood catchments to define the neighbourhood boundary was deemed appropriate in this examination given that schools function as a key destinations for children (first 'place' is home; second 'place' is school; and the third place is the public realm (e.g. public open space, shops, streets) (Oldenburg, 1989). Previous studies suggest that, in general, children's everyday lives are engaged with these three places (Pooley et al., 2005b, Rasmussen, 2004). In well-designed neighbourhoods, facilities such as parks and playgrounds are likely located within the school neighbourhood catchment, and therefore children are likely to spend other recreational time within this catchment area (Badland et al., 2015b).

Rather than utilising an arbitrary Euclidian or road network boundary around schools (e.g., 800 m scale), a 'school neighbourhood catchment' (Ministry of Education, 2011), where these existed, was used to define the neighbourhood boundary (six of the schools).

Details of the geographical boundaries were obtained from the Ministry of Education's website (http://nzschools.tki.org.nz/). In the instances where there was no school neighbourhood catchment (two schools), a Euclidean buffer of 1200 m was generated and applied from the school's x, y coordinates. Overall, 1200 m was the median buffer value for the schools with catchment zones available. For the two neighbourhoods without a predefined school zone, this buffer was considered appropriate to enable comparability in size with the other study neighbourhoods Figure 5, and the distance of 1200 m was considered a walkable distance from the school for children to engage in active travel. Earlier research suggests that walkable distances for 10-12 year old children range from 250-1600 m (Timperio et al., 2006, Villanueva et al., 2012, Harten and Olds, 2004).

For each school neighbourhood catchment, the neighbourhood size (m^2) was calculated and the total area allocated as public open space (m^2) within the neighbourhood using GIS software (GIS; ArcInfo 9.1 (ESRI, Redlands, CA)).

Public open space identification

Prior to auditing, the first author and senior members of the team (including a spatial analyst) established a public open space selection criterion. According to the study definition, the public open space selection criteria included natural vegetation, parks and reserves. Grass verges and green spaces on roundabouts (traffic circles) were excluded from the audit process. Where public open spaces intersected a school neighbourhood catchment, the additional public open space area outside the school neighbourhood catchment was calculated and added to the total public open space size and school neighbourhood catchment size. The reason for this is that potential users would likely use the entirety of the public open space rather than stopping at an arbitrary buffer boundary, particularly in small- to medium-sized

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public open spaces. All public open spaces that intersected, or were within the school neighbourhood catchments, were included in the audit.

Percentage of public open space (public open space area for each neighbourhood)

The total area of each public open space within each school neighbourhood catchment was calculated using GIS and percentage of public open space area calculated as below:

Percentage of public open spaces area = (Total area of public open space/Total school neighbourhood area)

Public open space auditing

A training and familiarisation session was conducted where two researchers used the NZ-POST along with a trainer to independently rate a public open space outside of the study areas. The NZ-POST is particularly useful for the current study as it is comparatively shorter version of the POST (so can be implemented across many public open spaces in a short time), assesses diverse public open space features in isolation and together, provides a scoring system that can be used to compare public open spaces, and has also been used in the Australian (as the POST tool) (Giles-Corti et al., 2005a) and New Zealand (Badland et al., 2010) context. However, neither the POST nor the NZ-POST account for public open space quantity, that is, space allocated to the public open space within a given boundary. NZ-POST is a modified version of the POST (Giles-Corti et al., 2005a). Modifications included removing the following items: size of water feature, evidence of grass watering, accessibility for dogs, and types of surrounding roads (Badland et al., 2010). Overall, the NZ-POST included 41 items across four subscales; 'activities' (2 items), 'environment' (17 items), 'amenities' (17 items) and 'safety' (6 items). Scoring responses differed by items assessed.

For stand-alone items (e.g., presence of playground, playing fields), scores were assigned as 0 = not present or 1 = present for each attribute assessed. Scores ranged from 0 – 1, and were graded for variables that were more relative (e.g., approximate number of trees present; 1-50 = 0.33; 50-100 = 0.66; more than 100 = 1). In all instances, higher scores indicated better quality. For details on the features, subscales and scores of public open space variables assessed in the NZ-POST see Appendix I.

Audits were manually conducted on the selected public open spaces by the two auditors using the NZ-POST (Badland et al., 2010). The second auditor audited 50% of the total public open spaces. Assessment of inter-rater reliability was conducted for duplicate public open space audits in the school neighbourhood catchment using intraclass correlation coefficients (ICC) (Appendix I).

Data treatment and analysis

Raw NZ-POST data were entered into Microsoft Excel by the lead author. Accuracy of data entry was checked with a 10% random selection of NZ-POST scores. The POSAI was developed by integrating the NZ-POST with public open space quantity. To create the POSAI, the total scores for each of the four NZ-POST 'quality' subscales and the sum of these (total public open space score) were calculated for each public open space within a school neighbourhood catchment. The area in m^2 for each public open space was calculated and the two area measures, 'quantity' for the eight school neighbourhood catchments were calculated.

Individual variable weightings derived from principal components analysis (PCA) were used to extract data component weightings and to calculate the POSAI for each school

neighbourhood catchment. The variables included in the PCA to calculate the POSAI were the total quality scores for each subscale (activities, environment, amenities, and safety), total public open space score and percentage public open space area. It is common to use data reduction techniques, such as PCA and factor analysis, when attempting to address the complex relationships between multiple built environment features (Yan et al., 2010, Broberg et al., 2013). PCA creates fewer dimensions, which can simplify further analysis in a meaningful way (Broberg et al., 2013). Individual POSAI scores for each public open space were calculated at the public open space level and POSAI scores averaged for each neighbourhood.

Results

Inter-rater reliability of the NZ-POST audit was deemed acceptable for three of the four sub-scales (activities ICC=0.91; environment ICC=0.95; amenities ICC=0.98), and overall public open space score (NZ-POST ICC=0.95). Fair reliability was shown for the safety category (ICC=0.22) (Landis and Koch, 1977). This suggests that safety as an independent subscale could not be used to make comparisons across public open spaces. However, the overall score (including the safety score) demonstrated acceptable inter-rater reliability and, as such, the safety score was retained for the overall public open space score and final POSAI calculation. Data from the auditor who completed all audits was used for analyses (rather than averaging inter-rater values), as duplicate auditing (and inter-rater reliability) was only conducted on 50% of the public open spaces examined.

Characteristics for the anonymised schools are outlined in Table 1. Across the school neighbourhood catchments, 88 public open spaces fulfilled the previously described selection criteria (out of 147 green spaces), and were audited. The total scores from the NZ-POST

subscales (activities, environment, amenities and safety) along with the two measures of area (standardised public open space area and percentage of public open space area) are presented as supplementary information (Appendix J). Table 3 presents the POSAI values for each of the eight school neighbourhood catchments.

Table 1. Demographic characteristics for Kids in the City schools and their school neighbourhood catchments, Auckland, New Zealand

School NH catchment[1]	School decile	Existing geographical boundary	Size of school NH catchment area (m^2)	Total n of green spaces per NH (catchment and intercepting)	Auditable public open space per neighbourhood
School A	1	No	316760	22	8
School B	1	Yes	446730	21	14
School C	1	Yes	659154	14	10
School D	1	Yes	26940	6	4
School E	4	Yes	205129	28	15
School F	5	No	247460	18	11
School G	4	Yes	1015122	17	8
School H	7	Yes	330576	21	18

[1]Ministry of Education defined geographical boundaries for school neighbourhood catchments

Note: m = metres; n = number; NH = neighbourhood

The locations of the eight socio-economically diverse school neighbourhood catchments are detailed in Figure 5. Public open space distribution, and variations in school decile for each location are presented. As shown in the sample, the quality of public open spaces across socio-economically and geographically diverse areas was relatively homogeneous. The Kruskal-Wallis test, a nonparametric test was applied to determine if there were any

statistically significant differences between the POSAI score and the dependent variables, school neighbourhood, school decide and NDAI (Figure 6).

Principal component analysis

Details of the component matrix and coefficients are provided in Table 2. Data from the PCA showed that component one explained 56% of the variance (Eigen value = 3.379) and this component was therefore utilised in the current study. Component one grouped the subscales for public open space activity, safety, and amenity variables. Component two of the PCA data reduction explained a further 18% of the variance (Eigen value = 1.082) and appeared to capture public open space size and public open space attributes.

Table 2. Component matrix for Principal Component Analysis data reduction

Characteristics	PCA reduction with percentage of public open space area[1]	
	Component 1[2]	**Component 2[2]**
NZ-POST activity score	0.800	0.373
NZ-POST environment score	0.778	-0.267
NZ-POST amenities score	0.686	0.558
NZ-POST safety score	0.475	0.472
Public open space area standardized	0.870	-0.407

[1] Proportion of neighbourhood area

[2] Component 1 explained 56% of variance and component 2 further 18% of variance from PCA reduction

Note: NZ-POST = New Zealand-Public Open Space Tool; PCA = Principal Component Analysis

Legend

Open Spaces
School Catchment

NZ Deprivation Index
1
2
3
4
5
6
7
8
9
10

School Catchment	Decile	Walkability	NDAI
A	1	20.0	3.7
B	1	21.3	7.4
C	1	21.2	10.2
D	1	19.7	6.5
E	4	25.5	16.6
F	5	19.7	12.0
G	4	28.0	22.5
H	7	29.2	17.6

0 1 2 4 6 8
Kilometers
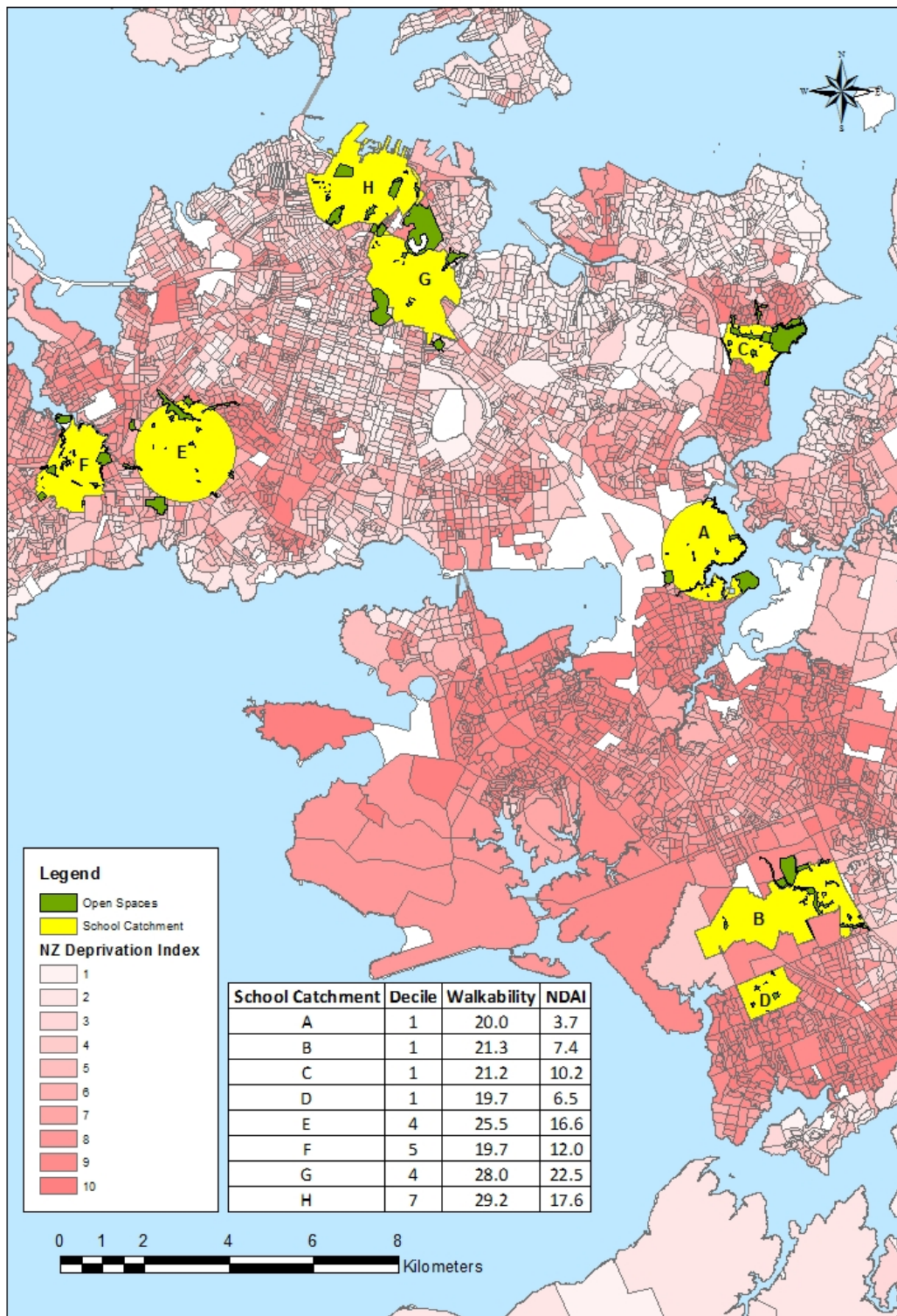
Figure 5. Geographical location of the eight school neighbourhood catchments

POSAI score

Descriptive results for the POSAI scores are presented in Table 3. The POSAI score was on average 15.11, ranging from 4.78 to 38.87.

Table 3. Public Open Space Attributable Index (POSAI) score descriptive information for percentage of public open space area

School neighbourhood catchment	POSAI Score (with percentage of public open space area)	
	Mean	**(min, max)**
School A	12.57	(4.78,26.50)
School B	13.39	(7.12, 22.03)
School C	16.29	(5.37, 29.79)
School D	11.34	(6.90, 15.06)
School E	14.18	(7.41, 32.77)
School F	15.04	(5.60, 30.67)
School G	20.98	(5.95, 38.87)
School H	15.96	(6.19, 38.86)
Total	15.11	(4.78, 38.87)

[1] Proportion of neighbourhood area

Note: max = maximum, min = minimum, POSAI = Public Open Space Attributable Index

PCA showed variation between total environments and area size versus the totals for activity, safety and amenities. When comparing the POSAI scores by walkability, NDAI, and school decile, some variability was observed, however the differences were not significant (Kruskal-Wallis t-test: neighbourhood $p = 0.668$, school decile $p = 0.628$, walkability $p = 0.668$, NDAI $p = 0.668$). This suggests the POSAI was stable and consistent across school deciles and was appropriate to use across a range of socio-economically and physically diverse environments Figure 6.
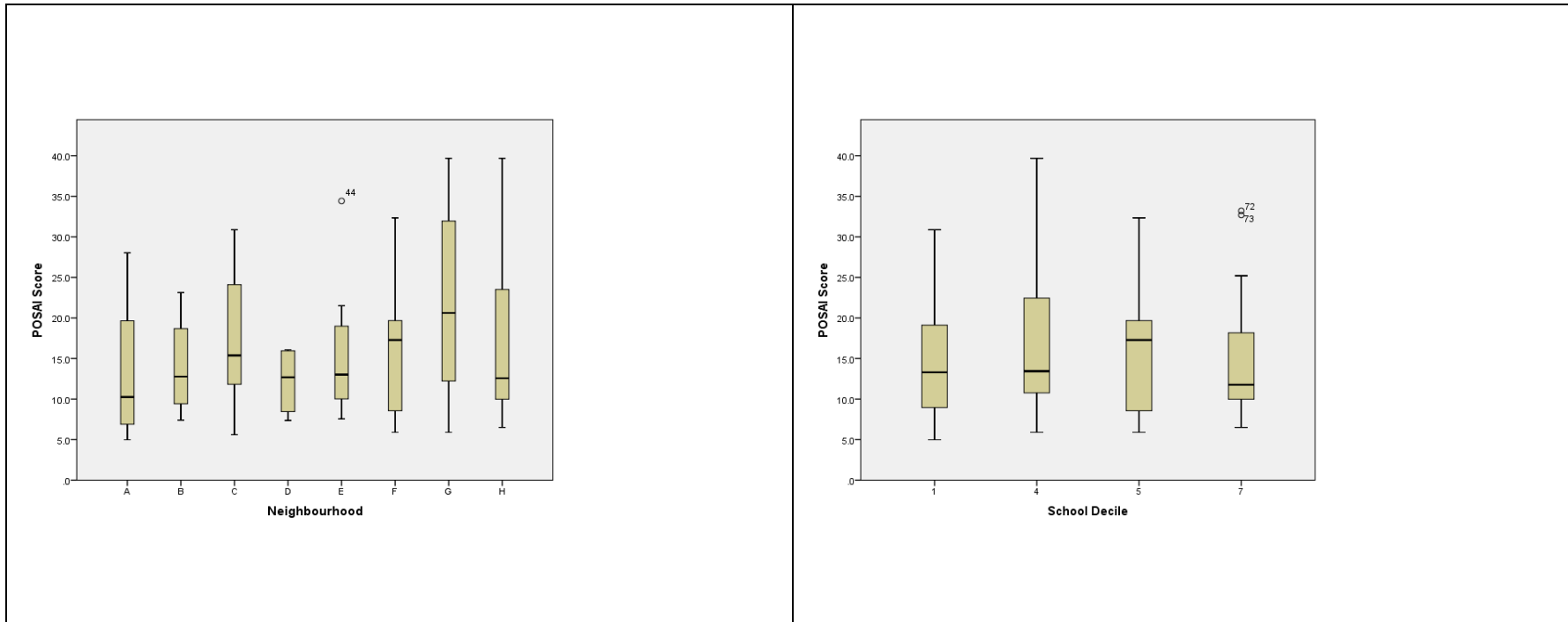
Figure 6. Boxplots of Public Open Space Attributable Index (POSAI) score (percentage of public open space area) by school neighbourhood catchment and school decile

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Discussion

The aim of this study was to develop and test the utility of a proof of concept tool, the POSAI. The POSAI may be used to compare both quality and quantity of public open spaces across different child-relevant built and social environments. A replicable methodology and tool has been created that is appropriate for at least the urban environment. Furthermore, the POSAI builds on existing POST and NZ-POST indexes (Giles-Corti et al., 2005a, Badland et al., 2010) by adding a measure of public open space quantity.

PCA was used as a tool in exploratory data analysis for the creation of the integrated POSAI tool. In data reduction of the component matrix, 56% of the variation was explained by component one. The environmental measures (i.e., environment, activities, amenities except for safety), and area measures (i.e., standardised public open space area and percentage public open space area) contributed positively and relatively similarly.

The results (Figure 6) showed some indication that differences existed between neighbourhoods of differing socio-economic status (a pattern of higher POSAI scores was seen in more disadvantaged areas), however in the current examination these differences were not significant. Crawford et al. (2008) found public open spaces located in disadvantaged areas had more amenities available (e.g., toilets, drinking fountains), better shading from trees, more walking and cycling paths, and adequate lighting compared with public open spaces located in more advantaged areas. Similar results have been reported elsewhere (Giles-Corti et al., 2003, Smoyer-Tomic et al., 2004). Findings from this study concur with existing research which has shown no clear

disparities across high/low deprivation neighbourhoods in terms of access to community resources such parks across New Zealand (Witten et al., 2011, Badland et al., 2010). Badland et al. (2010) found neighbourhood areas that were more disadvantaged tended to have more safety features present in public open spaces than less disadvantaged areas, but poorer public open space amenities.

Spatial distribution of public open space has been examined using an environmental justice lens (Edwards et al., 2013). Some research has concluded that distribution of urban parks varied within cites and in neighbourhoods (census tract data) of lower socio-economic status (Estabrooks et al., 2003), whereas other research has shown no socio-economic status patterning (Timperio et al., 2007). Regardless, distance to public open space within the same neighbourhood may vary for individuals if public open spaces are not uniformly spread across the given area. Timperio et al. (2004) reported that a lack of proximal parks was negatively associated with children's walking and cycling, and in adults having a 'nearby park or nature reserve' was associated with regular walking (Sugiyama et al., 2015). Proximity to public open space, and spatial distribution of public open space within a neighbourhood, were not measured in the current study as its focus was developing an integrated measure of public open space quality and quantity (area) at the school neighbourhood catchment level.

A standardised measure of public open space quantity that accounts for neighbourhood size is a useful approach. In studies where neighbourhood boundaries are identical (e.g., employing an 800 m Euclidean buffer) a standardised metric may not be necessary, however public health research is moving towards the utilisation of street network buffers (or in this case, school neighbourhood catchments) as the appropriate measure

for capturing neighbourhood boundaries (Learnihan et al., 2011). With this trend, the application of a standardised neighbourhood measure will become increasingly important and should be applied when street network buffers (or any varying buffer approaches between study areas) are used.

Limitations and strengths

Limitations of this study include that the POSAI calculations were reliant on GIS expertise as well as manual audits of public open spaces, which can be resource intensive. In the current study, POSAI was derived for school neighbourhood catchment areas, rather than an individually-derived area (i.e., a neighbourhood catchment around participants' residential addresses). Therefore, the relevance of this approach may be lessened on weekends and school holidays, especially if the tool is compared with individual-level or household-level outcome measures. The low inter-rater reliability of the NZ-POST safety category (ICC= 0.22) was likely related to the subjective nature of the items in the category, such as lighting coverage of public open space, appropriateness for walking, and suitability of public open space to play casual ball sports or cycling. Such assessments are predicated on personal perceptions of safety. School neighbourhoods were purposively selected in terms of high and low socio-economic status and high and low neighbourhood walkability/destination accessibility. At the inception of this research, it was anticipated that this would generate significant built and social environment variation. It is possible that built environment neighbourhood variation did not translate into public open space quality and quantity variation. A more targeted method would have been to systematically identify areas with better or poorer public open space quality, however this would have required substantial auditing prior to undertaking the research which was not feasible. It is

possible that the PCA method used in the analyses resulted in a loss of sensitivity in terms of identifying meaningful differences between areas. As discussed above, it is also possible that neighbourhoods in Auckland with varying social and built environment characteristics do not have significant differences between public open spaces when accounting for both quality and quantity. Further empirical testing of this measure is needed and more diverse environments should be compared.

The primary strength of this study is the development of a proof of concept tool which integrates both public open space quality (attributes) and quantity (size) measures in one index and which can be used in diverse urban settings. The POSAI, with its one score for neighbourhood, provides a useful measure that would enable planners and policy makers to prioritise one area over another where changes may be needed.

Conclusion

To the PhD candidate's knowledge this is the first study to provide a detailed methodological description of the development of a tool that simultaneously uses both public open space quality and quantity to derive an integrated measure, POSAI. The purpose of this study was to test a proof of concept tool that may be developed into a more generalizable measure. It is anticipated that POSAI scores can be related to behaviours such as physical activity, active transport and independent mobility levels thereby strengthening the evidence base for determining how public open spaces are related to children's health behaviours.

CHAPTER 4

Applying the Public Open Space Attributable Index (POSAI) tool to assess children's public open space use and access by independent mobility

Preface

In Chapter 3, the newly developed POSAI tool indicated that there was a trend towards differences between the neighbourhoods of different socio-economic status (a non-significant pattern of higher POSAI score was seen in the more disadvantaged urban neighbourhood areas). However, the examination in Chapter 3 was limited to understanding variation in scores by broad socio-demographic indicators (i.e., age, sex, ethnicity, and parental licence for freedom score). Building on this work, Chapter 4 examines the associations between POSAI scores and public open space use and independent mobility for children living in socio-economically and geographically diverse neighbourhoods. Applying the POSAI in diverse environments was an important step in enabling greater insight into children's public open space use and independent mobility in different contexts.

Introduction

Children's independent mobility is an integral part of a child's 'growing up' experience in their local neighbourhood environment. Children's independent mobility is described as the freedom to move to destinations outside of the home environment by active travel (i.e., walking, cycling) and to engage in outdoor play without adult supervision (Hillman et al., 1990). The benefits of children's independent mobility include fostering children's physical, social, emotional, cognitive and spatial development (Kyttä, 2004). By engaging in independent mobility children develop skills for safely navigating risky situations, such as crossing busy roads or encountering strangers, and contribute to greater community social capital (Rudner, 2012).

Over the last 40 years children's independent mobility has declined across a wide range of industrialised nations (Fyhri et al., 2011, Schoeppe et al., 2015b, Shaw et al., 2013). Long-term trend data from England showed that in 1971 86% of parents allowed their primary-school aged children to travel home from school alone; by 1990 this had declined to 35% and in 2010 this percentage had further reduced to 25% (Shaw et al., 2013). Increased parental concerns about children's safety when in outdoor environments (e.g. stranger danger and road safety) have likely contributed to this decreasing prevalence (Carver et al., 2008, Fyhri et al., 2011). In addition, the intensification of cities has contributed to a loss of suitable public open space in neighbourhoods for unsupervised travel and play (Ergler et al., 2013). Public open space refers to a range of spaces including green spaces (e.g. public parks, reserves, and planted areas), areas of natural vegetation (e.g. woodlands, grass verges), blue spaces (e.g. waterways, rivers, wetland and coast), and grey spaces (e.g. civic squares, streets, transport corridors) (Regional Public Health, 2010). Here the focus is on public open

spaces that are freely accessible to the public. Some of the public open spaces examined housed privately owned facilities which charged a fee for use. These facilities, however, were all associated with green space which did provide free of charge opportunities for children to engage in other activities, e.g., sports field, playground, walking trail. Public open spaces in this examination were delimited and defined as freely accessible parks, reserves, and green spaces (including those containing wetlands) located in urban neighbourhoods. In this chapter these spaces will be referred to as public open space.

Public open space provides children with opportunities to engage in physical activity is a destination to which children can actively travel (Floyd et al., 2011, Veitch et al., 2014). These settings also provide areas to relax, foster social connectedness, improve mental health and well-being and promote friendship development (Lachowycz and Jones, 2013, Maas et al., 2006, Sugiyama et al., 2008). Evidence suggests that children who have contact with areas of natural vegetation (e.g. bushland, woodlands, and forest) enjoy enhanced play, adventure, and exploration benefits (Freeman et al., 2015). This exposure to natural vegetation also provides children with opportunities to interact with nature and develop their physical prowess through activities including swimming, climbing trees, running and chasing (Freeman et al., 2015). At present, evidence suggests children's independent travel to areas of natural vegetation is limited. One recent Norwegian study (Skar et al., 2016) reported that children aged between 6-12 years spent more time in nature with adult supervision than without. This would suggest that parental directives are key drivers of whether children are able to visit these areas independently.

A recent study of Australian youth aged 8-15 years examined the associations between physical features in the neighbourhood environment and children's independent mobility to a number of local neighbourhood destinations, including public open space (Christian et al., 2015a) and reported independent travel decreased with increased distance to public open space. Similarly, another study found less than one third of adolescents used the closest park. They chose less proximate parks because of the presence of features such as a skate park, walking paths, barbeques, picnic tables, public access toilets, lighting around courts and equipment and number of tress (Edwards et al., 2015). Previous studies have also shown that living closer to public open space, irrespective of size, is positively associated with children's independent mobility (Alparone and Pacilli, 2012, Mackett et al., 2007, Christian et al., 2015a). Villanueva et al. (2013a), in a study of Australian children aged 10-12 years, found girls' independent mobility was higher when they perceived the closest public open space to their residence as safe. For boys, the likelihood of children's independent mobility increased if they perceived that their closest public open space had fun and interesting 'things to do.'

However, simply locating public open space in neighbourhoods does not guarantee their use. Design, quality, population-appropriateness and maintenance of the public open space have been shown to encourage, or discourage, public open space use (Villanueva et al., 2013c). For example, adult and child focus group findings from the Child's Play study in Australia (Wood et al., 2010) showed public open spaces that were inadequately or poorly maintained were used less than their well-maintained counterparts. Similar findings have been found elsewhere (Bedimo-Rung et al., 2005).

There is a growing body of literature examining different aspects of public open space (e.g., proximity to home, size, quality) in relation to use; however to date this research has primarily focused on adult physical activity outcomes (Koohsari et al., 2015, Ord et al., 2013). Giles-Corti et al. (2005a) showed that, after accounting for size, public open spaces which rated 'higher' versus 'lower' quality were more likely to attract users to engage in physical activity across all age groups. Conversely, Kaczynski et al. (2008), reported size of, and distance to, public open space were not significant predictors for use among adults, although specific features inside the public open space (e.g. paved trails) were positively related with use.

Previous studies examining environmental quality attributes of public open space and physical activity-related outcomes have applied separate measures of quality and quantity, and primarily focused on adults. The unique contribution of this study is to apply a public open space measure that combines both quality and quantity to investigate children's use of public open space. Applying this combined measure can help elucidate whether the physical attributes and size of a public open space are important factors in determining children's use of, and travel behaviours to, such spaces. Therefore, the aim of this study is to determine if public open space quantity and quality, as assessed using the newly developed POSAI, is associated with public open space use and children's independent mobility for children living in urban neighbourhoods in Auckland, New Zealand. This study hypothesizes that public open spaces which score higher on the POSAI (i.e., larger size and better environmental quality of the public open space) will be associated with higher levels of public open space use by children and will be accessed by children who are independently mobile.

Methods

Kids in the City study design

Data were drawn from the Kids in the City study. This was a cross-sectional study designed to examine the association between urban design attributes and children's independent mobility in Auckland, New Zealand's largest city. In brief, children attended one of nine participating schools (eight primary (elementary) schools (Years 0-6) and one intermediate school (Years 7-8), from socio-economically diverse neighbourhoods across Auckland. Parents/caregivers of the participating children completed a researcher assisted Computer Administered Telephone Interview (CATI) to report on child, parent and household demographics, and parental licence. Area-level population census data were collected between 2011 and 2012 (Statistics New Zealand, 2007).

POSAI environmental audits were undertaken between May and June 2012 and between October and November 2013. A detailed study design for the Kids in the City study (Oliver et al., 2011) and the POSAI development (Chaudhury et al., *under review*) can be found elsewhere. For this examination, data were extracted for all children attending the eight primary schools (n = 240, aged 9-12 years). Data for children attending the intermediate school were excluded, as it was likely the independent mobility behaviours and parental licences of the children in that group were different.

Ethical approval was granted by the respective research institutes (AUTEC 07/126; MUHEC 10/091; and UAHPEC).

Measurement

Children's demographic information

Data collected from the parent CATI included information on the child's sex, date of birth, and ethnicity.

Children's independent mobility and trips to public open space

Children's independent mobility was measured using travel diaries for seven consecutive days. For each day of the measurement period, children were provided with a paper travel diary to self-complete in the evening and the following morning. Time, origin, destination, mode of travel (e.g., walking, cycling, motorised vehicle, scootering), and accompaniment status were collected for each journey undertaken during the measurement period. To maximise travel diary compliance and accuracy, a member of the research team checked diaries and confirmed each weekday of data collection with the child. This included going through, in detail, the previous day's diary activities sequentially; including the trip destination, travel mode of each trip, time and accompaniment status of the child (Oliver et al., 2011, Badland et al., 2015a).

All destinations to which children reported travelling were classified into primary domains (e.g., education) and sub-domains (e.g., primary schools) based on the Neighbourhood Destination Accessibility Index–Child (Badland et al., 2015a). The 'parks' (sub-domain) variable of interest was classified under the 'recreation' primary domain in the NDAI-C and identified for use here. Only in some instances was the specific public open space visited by the child reported. In most cases the child would simply report the destination as a 'park', 'playground' or 'sports field.' Data were extracted from the travel dairies to determine the total number of trips made to public

open spaces and the total number of trips made to public open spaces independently (i.e. without adult supervision).

Parental licence for freedom

The parental licence for freedom score was derived from five questions asked of parents/caregivers (via the CATI) about 'licences' afforded to their child to go to particular destinations or play on their own, without adult supervision. Parents rated their responses for each of the statements using a 5-point Likert scale ranging from 'strongly agree' to 'strongly disagree.' Parental licence questions asked about travelling to the following destinations: school, friends' houses, shops, organized activities, as well as play without adult supervision. This measure is based on the original work by Hillman et al. (1990). A principal component analysis (PCA) was used to generate the parental licence for freedom score. PCA scores were rescaled to range between 1.0 (lowest freedom) and 10.0 (highest freedom). The parental licence for freedom score was split into quartiles to allow the examination of non-linear associations with the binary outcomes.

School neighbourhood public open space selection

Neighbourhood identification

To capture built environment variability, schools within the greater Auckland region were identified using a matrix of high/low school decile rating and high/low neighbourhood walkability (Frank et al., 2010) and destination accessibility (Witten et al., 2011). School decile is an indicator of socio-economic status of residents within a school's catchment area; deciles range from 1 (the 10% of schools with the highest proportion of students from low socio-economic areas) to 10 (the 10% of schools with

the lowest proportion of students from low socio-economic areas) (Ministry of Education, 2013). In this study sample, the school deciles ranged from 1 to 7.

Delineating the school neighbourhood catchment

'School neighbourhood catchments' were generated around the eight state primary schools. Where available (six schools), established school zones (Ministry of Education, 2011) were used to define the school 'neighbourhood' catchment. This was preferred over the arbitrary Euclidean or road network boundary around schools (e.g. 800 m scale). In New Zealand, children who live in the defined catchment of a state school are guaranteed a place at that school. Geographic boundaries of the school zones were obtained from the Ministry of Education website (http://nzschools.tki.org.nz/). Where there was no school catchment (two schools), a Euclidean buffer of 1200 m generated from the school's x, y coordinates was applied. This was the median buffer value for schools with defined catchments. Neighbourhood size (m^2) was calculated using Geographic Information Software (GIS) ArcInfo 9.1 (ESRI, Redlands, CA).

Public open space identification and auditing

Public open space that intersected or fell within the school neighbourhood catchments were identified for auditing. Spaces excluded from auditing were grass verges and green spaces on roundabouts (traffic circles). In total, 146 GIS-derived public open spaces were identified across the eight school neighbourhood catchments, of which 88 (60%) comprised of parks and reserves that could be readily accessed. The remaining 40% were those public open spaces that were deemed unsuitable for, or spaces not conducive to children's use, such as road side grass verges, roundabouts and public open space in busy intersections near main roads, as well as some some overgrown fields. A number of large established reserves/parks within the school neighbourhood catchments were, at

the time of audit, undergoing major refurbishments by the local council which meant they were cordoned off from use and therefore not audited.

Where public open space intersected a school neighbourhood catchment, the additional public open space area (i.e. the public open space area outside of the school neighbourhood catchment) was calculated and added to the total school neighbourhood size. It is likely that any potential user would use the entirety of a public open space rather than stopping at a synthetic buffer boundary, particularly in small- to medium-sized public open spaces.

Public open spaces were physically assessed by trained auditors using the NZ-POST (Badland et al., 2010). This was adapted from the validated 49-item POST (Giles-Corti et al., 2005a). The NZ-POST included 41 items across four subscales; activities (2 items), environment (17 items), amenities (17 items) and safety (5 items) (detailed below) and excluded the following four POST items: size of water feature, evidence of grass watering, accessibility for dogs and types of roads.

Scoring responses differed by the item being assessed as follows: (1) Items with a dichotomous outcome, for example, presence or absence of playground, were assigned 0 = not present, or 1 = present; (2) Items with a graded outcome, for example, approximate number of trees, were assigned a score ranging from 0 to 1; $\leq$ 50 trees = 0.33, 50-100 trees =0.66; > 100 trees = 1). Higher scores in all instances indicated better quality. Details can be found elsewhere (Badland et al., 2010).

Measures

Public Open Space Attributable Index (POSAI)

The POSAI is an environmental audit tool that assesses both public open space quality and quantity. In brief, the 'quality' of public open space was determined by the NZ-POST (Badland et al., 2010). The NZ-POST features a series of four subscale scores (activities, environmental quality, amenities, safety) and a composite score derived from the sum of the items. As explained above, the total area for selected public open space was calculated using GIS. A standardised measure of public open space area was applied in the analyses. Detailed information on the development of the POSAI measure is described elsewhere (Chaudhury et al., *under review*).

To combine the quality and quantity components, PCA was used to calculate the index variable for each school neighbourhood catchment. PCA techniques are increasingly being applied to address relationships between multiple built environment features (Broberg et al., 2013, Yan et al., 2010). PCA creates fewer dimensions, which can simplify further analysis in a meaningful way (Broberg et al., 2013). Accordingly, individual variable weightings derived from PCA were used to calculate the index score for each school neighbourhood catchment. Neighbourhood level POSAI scores were dichotomised as high or low using the median score for all public open spaces within the given neighbourhood. Descriptive information for the POSAI score was examined by school decile.

Data analyses

Bivariate logistic regression analyses adjusted for cluster effects were undertaken to determine associations between the school, potential child and parent predictor factors

(age, sex, ethnicity, parental licence for freedom score, POSAI score) with: (1) any trips to a public open space; and (2) any independently mobile trips to a public open space. Factors significantly associated with any trips to public open space at p-value ≤ 0.20 in the bivariate analyses were then simultaneously considered in a multivariate model (Sun et al., 1996). Non-significant factors (p-value > 0.05) were removed from the multivariate model in a stepwise manner to attain the final models. Analyses were undertaken using SPSS v22.0 (SPSS Inc., Chicago, IL) and SAS v9.4.

Results

Results from the inter-rater reliability testing of the NZ-POST subscales have been previously discussed in Chapter 3.

On average, there were fewer public open spaces in lower decile areas compared with higher decile areas. Compared with the lowest decile school areas, the one school area rated as high decile had double the number of public open spaces (18 compared with 9). On average, POSAI scores were lower in the most disadvantaged areas than the more advantaged neighbourhoods. However, POSAI scores varied substantially both within school neighbourhood catchments and within deciles. For example, the average POSAI score for the lowest decile schools (decile 1) was 14.52, with a range of 4.98 to 30.87. This compares with a range of POSAI scores from 5.89 to 39.69 for higher decile areas (deciles 4-7; data on request).

A total of 254 children aged 9-12 years participated in the Kids in the City study total sample. Of these, complete travel diary and parent CATI data were available for 240 children (94%). All the children living in and out of the school neighbourhood catchments were included in the analyses (n=172 -in zone; n=67 out of zone). In total

3,234 trips from home to a destination were identified from the travel diaries, of which 68 (2.10%) trips were made to public open spaces (hereafter 'any trips') and 35 (1.08%) were made by an independently mobile participant. Table 4 presents descriptive data for participants included in the analyses, by 'any trips' and 'independently mobile' trips to a public open space over the last seven days.

Table 4. Summary of descriptive data of children by public open space use and any independently mobile trips to park

Variable	N	Any trips to a public open space during last seven-days		Any independently mobile trips to a public open space during the last seven-days	
		Yes n (%)	**No** n (%)	**Yes** n (%)	**No** n (%)
Sex					
Girls	136	32 (23.5)	104 (76.5)	17 (12.5)	119 (87.5)
Boys	104	36 (34.6)	68 (65.4)	18 (17.3)	86 (82.7)
Age					
9	54	14 (25.9)	40 (74.1)	4 (7.4)	50 (92.6)
10	163	47 (28.8)	116 (71.2)	29 (17.8)	134 (82.2)
11-12	23	7 (30.4)	16 (69.6)	2 (8.7)	21 (91.3)
Ethnicity					
European	53	16 (30.2)	37 (69.8)	7 (13.2)	46 (86.8)
Indian/Asian /Other	62	13 (21.0)	49 (79.0)	2 (3.2)	60 (96.8)
Māori	30	12 (40.0)	18 (60.0)	6 (20.0)	24 (80.0)
Samoan	38	14 (36.8)	24 (63.2)	11 (28.9)	27 (71.1)
Other Pacific Islander	45	10 (22.2)	35 (77.8)	7 (15.6)	38 (91.0)
Parental licence for freedom (quartile)					
1 (lowest)	66	13 (19.7)	53 (80.3)	4 (6.1)	62 (93.9)
2	50	17 (34.0)	33 (66.0)	11 (22.0)	39 (78.0)
3	54	15 (27.8)	39 (72.2)	9 (16.7)	45 (83.3)
4 (highest)	56	18 (32.1)	38 (67.9)	9 (16.1)	47 (83.9)
POSAI score					
Low	131	44 (33.6)	87 (66.4)	23 (17.6)	108 (82.4)
High	109	24 (22.1)	85 (78.0)	12 (11.0)	97(89.0)

Results from the bivariate analyses for any trips made to a public open space are presented in Table 5. Ethnicity of the child and the POSAI score were related to any trips to public open space at $p < 0.20$ and therefore were considered simultaneously in a multivariate model. When considering these variables together, only ethnicity ($p \leq 0.0001$) remained significantly associated with children making any trips to public open space. Māori (OR 1.54; 95% CL 0.47, 5.06) and Samoan (OR 1.34; 95% 0.67, 2.70) children had around 1.5 and 1.3 greater odds, respectively, of making any trips to public open space compared with children of European ethnicity.

Table 5. Bivariate logistic regression[1] analysis of variables with any trips to a public open space

Variable	N	OR	95% CI	p-value
Sex				0.10
Girls	136	Reference		
Boys	104	1.72	(0.91, 3.27)	
Age				0.91
9	54	Reference		
10	163	1.16	(0.34, 3.98)	
11-12	23	1.25	(0.46, 3.43)	
Ethnicity				**<0.0001**
European	53	Reference		
Indian/Asian/Others	62	0.61	(0.28, 1.33)	
Māori	30	1.54	(0.47, 5.06)	
Samoan	38	1.39	(0.67, 2.70)	
Other Pacific Islander	45	0.66	(0.22, 1.95)	
Parental licence for freedom score (quartiles)				0.74
1 (Lowest)	66	Reference		
2	50	2.10	(0.48, 9.17)	
3	54	1.57	(0.50, 4.88)	
4 (Highest)	56	1.93	(0.58, 6.46)	
POSAI score				0.06
Low	131	Reference		
High	109	1.68	(0.98, 2.90)	

[1]Bivariate logistic regression adjusted for school effects

Bivariate analyses of children's independently mobile trips to a public open space revealed significant associations with age, ethnicity, and parental licence for freedom $p < 0.20$ (Table 6).A stepwise regression approach was used, starting with an initial model of all possible predictors, and manually dropping the least significant term one at a time. After stepwise elimination of non-significant variables in the multivariate logistic

regression (i.e., age, sex, POSAI score) ($p > 0.05$), ethnicity ($p = 0.003$) and the parental

licence for freedom score ($p \leq 0.0001$) remained significantly associated with the

likelihood of children making any independently mobile trips to a public open space.

Children with higher parental licence had greater odds of travelling independently to a

public open space, though this trend was not linear. Children in the second quartile (OR

4.97; 95% CI 2.03, 12.17) had the greatest odds of travelling independently to a public

open space. Compared with children of European ethnicity, children of Samoan

ethnicity were more likely to make trips to public open spaces independently (OR 2.60;

95% CI 1.17, 5.78).

Table 6. Bivariate logistic regression[1] analysis of variables with any independently mobile trips to a public open space

Variable	N	OR	95% CI	p-value
Sex				0.14
Girls	136	Reference		
Boys	104	1.47	(0.88, 2.44)	
Age				**0.03**
9	54	Reference		
10	163	2.71	(1.12, 6.52)	
11-12	23	1.19	(0.21, 6.85)	
Ethnicity				**0.003**
European	53	Reference		
Indian/Asian/Others	62	0.20	(0.05, 0.83)	
Māori	30	1.48	(0.25, 8.71)	
Samoan	38	2.60	(1.17, 5.78)	
Other Pacific Islander	45	1.15	(0.41, 3.21)	
Parental licence for freedom score (quartiles)				**<0.0001**
1 (Lowest)	66	Reference		
2	50	4.97	(2.03,12.17)	
3	54	2.67	(1.48, 4.80)	
4 (Highest)	56	2.83	(1.14, 7.01)	
POSAI score				0.27
Low	131	Reference		
High	109	0.58	(0.22, 1.51)	

[1]Bivariate logistic regression adjusted for school effects

Discussion

Over the last decade research exploring associations between built environment features and health outcomes and behaviours has grown (Giles-Corti et al., 2005a, Koohsari et al., 2013, Hunter et al., 2015, Christian et al., 2015b). This study applies, for the first time, POSAI, an innovative tool that combines measures of public open space quality

(environmental attributes) and quantity (size of public open space) with child behaviours. This tool can be useful for modelling relationships between public open space and health outcomes. The primary aim of this study was to determine if a combined measure of public open space quality and size, assessed using the POSAI, was associated with public open space use and travelling independently to public open space in a sample of children living in urban neighbourhoods. To date no one has used a combination of these two public open space measures in one index and nor have behaviours in a child population been tested in this context.

When examining relationships between the POSAI with total trips to public open space and children's independent mobility trips to public open space, a significant association was found with ethnicity. Findings on children's ethnicity being associated with independent trips was unexpected. Children of Samoan descent were more likely to travel independently compared with those of European descent. One possible explanation as to why children of Samoan, or Māori, descent were more likely to travel independently to public open space could be because there is a higher proportion of single parent families in these ethnic groups (Social Policy Evaluation and Research Unit, 2015). Additionally, in the Auckland, New Zealand context, neighbourhoods with higher Pasifika ethnicities may have more extended family living in close proximity (Poland et al., 2007, Schluter et al., 2007) and therefore children's active travel maybe be independent of adults but undertaken with other siblings and or child/adolescent relatives (Carroll et al., 2013). At present only a small number of studies have looked at child's ethnicity and active travel to destinations (Mendoza et al., 2010, Yelavich et al., 2008). Further studies are needed to better understand this phenomenon.

A systematic review by Pont et al. (2009) examined environmental correlates of active transport in children aged 5-18 years. The authors found a positive relationship between children of minority ethnic backgrounds (Hispanic, Asian, Māori, Pacific Islander, or other) and children's active travel. Two studies by de Bruijn et al. (2005) (the Netherlands) and Yelavich et al. (2008) (New Zealand) found that children of recent immigrant backgrounds were between two and half to three times more likely to use active transport than those who did not have an immigrant background. However, results from this current study could not be verified as data on generational immigration was not assessed.

Earlier findings from a sub sample of the Kids in the City examined children's active travel (Tav'ae et al., 2012). showed the odds of a child of 'other Pacific Island' ethnicity (i.e., Tongan, Niuean, Cook Island Māori), excluding Samoan, walking both ways to school were 6.1 times greater than those of a child of 'European/Asian/Other' ethnicity (p = 0.001). Both Tav'ae et al. (2012) and the present study are based on small sample sizes, however these travel behaviour patterns by ethnicity are similar to national survey data. Such nationally representative data for New Zealand show that Pacific children have relatively high levels of active transport (such as walking to school), although they participate less than other groups in organised leisure and sport (Ministry of Health, 2003). In other work examining children's spatial mobility in urban settings in the United Kingdom, researchers found that minority ethnic children were more restricted in their use of urban space compared with white children, though the magnitude of the differences were not reported (O'Brien et al., 2000). Further in-depth exploration may be warranted to look at ethnic differences in children's independent mobility and associated variables across different geographic contexts.

It is worth noting that although the POSAI score was not statistically significantly associated with any trips to public open space, the p-value was only just above the 5% significance level for the bivariate analyses (p = 0.0506 not reported) and had a p-value of 0.08 if considered for additional inclusion in the multiple variable model. This indicates the POSAI has potential relevance to the modelling of children's use of open space and may be significant for a larger study. Study results show that when POSAI was high (indicating higher quality and larger sized public open space), the odds of any trip made to a public open space was almost half that of when the POSAI was low. This was a curious finding, especially in light of existing literature. Previous studies have shown that better quality (e.g., aesthetics) public open space, as assessed by direct observational audits, are associated with higher public open space use and increased activity amongst children (Timperio et al., 2008, Veitch et al., 2006). Veitch et al. (2012) collected observational data including pre- and post-public open space improvements. They found that improvement of 'internal' features resulted in an overall increase in public open space use (i.e., walking and physical activity) across all age groups. A Canadian study (Kaczynski et al., 2008) found associations with physical activity and park features, but not with size or distance. The findings of this study did not suggest that better quality or larger public open space influenced any trips or independently mobile trips to public open space. In this study's sample, the mean number of trips made to public open space was 2 (range 1-6 trips) and the mean independently mobile trips made to public open space was 1 (range 0-5 trips) in the seven-day period. However, in the final multivariate variable analyses, the POSAI reported no association for any trips to public open space (p = 0.06), although this was borderline. Suggestion of these findings could be an artefact of the small number of children in the study. It is possible that environmental features such as size or proximity

of local parks to home may have a bigger influence on children's independent mobility than public open space quality. The importance of park proximity, size and environmental quality attributes of neighbourhood public open space for children's independent mobility therefore remains relatively unknown (Christian et al., 2015a).

Children with a higher parental licence had greater odds of travelling independently to a public open space. However, the trend was not linear, with the second quartile having the highest odds of children making independent trips to a public open space.

This study hypothesised that a higher POSAI score would be positively related to increased levels of children's independent mobility to the public open space. Our findings did not support the hypothesis. Children were more likely to make independently mobile trips to public open spaces with a lower POSAI score. This finding could be due to the low number of trips made to public open spaces within the sample; therefore, caution needs to be exercised when interpreting the findings from these data. International studies with adults have shown that those living in a more socio-economically disadvantaged neighbourhood are more likely to report walking for transport than those living in more advantaged neighbourhoods (Turrell et al., 2013, Cerin et al., 2009). Likewise New Zealand data show that children of low socio-economic status are more likely to walk to school than those of a higher socio-economic status (Ministry of Health, 2003). As such it is possible that confounding in terms of area-level disadvantage existed in the current study. This study examined the prevalence and proportion of public open space rated as high or low by school decile (socio-economic status). While a substantial variation in POSAI scores was observed within neighbourhoods and deciles, findings did show some evidence of a greater number of

public open spaces and of higher quality in higher versus lower decile areas. These findings may be an artefact of the study design, as the higher decile schools were all located close to the central city. There may have been a different outcome if higher decile schools in suburban areas had been included in the study. We found that child ethnicity was associated with any trips and independently mobile trips made to public open space; specifically children of Samoan ethnicity were more likely to make independently mobile trips to public open space.

Sugiyama et al. (2010) investigated recreational walking in Australian adults. They found that the presence of a large, high-quality park within walking distance of participants' homes was more important in promoting recreational walking for health benefits than the presence of an open space within a shorter distance. Previous studies have reported mixed findings. For example Veitch et al. (2006) found that children visited parks with the most appealing aesthetics and attributes rather than the closest green space. It is therefore possible that if lower quality public open spaces were located closer to home children would be more likely to visit them independently.

Strengths and limitations

This study has several limitations. Although a total of 3,234 trips were made by children, only a small proportion of those trips were made to public open space, and even fewer were made independently. This study is delimited to the public open spaces the children visited within the school neighbourhood catchments. It is highly possible that children visited public open spaces outside of this predefined boundary. In the Kids in the City study over one third of the children participants lived outside the school neighbourhood catchments. With this in mind, the use of individual neighbourhood boundaries for each child would likely be a more sensitive approach for capturing

public open space visits in this sample. The findings from this study are limited by the cross-sectional design and therefore causality cannot be assumed. Despite these limitations, this study had several strengths. First, it included a large number of public open spaces objectively audited from socio-economically and ethnically diverse urban neighbourhoods (Brannon et al., 2013, Schoeppe et al., 2014b). Second, one component of the tool (derived from the NZ-POST) has previously demonstrated acceptable reliability for use in the New Zealand setting. In addition, statistical rigour was applied to develop the POSAI. For example, a range of geographic areas may be employed across a single study, yet the POSAI can account and standardize for differences in study area size. Further strengths include the high level of travel diary completion (Oliver et al., 2011).

Conclusion

This research sought to utilise a new innovative tool, the POSAI, a combined measure of quality and quantity to examine associations between public open space and children's independent mobility in urban neighbourhoods. Findings from the application of the POSAI tool did not reflect the hypothesised link between higher POSAI scores and children's independent mobility. However, some interesting findings related to ethnic differences were reported. The POSAI did not show significant associations with any trips or for independent trips made by children to public open space. Children of Samoan ethnicity were more likely than children of other ethnic groups to make independently mobile trips to their neighbourhood public open space. Children with a higher parental licence have greater odds of travelling independently to a public open space, though this trend was not linear. The key findings from this examination indicate there are possible ethnic differences in children's independent mobility and active travel

to public open space. Future studies in this discipline call for more contextual-based qualitative research to include a focus on ethnicity to examine differences in children's experiences in an urban setting.

CHAPTER 5

Children's independence and affordances experienced in the context of public open spaces: A study of diverse inner-city and suburban neighbourhoods in Auckland, New Zealand

Preface

Two key findings emerged from Chapter 4; first, significant differences in total trips and independently mobile trips by children to public open space were found by ethnicity. Second, children who were given more parental licence for freedom had greater odds of travelling independently to a public open space. In Chapter 5, qualitative research was used to gain insights from children's perspectives into how public open space experiences were related to children's independent mobility and active travel. The individual and social factors that could influence children's place preferences were also investigated, drawing from the concept of environmental affordances.

Introduction

Children's exposure to the outdoor environment is important for healthy physical, social, spiritual, emotional, intellectual and cognitive development (Aziz and Said, 2015). Public open spaces such as parks, playgrounds, school grounds and the natural environment (e.g., woodlands, grass verges) provide outdoor places to play (Fjørtoft, 2004), interact with peers (Kyttä, 2002) and experience other diverse social interactions (Hoskins, 2008). A number of public open space definitions exist. These include green spaces (e.g., public parks and planted areas), blue spaces (e.g. waterways, rivers and coast), and grey spaces (e.g. civic squares, streets, transport corridors) (Ministry of Education, 2011, Regional Public Health, 2010). In this Chapter (experiential study), the definition of public open spaces reflects the types of green spaces that children took the researcher along the go-along interviews, and not specifically delimited as in Chapters 3 and 4. Parks, reserve, 'wild bush/nature' fields, and school grounds, were collectively defined as public open space. Such settings provide areas for relaxation and foster social connectedness, communication and friendships (Francis et al., 2012, Sugiyama et al., 2008, Lachowycz and Jones, 2013) and also provide children with opportunities to learn how to negotiate unfamiliar situations and gain new skills and competencies (Day and Wager, 2010). Good play areas enable children to play independently or with other children. Attention, therefore, needs to be given to playground design and age appropriateness of playground equipment when designated playgrounds are located within public open space environments.

These outdoor environments give children the chance to experience and judge their outer world, not by its aesthetics but rather as a stimulating experiential component of their activities (Sebba, 1991). Much of the research on public open space and children has focused on quantitative research and on issues such as environmental quality,

distance and availability or access to public open space (Timperio et al., 2008, McCormack et al., 2010).

Active travel to, and children's independent mobility in public open spaces

Evidence suggests that children residing in close proximity to public open space (i.e. within one mile of their residential address) accumulate higher levels of health-promoting physical activity than their peers who live further away from these settings (Cohen et al., 2006). This may be due to public open space providing locations for formal and informal physical activities (Veitch et al., 2008). Children may also accumulate physical activity through active travel modes (e.g. walking, cycling) and unsupervised active travel when travelling to public open space (Chaudhury et al., 2015). While some evidence of plateauing has emerged for active travel (Ministry of Transport, 2014), internationally trend data over the last few decades has mostly seen a decline in children's active travel and independent mobility (Shaw et al., 2015, Fyhri et al., 2011, Schoeppe et al., 2015a, Oliver et al., 2016). The prevalence of these behaviours is low in New Zealand children, despite the fact that the health benefits of active travel are well recognised (Maddison et al., 2016 - *in press*). Recent work with New Zealand children by Carroll et al. (2015) indicated that local parks in urban neighbourhoods were important destinations for children to engage in independent mobility.

Children's independent mobility and parental licence for freedom

As with active travel, children's independent mobility has been associated with higher levels of physical activity (Oliver et al., 2016, Schoeppe et al., 2014a). When engaging in independent mobility children have many opportunities to develop spatial skills and the skills needed to navigate risky situations (Kyttä, 2004). Landmark research in children's independent mobility measured this outcome in terms of geographical

distances (territorial ranges) that children could travel from their residential address to places they were permitted to go (van Vliet, 1983). Thereafter, children's independent mobility was operationalised as a 'licence', namely the degree of licence for freedom parents/caregivers afforded their child (e.g., to ride a bike independently or to cross main roads by themselves) (Hillman et al., 1990, O'Brien et al., 2000). To date there is limited research that looked at children's independent mobility and active travel behaviour from the child's perspective, particularly with regard to public open space. The literature suggests that more rules and restrictions are applied on the activities a child is permitted to do independently and more licence for freedom is afforded children as they age. However, trends over the last 40 years have shown that parental licences are being afforded children at a later age than for past generations (Shaw et al., 2015).

Perceptions and other factors associated with the decline in children's independent mobility

Studies on children's independent mobility have employed a number of quantitative methodologies using child self-report or parent proxy report (e.g. survey questionnaires and travel diaries). The majority of the research has primarily focused on trips to school, with a paucity of research investigating independent mobility to other neighbourhood destinations, such as public open space (Prezza et al., 2001). Some studies cite heightened parental concerns about neighbourhood safety, both in terms of road safety and stranger danger, as key factors related to the decline in children's independent mobility (Carver et al., 2008). Qualitative studies in this area consistently document that parental safety concerns are the principal reason for parents restricting a child's independent mobility (Jago et al., 2009, Veitch et al., 2006, Carroll et al., 2015). Similar findings have been reported from quantitative studies too (Foster et al., 2014, Mitra et al., 2014, Timperio et al., 2004), with parental perceptions of aspects such as stranger danger, traffic density and road safety in the local neighbourhood environment being

self-reported. Parents' perceptions of stranger danger have been reported as limiting children's independent mobility for both boys and girls, with stronger associations observed for girls than for boys (Foster et al., 2014, Mitra et al., 2014). Advances in mobile phone technology enable parents to monitor children's movements when they are away from the home environment. Brockman et al. (2011) reported children's use of mobile phones has helped alleviate parents' safety fears and encouraged children's active play. This technology may also facilitate children's independent mobility.

Children's independent mobility in the New Zealand context

A recent study of New Zealand primary school aged children reported a number of possible ethnic differences in independent mobility and active travel to public open spaces in eight urban neighbourhoods (Chaudhury et al., 2016). Those children with a higher parental licence for freedom were found to have greater odds of travelling independently to a public open space. Earlier investigation in this study showed that of the total 3,234 trips made from home to a destination, only 68 of these were made to a public open space. The most frequently travelled to destinations were primary schools (only trips to school were assessed), retail outlets, sport facilities, other recreational destinations and churches (Badland et al., 2015a). The public open space trip data were based on the trips made by children in eight of the nine schools (Badland et al., 2015a) and not from the trips children made from the nine schools (including the intermediate school) as detailed in a parallel study from the same cohort (Carroll et al., 2015). More contextual-based qualitative research is needed to provide further useful insights from children's own experiences and perspectives of neighbourhood public open space to understand public open space affordances for independent mobility. A paucity of research examining the relationship between children's independent mobility and public

open space from the child's perspective suggests further investigation needs to be undertaken to understand this relationship.

Concept of affordances

Some research suggests that in the outdoor environment children are attracted to their functions, rather than the forms and shapes of the environment (Fjørtoft, 2004). Applying the concept of affordance in understanding the dynamic interplay between the environment–person interactions (Kyttä, 2002, Kyttä, 2004, Heft, 1988, Gibson, 1979/1986) for facilitating children's play not only provides insights about important environmental properties and attributes, but also indicates the children's abilities to cope with and adapt to the environment (Aziz and Said, 2015).

Theoretical perspective of affordances

This research drew on the ecological perspective of affordances. This theory provides an ideal foundation from which to explore the interplay between public open space and children's behaviours, and to explore factors that may lead to actualizing these affordances.

In the 1970s, driven by his research on perception and 'how do we see this world', Gibson first theorised affordances as a concept to explain how the individual perceives, experiences and interacts with their environment (Gibson, 1979/1986). Heft (1988) further defined affordances as the perceived opportunities and restrictions concerning a person's actions in a given environment. Kyttä distinguished affordances in terms of being potential or actualised (Kyttä, 2004). Potential affordances relates to the infinite number of possible affordances of an environment or object (Kyttä, 2003). Potential affordances are different for each individual or group of people (Storli and Hagen, 2010). There are several different levels of actualised affordances: perceived, utilised,

and shaped (Kyttä, 2002, Kyttä, 2003). Kyttä (2003) expanded this original concept to include emotional, social, and socio-cultural opportunities and restrictions that an environment can offer. Actualised affordances are what the individual perceives, and are revealed through actions of the individual (Kyttä, 2004). For example in the context of children's independent mobility, once the potential affordances are perceived as inviting opportunities for children's independent mobility and are experienced through action, they are known as actualised affordances (Aziz and Said, 2015, Heft, 1988, Kyttä, 2003, Kyttä, 2004).

Changing demography and urban intensification

Population growth has seen strategies of intensification in major cities, including Auckland, New Zealand (Witten et al., 2015). Residential intensification seeks to contain urban sprawl through developing more compact built environments (Carroll et al., 2015, Auckland Council, 2012a). More young families with children are now living in apartment blocks in inner-city areas (Carroll et al., 2011). While there is compelling evidence to suggest adults living in a more compact neighbourhood are more active for transport and leisure (Sallis et al., 2012, Witten et al., 2012), there remains limited knowledge of the impact of neighbourhood intensification on children's independent mobility. What is clear is that urban design and planning practice in countries like Australia and New Zealand have been slow to take into account the specific needs of children (Gleeson and Sipe, 2006). In New Zealand, Freeman and Tranter (2011) have highlighted that children are not only excluded from the planning process, but urban planning practice largely confines children's use of the public realm to specific places such as swimming pools, libraries and playgrounds.

There is a need to develop an in-depth understanding of neighbourhood affordances for children's wellbeing in intensifying environments. Despite a growing interest in this

field, much is still unknown, particularly from the perspective of the child, about children's public open space experiences and wellbeing outcomes such as active travel and independent mobility. Accordingly, the aim of this research was to explore children's experiences and perceptions of neighbourhood public open space in order to understand public open space affordances for children's independent mobility.

Methods

Context

Auckland is the largest and most ethnically diverse city in New Zealand, comprising over 180 ethnicities. It has a population of 1.4M, of which 300,000 are children (Auckland Council, 2012a). By 2040, it is estimated Auckland will be home to an additional 100,000 children (Auckland Council, 2016). In the early 1980s, Auckland's main population groups were indigenous Māori, descendants of earlier European settlers and migrants from the Pacific islands. However, since changes to New Zealand's immigration policy in 1987, there has been a steady growth of new migrants from around the world, particularly from China, South Korea, and India (Friesen, 2015).

Protocol

In this study, the PhD candidate drew on and analysed the experimental data; go-along and home interviews, collected in the larger cross-sectional Kids in the City study in 2011-2012. Of the nine schools, six primary schools were in the suburban neighbourhoods and two primary and one intermediate were in inner-city neighbourhoods. The study protocols, including, schools selections, participant recruitment and selection criteria are detailed in-depth in Chapter 1. As there were no predetermined selection criteria, 100 suburban children participated and only 40 inner-city children were selected based on dwelling type.

In brief, of the total 253 children from the Kids in the City study, a sub sample of 140 children (77 girls) participated in the go-along neighbourhood walking and home-based interviews. Go-along interviews (n=100) for the six suburban neighbourhoods were undertaken by trained high school youth researchers in 2011. For inner-city dwelling children, (n=40), go-along and home-based interviews were conducted by senior academic researchers of the Kids in the City team. The sub sample study population was ethnically diverse (17.9% Pacific, 28.6% New Migrant (Indian, Asian and other), 17.9% New Zealand European, 14% Māori and 3.6% missing ethnicity data) (Carroll et al., 2015). This compares with an ethnicity breakdown across the New Zealand population of 7.4% Pacific, 14.9% Māori, 1.8% Asian, and 74% European (Statistics New Zealand, 2013). A detailed study design and methods for Kids in the City can be found elsewhere (Oliver et al., 2011, Carroll et al., 2015). Measures and methods specific to the current examination are detailed below.

Measures

This qualitative study drew from the home-based and go-along walking interview data for children aged 9-13 in school years 5-8 attending the eight primary schools (to enable age comparison) and one intermediate school.

Two interview methods were adopted: go-along neighbourhood walking interviews and home-based interviews. These methods allow children to provide their own views and knowledge of the neighbourhood. The children were the key informants and co-producers of knowledge who reported their viewpoints on their neighbourhoods. Discussions involved likes and dislikes, safety concerns and how to make the neighbourhood 'child-friendly.'

'Go-along' neighbourhood walking interviews

In total, 140 children (100 suburban and 40 inner-city) participated in go-along interviews. These interviews started from the child's home, from where the researcher was taken on a child-directed walk around the local neighbourhood. Destinations visited in the neighbourhood depended on where the child wanted to take the researcher. To encourage rapport-building and ease of dialogue, these go-along interviews were conducted either by a researcher (n=40) or by trained local high school students (n=100) aged 16-18 years and of the same sex as the participant where possible. Student researchers were briefed on the general aims and objectives of the study and provided with training on interviewing techniques. Previous research has shown the benefits of engaging youth as researchers in community based participatory research (Wang, 2006, Findholt et al., 2011).

Home-based interviews

For a subset of inner-city children (n=40), a home-based interview was also conducted prior to the go-along interview. These were facilitated by a senior academic researcher and were undertaken to obtain a deeper and broader understanding of children's typical movements in their urban environments. All interviews were audiotaped and transcribed. Go-along and home interviews were transcribed by professional transcribers and the PhD candidate coded and conducted thematic analysis. NVivo was used to facilitate data management.

Analyses

Themes identified, coded and analysed in this study

In this examination, the PhD candidate was interested to explore themes arising from experiences specifically related to public open spaces. Where children spoke about freely accessible spaces such as parks, reserves, 'wild bush/nature' fields and school

grounds, these were collectively defined as public open space. 'Freely accessible' included accessibility on weekdays and weekends. Transcripts were read multiple times by the first author and deductive thematic analysis was used to identify, develop and interpret emerging themes and sub-themes within the data related to public open space visits. Findings are discussed in light of similarities across suburban and inner-city neighbourhoods as well as results that were different or unique to either type of neighbourhood.

Results

Findings are discussed under four themes and directly related to visitation to neighbourhood public open spaces: (1) Parental licence for freedom and active and independent travel, (2) public open space affordances, (3) affordances of play in public open space, and (4) safety of public open space. Direct quotes, as spoken by the children were used to illustrate the findings.

Theme 1 - Parental licence for freedom and active and independent travel

Licence for freedom varied across the neighbourhoods for inner-city and suburban children. Over half of the children in the suburban neighbourhoods were allowed to go to the public open space independent of adult supervision, however less children living in inner-city neighbourhoods reported having this parental licence for freedom. The striking difference in children's independent mobility between the inner-city and suburban children was previously reported (Carroll et al., 2015). Aggregated by school type (inner-city, suburban mid-decile and suburban low-decile) informal physical activity trips (e.g., play in local streets and parks) were more than twice as likely as formal physical activity trips (e.g. team sports and training sessions) to be made for all the groups - 64% versus 23.3%, 28.6% versus 13.5%, and 41.3 versus 16.3% - respectively.

Overall, when independent mobility was possible, children were usually accompanied by peers or siblings. One girl spoke about a popular public open space in the inner-city: *"Um, no, I don't think I'm allowed to go there by myself."* [and] *"But if I'm with like a lot of, a few of my friends, I can go with my friends."* The same situation was true in the suburban context. For a majority of these instances, older siblings, cousins, other family members or friends were in accompaniment: for example, *"Goes with aunty"*, *"That's where I normally go, with my brothers"*, [and] *"my sister."*

Interestingly, a number of children from the inner-city spoke about being afforded more licence for freedom when venturing outdoors to public open space if they carried a mobile phone. One boy (aged 10 years) living in an apartment block in the inner-city when asked, 'what would your mum say the rules are if you are going out by yourself' responded *"My mum tells me to take my phone."* Another girl who divided her time between her parents' homes, one parent (father) lived in the inner-city, said *"no need to take cell phone because it's close to dad's house in Western park."* However, when she was staying at her mother's in a suburban area the rules were different, *"But at mum's place, I take a mobile phone if mum wants us back, well she can just ring us, 'cause we'll take our phones, but, yeah."* Interestingly no child from the suburban neighbourhoods reported the use of mobile phone for accompaniment to public open space.

In general, children were given licence to travel independently to public open space when those public open spaces were "close to home", and no children reported being allowed to go independently to destinations "further afield." Exactly what the participants meant by "close to home" and "further afield" could not be determined from the transcripts. Language such as 'near home' and 'close by park' were common responses from those independently visited public open spaces nearer their home.

Public open space that required motorised transport 'travelling 'by car' meant children travelled further out to visit the public open space. The reasons given by children included: distance to a public open space *"Cos we're not allowed to go that far,"* and parental perceptions of danger and safety *"I am not allowed to go outside because dad says it's dangerous out there,"* [or] *"Not really when it's dark."* Children reported that stranger danger and road traffic concerns were the main reasons for their decreased levels of independence. These concerns were expressed by the children reflecting their parents' perceptions as well as their own fears.

One boy said *"Only allowed to go to park with an adult, not allowed because of strangers* [and]… *parents think park is dangerous, cos there are bigger people than us. And they may be bad with me."* Similarly, children living in the inner-city apartments spoke about many interesting places in the city, but any real independence to roam was minimal because of parental fear of stranger danger.

Theme 2 - Public open space affordances

Some children in the study spoke of going to play in a public open space every day. In many cases (inner-city and suburban) when the researcher asked where the child would like to go in the neighbourhood on the go-along, *"I'd like to take you to the park"* reflects the majority of the responses from participants. When asked where their favourite place in their neighbourhood was, *"park"* was frequently quoted. Reasons for this were wide and varied, for example, *"It is my favourite park because it is so big";* *"it's pretty much my favourite and its…there's the club down there. Stag's club"* and *"well, um, we go there to play all kinds of sports. And like me and my cousins and my uncles and aunties and mums."*

Different affordances were observed across the sample. The local public open space was consistently reported by the children to be important for them to engage in activities, (formal and mostly informal), and to play (on the fields and particularly on playground equipment). Affordances related to play and playgrounds are reported in more depth below. Children's interactions with trees were often spoken about, for example: *"I like to climb the trees"*; and *"sit and talk with my friends."* In addition to the various physical attributes public open spaces offered, they were identified as important destinations at which children could connect, socialise and have fun with friends. In a few instances, children liked to use public open space to reflect and have 'quiet' time. One girl spoke of enjoying going to a multi-purpose destination public open space in the inner-city, *"sometimes like to go there lie in the sun and read.'* Sometimes she would like to go through the bush or the 'forest' in the same public open space, *"I pretend to be a character in my book."* Another girl from a suburban neighbourhood who frequented her local public open space spoke of enjoying the views; *"Then I stand up and watch the sunset sometimes and then just stand there and see the view 'cause I love views."*

Only a small number of children from the study spoke about not going to the park anymore or not that much. As one inner-city boy reasoned, *"it's boring"* when speaking about the public open space closest to his apartment. He had frequented the public open space (i.e., park) so many times that he no longer found it fun. Some didn't go as they were not allowed to go unsupervised and parents would not take them. A few mentioned that they rarely frequented the park anymore, even if allowed, *"I am pretty busy these days so I don't usually go that much."* However, it was evident that public open spaces were important destinations for most children across the neighbourhoods.

Theme 3 - Affordances of play in public open space

Play was the most prevalent affordance of public open space identified by children. Different types of play emerged from the analyses, including: (1) formal sporting activities (e.g., rugby, soccer, cricket team play), (2) informal games (e.g., tiggy/tag, hide and seek), (3) playing on the playground (e.g. swings, flying fox, monkey bars), (4) adventurous play (mostly playgrounds), and (5) imaginative play with siblings or peers.

As well as mentioning formal sports, public open spaces were viewed as a place for fitness, *"that's my fitness place, I go there for fitness."* Some children spoke about informal activities they liked to play, including tiggy (the children's game tag), soccer, rugby, touch rugby and hide and seek, often with siblings, other family members or friends. Not surprisingly, overall playing on playground equipment was popular for a large number of the children (those in neighbourhood public open space and those on school grounds). Children spoke most about slides, swings, flying fox and monkey bars. Some children spoke of liking a diverse playground to be able to play, *"Um.. Like we.. all the playgrounds like are challenge courses.",* a statement by one boy living in a suburban neighbourhood.

The playground afforded a sense of adventure play for some children by providing opportunities for engaging in challenging and so called adventurous or risky play. This included climbing, sliding, balancing, jumping from heights, hanging and hanging upside down. One boy living in an inner-city apartment spoke about an exceptional playground for adventures; *"Um, um, well sometimes I like going in Victoria Park at the playground"* [and] *"Cause there's like, this long sculpture of like an eel, a massive eel and a frog. And it's cool."* One boy from the suburbs voiced his concern that there were not enough playgrounds that were age and sex appropriate to make all children happy. *"Everyone. Even the little kids. And the big kids. Because if they got like new…*

extreme playgrounds the boys would like it. And if they had like, calm playgrounds the girls would like it so it's like everyone would be playing on a playground." He then went on to detail the differences of what extreme would be *"Like you gotta like... in part of a challenge course you've gotta like, jump off, the thing, land, jump through a hoop um... run around, go down into a dark pit, come out um... and like, it's like a challenge course in the um... dark bit."* When asked what a calm playground for girls was his response was *"A calm playground is like that the playgrounds in the first court"* (referring to a basketball court).

Other children in both the suburban and inner-city areas spoke nostalgically of past (and more recent) times of frequenting the playground in their local park. As with the comments above, these children spoke of the playground no longer being age appropriate, *"more for younger kids"*, the need for a *"senior park"*, not *"extreme enough for older kids"*, and *"kids my age."*

Imaginative games were also a popular form of play in public open space. On occasion, children spoke of games created by joint effort by various children, which included games named 'the murder game' and 'the family tree game.' When asked what he liked doing for adventures, one boy (who was independently mobile), spoke about an imaginative game he played with his friends, *"We pretend we are in a like Fat Water Fantasy and we like there is magic and stuff and we fight people and stuff like that."*

Theme 4 - Safety of public open space

When asked if they 'felt safe' in public open space, a majority of children responded positively. However, on further discussion, either from their perspectives or those of their parents (by child proxy), a number of safety concerns came to light, particularly around 'stranger danger' and 'road traffic.' Some children spoke about some 'scary'

people or areas/facilities they avoided to go near in the park (e.g. public toilets). For instance, a participant from one suburban neighbourhood was not allowed to the park on her own, not only because of the busy road, but also because of the undesirable people in the park: *"we always need to go with an adult because black power [New Zealand gang] is there so yeah."* Gang members living in her neighbourhood made her feel unsafe and scared: *"I don't like where the black powers live, because it is kind of scary."*

Children's prior experiences in public open space at times influenced their (and those of their parents) perceptions of safety. One girl, for example, had never been to the nearby multi-purpose destination park which was popular with a large number of her inner-city peers. The reason for this restriction became clear when discussing ways to make the area more child friendly In this context she stated: *"Make it [the park] more safe, because mum doesn't think it is safe but I am not sure why. I think it is because they are strangers cause in the Philippines we went to a park and I got lost from a stranger."*

A few children, who had licence to roam more freely than many of their counterparts, self-restricted going to particular public open space, quoting personal safety concerns. One boy said: *"Yeah. 'Cos I don't want to go, I don't really want to go out of my boundaries um, that I think I'm not safe with. I just um, I just like hanging out in this..[area]."* The suburban children studied generally preferred adult accompaniment when visiting a public open space.

A few children voiced concern about homeless or drunk people en route and around or within particular public open spaces: *"They (drunks) usually hang out in the park at night times."* This was more of an issue for some of the children living in the inner-city

apartment blocks because specialised health and social services facilities were located en route to inner-city public open space destinations.

Geographical relocation

Geographical relocation to a new neighbourhood may impact on how safe the new environment feels for the child. Geographical relocation could range from international migration to relocating to a new neighbourhood. Self-imposed restrictions to roam may be set because of 'new fears' of the unknown environment. This was experienced by one boy who had recently moved to Auckland from a smaller New Zealand town. Parental restrictions were not imposed, but the child's own fear of the new environment (including a busy road near his home) deterred him from exploring on his own. This child expressed that he would like to go to the central city public library. Although he knew the library was safe place, walking there may not have been, both from stranger danger and road traffic. *"It's like, a little dangerous."* With increasing patterns of migration, the impact of being a new migrant on neighbourhood experiences is worthy of further examination.

Discussion

Children took the researchers to a wide range of destinations in their local neighbourhood during the go-along interviews. Apart from the local public open spaces such as parks, other common destinations included libraries, community centres, churches, local diary or corner shops, other food outlets and homes of friends and extended family. The go-along interviews provided validation of the earlier travel diary data that looked at the locations the children went to over a week (and not necessarily independently) (Badland et al., 2015a). The travel diary data and the 3,234 identifiable journeys made during monitoring week, showed the most common destinations a child

frequented were primarily schools, other types of retails (e.g., DVD store, mall), sport

facilities, parks, other recreations, and churches. These six destinations represented 78%

of all trips undertaken during the monitoring week (Badland et al., 2015a). In this

chapter only the public open spaces destinations were of interest and analysed in-depth.

A dominant finding that arose from this study was that public open spaces, specifically

parks, were preferred and favourite locations for children to engage in various forms of

play in the neighbourhood. Similar findings were reported in another recent New

Zealand study (Freeman et al., 2015) whereby 187 children from three cities (Auckland,

Dunedin, Wellington) reported the most frequently visited places were parks, especially

local parks in their neighbourhood. This was in contrast to the travel diary for the week

of data collection from the current study (Carroll et al., 2015), where of the 3,234 total

trips recorded, only 68 trips were recorded as made to a public open space (Badland et

al., 2015a). It is possible this is because the seven day diaries reflected only one week in

a participant child's life and did not reflect their personal preference for outdoor

activity, or their usual activity.

Public open spaces were also important destinations for participating in other

adventurous and social activities in company with friends and siblings. For some

children, public open space was a place of 'retreat' to simply enjoy the outdoor view or

spend personal, quiet reflective time on their own. Parks were the most favourite place

to visit in the neighbourhood for both suburban and inner-city children. The main

attributes within the park that children spoke about and often engaged with were trees

(mainly to climb or to play around with other friends).

Restrictions on independent mobility were experienced across all neighbourhoods, with

varying levels of independence discussed by the children during the interviews. The

findings are unsurprising and follow the global trend of children's independent mobility decline (Shaw et al., 2015). In many of the suburban neighbourhoods a high proportion of children spoke about going to local public open spaces, but did so accompanied by older siblings and friends or extended family members. Future research may benefit from examining household demographics (e.g., number and ages of siblings) to account for the importance of family networks in facilitating independence.

Parent and child safety concerns consistently arose as a limiting factor for children's independent mobility, in particular stranger danger and road traffic. A number of children in the inner-city spoke about carrying a mobile phone when they went to public open space. At face value increased use of mobile phones may be negatively associated with contributing to children's sedentary lifestyles. Advances in mobile technology have meant, in the confines of their own home, children can play games, listen to music or surf the internet. A recent international comparison study in 14 countries (Shaw et al., 2015) reported that mobility of children did not appear to be affected by whether the child had a mobile phone or not. Only four countries, France, Ireland, South Africa and Australia reported statistically significant differences with phone ownership and children's independent mobility. Phone ownership was significantly associated with 'allowed to go to places' within walking distance alone for France and Ireland; and 'allowed to travel on local bus alone' for Australia and South Africa.

Previous research has highlighted a number of attributes in the built environment deemed important by children. For example, public open space, close to residential areas affords opportunities to play outdoors in nature, in turn this contributes to the health and social development of the child. In conjunction with well-designed amenities within a public open space, including playgrounds and sports facilities, public open spaces provide opportunities for physical activity, engaging with peers and personal

space (accompanied or independently) for relaxing. In a United Kingdom study, their top priority was having more and better play spaces (e.g., better parks), followed by feeling safer (from both stranger danger and road traffic) and having litter and graffiti cleared up (O'Brien, 2003). These findings were reflected in the current study.

Interpretation of the data in this study highlighted that public open space afforded a number of meaningful experiences between the outdoor public open space environment and the child. Each child's experience was unique yet similarities in what were afforded could be drawn out. Public open spaces provide a platform for play spaces potentially important to let the child fulfil their sense of playfulness and curiosity (Aziz and Said, 2015). The positive impacts of being surrounded in natural environments means children judge such areas not by aesthetics, but rather as a stimulator and experiential component of their activities (Sebba, 1991). However not all experiences were favourable. For example, in this study, some children spoke about contact with homeless or drunk people en route to or within a particular public open space as a deterrent to going there.

Many children spoke about the age appropriateness of the playground equipment. Interestingly, a number of children wished that the playground was more 'extreme' in design and the equipment better suited for older children. Challenging playground equipment is associated with attracting children to play outdoors (Veitch et al., 2008). The children in the interviews reflected that the playgrounds were often 'kiddy' or for younger children and not for them. Earlier work by Veitch et al. (2006) reported that Australian parents considered much play equipment at parks to be more suited to younger children and that there was a need to design more challenging and interesting playgrounds to cater for older children.

Concerns of stranger danger and traffic, both in terms of parental and child perceptions, have contributed to a global decline in parental licence for freedom and declines in children's independent mobility (Carver et al., 2008, Foster et al., 2014). Taking a broader perspective, the relationship between the child and the environment is most likely not linear but possibly influenced by a number of factors across a socio-ecological structure (Badland et al., 2015b). The systems model developed by Badland et al. (2015b) detailed the complexity of children's independent mobility and acknowledged the interdependent relationships across five levels, which included policy and society norms, neighbourhood (child/parent perceptions), household, individual and behaviour.

Strengths and limitations

A key strength of the research is the volume of in-depth data collected with a socio-demographically and geographically diverse group of New Zealand children. By engaging children to share their experiences, the current study provides a deeper understanding of the children's behaviour beyond destination descriptives. The findings suggest the importance of applying both quantitative and qualitative methods to determine actual trips and behaviours of children using public open space and other neighbourhood destinations.

A limitation of this study, when participants spoke about "close to home" and "further afield," the actual public open spaces discussed or the distances from home or school were not captured. However, the focus was to garner information from children about their general neighbourhood experiences rather than about specific destinations or distances travelled. Inclusion of the intermediate school children's go-along (Years 7-8, aged 10-12 years) in this qualitative study may have biased the results. The children were not only slightly older which would suggest that they would have more mobility

licence, but the school neighbourhood catchment covered a larger area than the rest of the study population in the thesis. It is possible that these children experienced more independent mobility and licence for freedom, which would have reflected in the findings in this chapter. Future research may benefit from considering spatial data in addition to qualitative experiential data to enrich discussions and provide specific evidence for policy recommendations.

The novel approach of involving youth researchers may have been a successful strategy to attain meaningful participation knowledge from the child (Jardine and James, 2012). The youth researchers were closer in age to the participants and may have been able to communicate in a language children were more comfortable with. They may have grown up in the same neighbourhood and were familiar with the surroundings. Ultimately, this approach aimed to put children at ease and to draw out more meaningful information about children's experiences and perceptions. However, perhaps not surprisingly, when comparing the transcribed interviews conducted by the youth researchers (suburban neighbourhoods) with those conducted by the senior academic researchers (inner-city), there was an evident lack of interviewing experience in the former. With less finesse in question probing children's responses were often cursory. For example, at times when a youth researcher asked the child what was their favourite place to go in the neighbourhood, 'the park' was the popular response. However, in many instances the youth researcher did not follow on and ask, for example, 'what is it about the park that makes it your favourite place' but instead responded with an "oh ok." This was potentially because the youth researcher only had a few hours of training, in comparison with the senior academic researcher's expertise in probing participants to garner more information. Even so, the engagement of youth researchers to conduct interviews with children is recognised as having great potential

to gain unique insights and warrants further exploration in research studies (National Children's Bureau, 2015).

Conclusion

Neighbourhood public open spaces are important and favourite destinations for children. They facilitate many meaningful experiences for children in their local environment. Mobile technologies may be useful for increasing children's independent experiences in their neighbourhood. The present research findings contribute to the limited literature currently available on children's personal experiences of environmental attributes of local public open space. In particular, the affordance of public open spaces for diverse forms of play including formal, informal, playing on playground, adventurous and imaginative play was a novel finding. With increased residential intensification, this study provides some important considerations for planners creating or designing public open spaces for children.

CHAPTER 6

Discussion and conclusion

Summary

At the inception of this research, little was known about how the quality and quantity of public open spaces were associated with children's independent mobility and public open space use in the New Zealand context. The focus of this thesis was thus to address the research question, "What are the associations between public open space attributes and children's independent mobility experiences in a sample of children aged 9-12 years living in socio-demographically and geographically diverse neighbourhoods in Auckland, New Zealand?"

The emphasis progressed from developing a method of measuring the quality and quantity of public open space to applying the new measure and comparing it with children's independent mobility and open space use, and finally to understanding these relationships from a child perspective. Taken together, the findings from this thesis support the systems model of children's independent mobility developed by Badland and colleagues (2015b) (Figure 1). Factors associated with children's independent mobility were multiple, multi-layered, and complex. For example, factors at the individual (child ethnicity), built environment (public open space safety), and social environment (parent directives) levels contributed to reduced children's independent mobility opportunities in the local neighbourhood. To clearly demonstrate specific contributions this body of work has made to this area of research, a revised systems model (Figure 7) demonstrates how the current research findings fit into the systems map. Contributions from this thesis are highlighted (in blue) and the key findings in

relation to each level of the model are stated briefly here and critically discussed in more detail later in the discussion.

The flexibility of the adapted Badland et al. (2015b) systems model has meant that it supports the four potential new factors reported in this thesis; children's agency, POSAI tool, companion devices, and new migrant status. The systems model and addition of findings from this thesis highlight the interdependencies between child, family and various built environment factors that may influence children's mobility. Findings reinforce previously known issues associated with decreasing child mobility, for example safety concerns (Rudner, 2012, Jago et al., 2009, Carroll et al., 2015). Though these findings are integrated into the systems map, detailed understanding of the interdependencies between factors identified in this research were beyond this scope of investigation in this thesis. For example, parents' attitudes towards their child carrying a mobile phone on outdoor trips to public open spaces may influence the child's mobility. Future research would benefit from addressing issues around accompaniment with a companion device from the perspective of adult and child.

The following factors were added to the systems model as follows (see Figure 7).

1. *Regulations and Rules* - Considering and planning for children's agency arose from go-along interviews with children in Chapter 5
2. *Built Environment* – The use of the POSAI tool developed in Chapter 3, enables the simultaneous quantification of quality and size of public open space.
3. *Parent and Child Perceptions* – Findings from Chapter 5 reaffirmed the relevance of safety considerations of public open spaces in the built environment.

4. *Companion Device* – Chapter 5 identified the importance of companion devices (e.g., smart phones) in facilitating children's independent mobility. Accordingly a new factor was included to the model to highlight the possible role of companion devices in children's independent mobility.

5. *Parents' Attributes* – Findings related to ethnicity in Chapter 4 aligned with the existing model. Additionally, new migrant status has been included, informed by findings from Chapter 5, where differential independent mobility experiences were noted by new migrant children compared with their non-migrant counterparts.
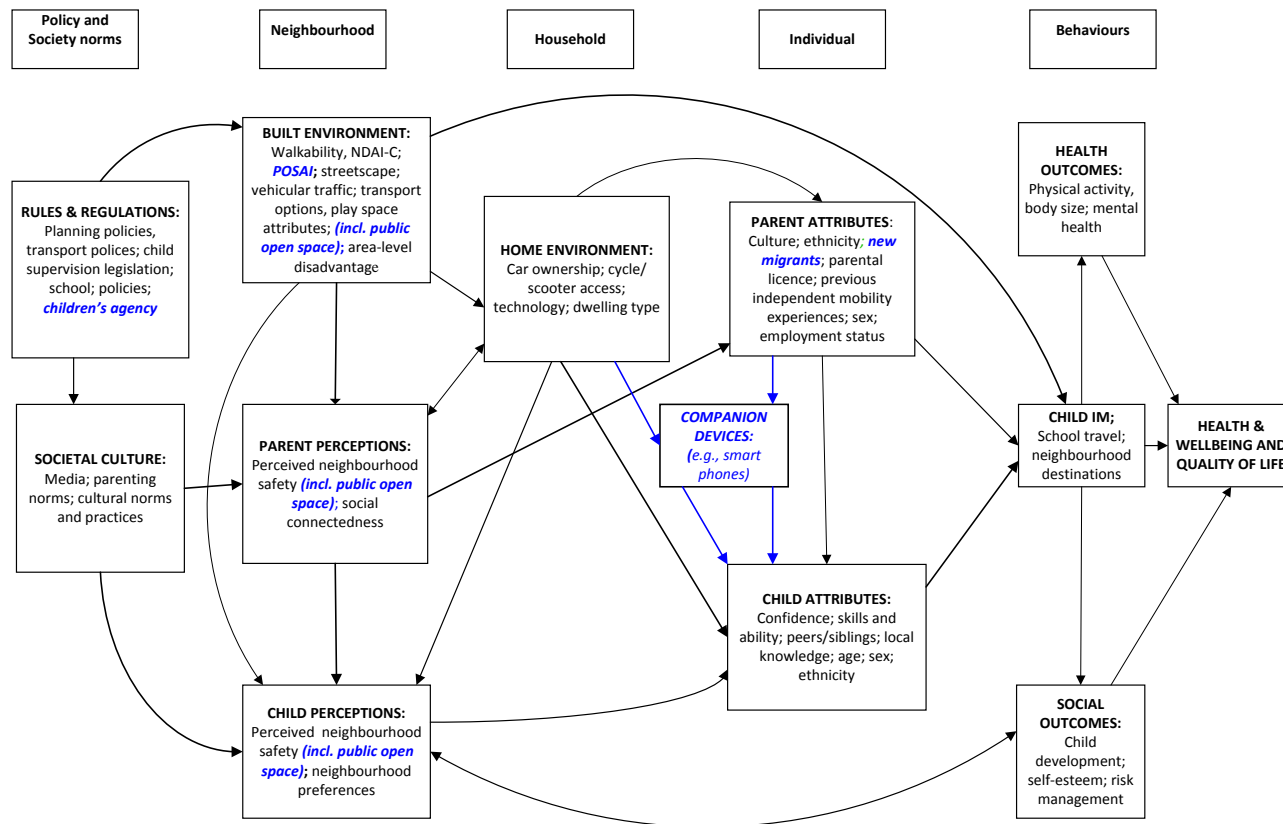
Figure 7. Revised systems map of factors influencing child independent mobility (Key: IM= independent mobility; POSAI= Public Open Space Attributable Index; NDAI-C= Neighbourhood Destination Index-Child)

Research contributions and implications

As a whole, the findings from this doctoral research provide a deeper understanding for how public open space attributes are associated with children's independent mobility experiences. This study lends itself to an adapted systems model approach to investigate the relationship between public open space and children's independent mobility in the built environment (Figure 1). The novel contributions of this thesis are as follows:

1. The development of the integrated POSAI tool that can be used in diverse environmental settings (Chapter 3) to assess both quality and quantity of public open space.

2. Application of the POSAI tool to examine associations between public open space visitation and children's independent mobility. Ethnic differences were observed in children's independent mobility (Chapter 4). This contributes to the limited research currently available on ethnic differences in children's independent mobility and public open space visitation.

3. As identified from the children's interviews (Chapter 5), public open spaces were important destinations to visit and engage in different forms of play (formal, informal, adventurous and imaginative play).

4. Public health research has increasingly adopted the socio-ecological model (and adaptations) to integrate the various multi-correlates correlates influencing health related outcomes (Stokols, 1992). The research contributes new evidence to support, and add to, the conceptually driven adapted socio-ecological systems model for identifying factors associated with children's independent mobility.

Thesis contributions to the adapted systems model of factors influencing children's independent mobility

Through the process of conducting this research, key themes and novel findings emerged that contributed towards the revised systems map (Figure 7). This revised model both expands and refines the understanding of children's independent mobility issues across multiple levels of the socio-ecological framework. In the following section specific factors that have been included in the model are critically discussed. These are arranged according to the levels of the systems map into which each factor has been included.

1. Policy and societal norms

Though not an original focus of this study, children's agency, both in terms of measurement approaches, and environmental design was a recurring theme of this research. This finding aligns with the UNICEF Child Friendly Cities Initiative, reflecting the need for cities to empower children to have their say and influence decisions about their city at the policy level (UNICEF, 2010). Accordingly, children's agency has been included as an indicator under "Rules & Regulations." Downstream outcomes of this approach are fulfilling children's rights to walk safely in the streets by themselves, meet friends and play, live in a clean environment with green spaces, participate in cultural and social events, and be an equal citizen (van Vliet and Karsten, 2015, Shaw et al., 2013, Hillman, 2006).

Rules & regulations:

Children's voices and policy implications

The process of capturing children's perspectives using child-centred data collection methods in the local neighbourhood in Chapter 5 elucidated the utility and importance

of this approach. Previous examinations on children's everyday mobility have called for representation of children's voices and mobility experiences in research (Mikkelsen and Christensen, 2009, Shaw et al., 2013, Zubrick et al., 2010, Salmon et al., 2007) and in doing so to promote children's voices in more mainstream built environment debates (Weller and Bruegel, 2009). In particular, these methods generated insights for understanding children's needs and preferences that might not otherwise be captured using adult-centric approaches as employed in earlier chapters. Additionally, the unique findings highlighted the value of these approaches in generating relevant information to contribute to children's agency in the planning of public open space infrastructure. For example, a key issue raised by a number of children was the need of age specific playgrounds. A number of the children said they enjoyed playgrounds and referenced nostalgic memories to their local playground, however they did not enjoy them now due to the equipment no longer being age appropriate. Findings such as these are important, and merit dissemination to local council and planners as they voice the children's opinions.

These findings come at a timely manner as Auckland has already started a strategy for improvements in public open spaces and local city councils have put forward planning ideas (Auckland Council, 2012b, Auckland Council, 2014, Auckland Council, 2013b, Auckland Council, 2012c). Two suggestions for future strategies to continue to support children's agency in this context are:

1. Running a local survey in the neighbourhood (or at child/youth group meetings) that offers children the opportunity to voice on how they would like (or dislike) the development of their neighbourhood public open space, for example provision of more age specific playground equipment.

2. Involving children in the advising or auditing process of public open spaces that may be considered for (re)development. This could be achieved by utilising a 'child friendly audit' tool. In this case the concept of the POSAI tool may be useful by integrating child's direct observations (quality) of the public open space and the GIS derived size (quantity) to create a score. To the authors knowledge, no standardised child friendly audit tool has been created and tested for the sole purpose of children's administration of the tool.

Evidence of successful child and community agency strategies exists in the New Zealand context. Firstly, the multi-purpose Margaret Mahy playground in Christchurch, New Zealand was developed by way of collaboration between local children, play equipment specialists, and planners. This playground included play spaces that catered for all age groups of children, including a unique mix of playground equipment, interactive spaces, gardens, water features, recreational and picnic areas and visitor parking and brought together a sense of connectedness amongst the community (Christchurch City Council, 2015).

Secondly as with the use of youth researchers and data collection in the setting of interest (i.e., the neighbourhood) in Chapter 5 to attain "real" and spatially-referenced participant knowledge, allowing children to be the actual auditors of a public open space may give a clearer perspective of what they want (e.g., activity and play equipment) and what they think is safe. In collaboration with Auckland Council and the Kids in the City research team, a recent child friendly audit of a popular local public square for redevelopment resulted in children's feedback being considered in the draft concept plan for the square (http://kidsinthecity.ac.nz/).

2. Neighbourhood-level factors

The POSAI tool has been included as a neighbourhood built environment indicator, the first tool to integrate existing measures for quality and quantity of neighbourhood public open space. Secondly, aligning with general neighbourhood environment research, diversity in safety perceptions was a key underlying theme throughout the thesis. Safety is a concept that is both real and perceived and was of major concern for both children and parents (as reported by the child). Safety issues that arose in this research included low inter-rater reliability of the safety score component of the NZ-POST and children's and parents' (as voiced by the child) perceptions of safety which are discussed below.

Built Environment:

Public open space attributable index (POSAI) tool

The first step in this thesis was the development of the novel POSAI tool that can be applied in diverse urban settings in the built environment. The POSAI tool integrates public open space quality (internal attributes of public open space) and quantity (GIS derived size of public open space) into one measurement. The use of composite indices is not new in built environment research with a number of GIS-based indices available now that have been designed specifically for children. Examples include indices for child walkability (Rigolon and Flohr, 2014, Giles-Corti et al., 2011) and child-specific neighbourhood destination accessibility (Badland et al., 2015a). Although not child-specific, the POSAI captures elements identified as of importance to children's independent mobility, as identified in earlier research and in Chapters 4 and 5. In their review Giles-Corti et al. (2009) identified a need for more age and sex specific research using behaviour and context specific measures of the environment. The POSAI is a step in that direction by using the school neighbourhood catchment as the foci, as the school environment can act as community hubs (Sanjeevan et al., 2012). In consideration of the

findings in Chapters 4 and 5, as a next step, it is possible to make improvements to the POSAI tool to be more child-specific. Amendments could include using the child specific version of the NZ-POST, the Children's Public Open Space audit tool (C-POST) to collect environment public open space quality and the open to obtain the quality and adding more quantitative GIS spatial built environment measures. For example street connectivity and park accessibility around the neighbourhood public open spaces. This may be achieved by integrating a child audited NZ-POST together with the GIS derived of public open space.

Schools are a nucleus for children's daily life, therefore the school proximity (and accordingly, public open spaces encompassed in this vicinity) is an important tool for supporting active travel, independent mobility and play activities. With that in mind, the POSAI tool was applied in the school neighbourhood catchment zone. It is recognised that there needs to be consistency in the tool and indicator selection to enable comparability across diverse neighbourhoods (Badland et al., 2015a). This has been achieved by building the POSAI tool with established measures, being the NZ-POST (Badland et al., 2010, Crawford et al., 2008, Giles-Corti et al., 2005a) for use in public open spaces, and GIS software to calculate the area sizes.

POSAI safety score

The POST and NZ-POST have demonstrated acceptable reliability in the Australian and New Zealand settings (Badland et al., 2010, Giles-Corti et al., 2005a). However, despite in-depth training and application of the clear NZ-POST framework, findings showed low inter-rater reliability for the safety subscale of the NZ-POST audit tool (ICC = 0.22). This result was not unexpected as perceptions of safety items are subjective to the individual rating the public open space, for example lighting coverage of public open space, visibility of houses around the public open space vicinity, and appropriateness

for walking. Similar results have been reported with other park evaluation tool reliability studies (Troped et al., 2006, Giles-Corti et al., 2005a, Saelens et al., 2006). Earlier research has reported that subjective question items, such as one in the NZ-POST safety component: "From the centre of the POS [public open space], how visible are surrounding roads", are inherently subjective in nature and tend to generate lower reliability estimates from independent observational raters (Bird et al., 2015). This study was able to overcome that limitation, performing a rigorous data reduction technique using PCA. The overall score which included the safety component achieved acceptable reliability, therefore accounting for all four of the categories of activity, environment, amenities and safety.

Although non-significant, when considering the POSAI score in the multivariate logistic regression (Chapter 4), an interesting association emerged in the bivariate analysis. Higher POSAI scores (that is better quality and bigger size), were observed in more disadvantaged neighbourhoods. A possible explanation for this POSAI relationship is that these findings reflected the New Zealand context, where most neighbourhoods in New Zealand have relatively good access to public open space (Pearce and Maddison, 2011, Badland et al., 2010). Findings in this study aligned with earlier research, whereby, a relatively high number of public open spaces within all study neighbourhoods was observed (Badland et al., 2010).

Childrens' and parents' (as voiced by children) perceptions:

Safety perceptions

Findings in Chapter 5 showed that parents' perceptions (voiced by the child) of public open space safety did impinge on children's independent mobility opportunities to access public open spaces. The most common reasons given for limited independence were related to neighbourhood safety, particularly child reports of their parents'

perceptions of road/traffic safety and stranger danger. These findings are not surprising, parents' safety perceptions are well documented as one of the greatest deterrents of children's independent mobility (Jago et al., 2009, Veitch et al., 2006, Badland et al., 2015a, Zubrick et al., 2010). The children echoed similar fears of neighbourhood public open space safety perceptions at the go-along and home interviews (Chapter 5), though often fuelled from parental concerns rather than from their own concerns or experiences. These fears may further be exacerbated by media reports from social media websites, newspapers and TV news on kidnappings or sighting of an unfavourable character near school premises. For example, in the work of Carroll et al. (2015), one child stated:

"I got frightened when I heard on the news [...] like a few nights before I was asking my mum if I could walk but then when I heard, I went into the living room and there on the TV [... was] the news and it was like two children got lost, like kidnapped. So watching that made me kind of think that maybe going with my mum is better."

Neighbourhood preferences

Adding to existing research on preferred locations in the neighbourhood environment, public open spaces, that is parks and green spaces, were the most preferred destination within the neighbourhoods for children to visit, outside of the residential home. This is similar to existing research of New Zealand children aged 12-13 years, where their favourite places for physical activity were public open spaces (including parks) and nearby beaches (Rehrer et al., 2011). Other research across age groups in the population, have reported similar findings of 'natural settings' (such as parks, beaches or forests) as favourite places to go to in their everyday surrounding (Korpela and Ylén, 2007, Cattell et al., 2008). The implications of such findings are that the existence and good condition of natural features in public open spaces may be important to encourage

public open space use. Cohen et al. (2016) recently conducted the first nationwide study of neighbourhood parks in 25 major cities across the United States. The authors concluded that investment, good management practices, and installation of facilities, such as walking loops and paths, may encourage use of parks that were currently underutilised by the population.

Critical reflection: Importance of children's point of view

A majority of the qualitative literature on children and a wide range of perceptions of the neighbourhood built environment (e.g., safety issues, active play independent mobility, and active travel) have been collected from an adult/parents' perspective (Foster et al., 2014, Lin et al., 2017 (*in press*), Santos et al., 2013, Veitch et al., 2006, Ahern et al., 2017, Foster et al., 2015, Tappe et al., 2013, Witten et al., 2013, Roberts et al., 2016). In only relying on parents' perceptions we are giving a biased view which does not incorporate the child's voice and perceptions of the environment. To a lesser extent, attention has been directed to investigating the child's voice and lived experience (Loebach and Gilliland, 2010, Nansen et al., 2015, Ergler, 2011, Quigg and Freeman, 2008, Race et al., 2017).

As Rehrer et al. (2011) identified, involving young people in the research process allows researchers to draw attention to issues that may not be considered relevant by adults. It was evident in this research that 'how' and 'why' children use the environment was individualistic with a combination of individual constructs around the social and physical characteristics of a place (e.g., ability to do activities, types of facilities available, socialising with peers, perceived safety etc.). Therefore not considering children's viewpoints may exclude important knowledge that may impact children from visiting and using destinations such as public open spaces.

A recent New Zealand study by Freeman and colleagues (2015) sought to understand 'nearby nature' experiences from a child's perspective in a sample of children aged 9 to 11 years from nine schools across three cities. Natural environments were classified as formal and informal green spaces which included gardens parks and reserves, street trees, and vacant lots. Information was garnered from interviews and a GIS mapping exercise. The authors found that children were aware of natural environments places, and why they chose to use or avoid them. They were able to identify how family life and parental restrictions influenced their own neighbourhood engagement and independent interactions with nature. Along with several studies focused on child-led discussions on experiences (Mitchell et al., 2007, Loebach and Gilliland, 2010, Race et al., 2017) children showed they were capable of recognising environmental or parental issues (related to safety concerns) impacting active travel or independent mobility restriction. These associations have been in the context of the local neighbourhood, including accessing a local public open space, school, or destinations in the wider neighbourhood environment. This research reiterates the value of recognising children's perspectives as fundamental to generating solutions to declining independent mobility.

3. Household and individual factors

A novel finding from the research was the consideration of new migrant experiences in the context of children's independent mobility. This has been included as a distinct indicator from existing socio-demographic variables in the model. Migration may be from another country or from a different region within a country, with the impact of adopting new rules or cultural practices or losing established support systems (Witten et al., 2015), which can impact the parental licences of freedom afforded to a child. Accordingly, this has been included in the parent-level attributes for influencing child independent mobility.

Companion devices (e.g., smart phones) for accompaniment and increased parental licence for independent mobility was an emergent finding in this thesis. Though it was only identified in Chapter 5, companion devices warranted a category of its own in the adapted systems model, because use of mobile phone have become central to parent-child negotiations relating to children's independent mobility in the public realm, and thus their health and wellbeing (as shown in Figure 7). Some children in this study indicated they were only allowed to go to public open space in accompaniment of a mobile phone, which is supported by other research (Shaw et al., 2015, Nansen et al., 2017). Based on findings from this research and others, future studies could consider re-evaluating the concept of accompaniment within the definition of children's independent mobility (discussed below); however, this is beyond the scope of this PhD thesis.

Parent Attributes:

Ethnic differences

Novel findings from Chapters 4 and 5 eluded to possible ethnic differences in children's independent mobility. Children of Samoan ethnicity were more likely to travel independently to public open space compared with children of other ethnic groups. To date there are limited New Zealand data available to draw comparisons from. There is a dearth of research that has focused on ethnic differences in children's independent mobility and the use of public open space. One earlier study in the United Kingdom reported ethnic differences in restrictions for independent use of public spaces. Asian and Black minority ethnic children aged 10-14 years had more restrictions than white children in the use of public open space (O'Brien et al., 2000). Interestingly, differences within ethnic groups were observed by sex; only 37% of Asian girls were allowed to play unaccompanied in the public realm, in contrast to 92% of the Asian boys in the

same neighbourhood. Sex-related differences in independent mobility have consistently been reported, albeit usually not to such a large degree (Shaw et al., 2015). These findings suggest that ethnic or cultural differences in independent mobility are complex, and that sex of the child should be considered alongside ethnicity in future research.

The 16 country international comparison study from the Policy Studies Institute, found that children's independent mobility varied widely across the countries studied (Shaw et al., 2015). Countries in Northern Europe (Finland, Germany, and Norway) had higher aggregated rankings compared with Portugal, Italy and South Africa. In relation to independently mobile trips to neighbourhood destinations in general, earlier research has shown the main factor affecting mobility licence was parental fear of road traffic, irrespective of ethnic background (Zwerts et al., 2010, Shaw et al., 2013, Johansson, 2006).

Some other reasons as to why these ethnic differences were found in this thesis could be that neighbourhoods with higher Pasifika ethnicities may to be more established although some conflicting evidence exists; (Statistics New Zealand, 2013) and the residents have a sense of familiarity with the local community (Auckland Council, 2012a). Mitra et al. (2014) previously demonstrated that those who lived in the current residence for an extended period of times (>9 years) were more likely to afford children's independent mobility. Familiarity of local residence and trust built in the neighbourhood social and built environment is likely an important factor in facilitating children's independent mobility (Witten et al., 2013). Findings from this thesis set the pathway for future work to explore ethnic differences and cultural variations in perceptions of independent mobility in more depth.

From the nine participating neighbourhoods, the different ethnic groups were clustered in similar geographical neighbourhoods. In this case, most of the Māori, Pacific Island including Samoan children lived in suburban, lower decile neighbourhoods. In contrast, most children of Asian ethnicity resided in the inner-city neighbourhoods. As previously mentioned, the neighbourhoods selected were socio-demographically and geographically diverse and the qualitative sample was designed to achieve heterogeneity and saturation. At the inception of this PhD study the focus was not on ethnic differences in independent mobility and visitation to public open space, however ethnic differences became apparent. In Chapter 4 ethnic differences were observed whereby Samoan and Māori children were more likely to have made any trips or independently mobile trips to public open space than children from other ethnic groups. Further interesting insights emerged in Chapter 5 from the children's go-along interviews, whereby a number of inner-city children from new migrant families (i.e., Chinese and Korean) reported having more parental licence to go to parks after school and weekends unsupervised. A number of these children's parents worked long hours (e.g., as chefs in central business district restaurants or as dairy shop owners as narrated by the child). In instances where neither parent was at home after school hours, children were given licence of freedom to go to public open spaces, but still had to return home by an agreed-upon time.

Recent work from the wider Kids in the City study (Lin et al., 2017 (*in press*)) also revealed ethnic differences in parent's safety concerns in the context of understanding licence for independent mobility. Findings reported that for New Zealand European, Māori, Samoan and other Pacific parents, stranger danger was the most common concern for allowing children to go out alone. For Asian and Indian parents, traffic danger was the main concern in limiting their child to be independently mobile.

Disentangling findings relating to area-level socio-economic status and ethnicity is challenging across the quantitative and qualitative studies. With Samoan and Māori children likely to make any trips or independently mobile trips to public open space from the travel diary data, but children of Chinese and Korean ethnic background reporting more parental licence to go to parks unsupervised in the higher decile inner-city neighbourhoods it was not possible to make a definite conclusion on particular ethnicities and more in-depth research needs to focus on ethnicity and new migrants. It is possible that the collinearity of ethnicity and neighbourhood characteristics hindered a clear understanding of ethnic differences in the links between the POSAI and independent mobility to, and visitation of, POS. Future research would benefit from taking neighbourhood characteristics into account when modelling these relationships.

Statistics on geographical distribution (Friesen, 2015) report the evolving 'ethnoburbs', not only for the different Asian ethnicities (Xue et al., 2012), but the wider population, especially around Auckland (Ishizawa and Arunachalam, 2014). An ethnoburb can be viewed as a cluster of ethnic residential areas and business districts, in which one ethnic minority group contributes a substantial concentration within a geographic area, but does not necessarily comprise the majority (Li, 1998, Li, 2009). This further complicates a clear understanding of ethnic differences in associations between environments and behaviours, due to the geographic clustering of ethnic groups. Large studies that allow for geographic clustering of different socio-demographic groups are warranted.

Companion devices:

Smart/mobile phones

One of the unanticipated findings in this study was the role of mobile technologies (e.g., smart phones) for facilitating children's independent mobility. To the authors

knowledge this had not been previously investigated in the context of public open space visitation but has recently been considered in relation to child mobility (Nansen et al., 2017). Previous research has shown the increasing use of mobile phones for confirming transport arrangements (Lopes et al., 2014), and in child-parent communication (Christensen, 2009, Nansen et al., 2015). Shaw et al.'s (2015) recent 16 country comparison found that in all but one country, children's mobile phone ownership corresponded to a higher level of independent mobility.

Findings from this research adds to this emerging body of research and provides an opportunity for future research to investigate the use of companion devices as an accompaniment mode in children's independent mobility. To the author's knowledge, 'accompaniment with a mobile phone' has not been investigated in the definition of children's independent mobility. It may be that researchers could reconceptualise how accompaniment is viewed in the context of defining and measuring children's independent mobility.

Notably, this finding only emerged for children living in the inner-city. A plausible reason for this could be the inclusion of the intermediate school in this group (Chapter 5). The intermediate school not only covered a larger school neighbourhood catchment area but the children were slightly older in age than the rest of the study population (by approximately 2 years). This is a significant stage in children's independent mobility development (Shaw et al., 2013) and most likely children would have to travel a greater distance to school and everyday locations unsupervised by an adult. On that proviso parents may have provided them with mobile phones. Other research findings showed that children were often provided their first mobile phone in response to increased travel unaccompanied by adult, in particular to and from school and traveling greater distances to school (Haddon and Vincent, 2007, Nansen et al., 2017, Underwood, 2011). A

comparative study between Australian and New Zealand school children reported children as young as nine years were provided with a mobile phone to travel to school independently (Nansen et al., 2017), demonstrating the uptake of this technology in young children.

Critical reflections on the thesis methodologies

Use of NZ-POST instead of POST

Having previously been validated and modified to the New Zealand setting, the NZ-POST (Badland et al., 2010) was deemed the appropriate audit tool to use over the original POST (Giles-Corti et al., 2005a). As highlighted in Chapter 1, removal of the five questions from the original POST occurred in the NZ-POST development, as the questions were considered to be irrelevant or ambiguous. For example, the type of surrounding roads was removed because it was not clear how the roads impacted behaviour. Busy roads could be linked to lower levels of children's independent mobility, but busy roads often provide car parking, which allows people to drive to public open spaces such as parks. Similarly the relationship between physical activity and dog access at the public open space was regarded as ambiguous, as dog access may be perceived as a positive feature for dog owners but a deterrent to public open space use for those without dogs. Grass watering was removed, as this was an irrelevant item in New Zealand due to higher levels of rainfall. Inclusion of GIS derived spatial measures, such as street connectivity around the neighbourhood public open spaces, in the development of the POSAI, may have distinguished between public open spaces with high or low accessibility for children commuting actively and independently.

Use of youth researchers and use of two different interview techniques (go-along and home interviews) for qualitative research components

Engaging youth researchers to undertake the go-along interviews for children from the suburban schools was considered to be beneficial for engaging with the participants. Youth researchers potentially provide a more relaxed atmosphere for the child to engage with (National Children's Bureau, 2015, Jardine and James, 2012, Dunne et al., 2015). In recent times it has become more widely acknowledged that research involving youth researchers is both significant and under-utilised (Jones et al., 2011). Youth researchers in the current study were close in age to the participants and were selected from the local secondary schools in the participating neighbourhoods so had a mutual understanding of their neighbourhood. In general, the depth of the go-along question probing in the youth researchers was lower compared with the interviews conducted by senior academic researchers (e.g., there was minimal evidence of probing to generate further explanations of topics). Even with additional training time for student researchers it was unrealistic to expect: (1) the same rigorous interview techniques to be applied, and (2) the same quality of data to be gained compared with senior researchers with decades of interviewing experience. The lack of data depth was only evident after the senior academic researchers viewed the transcribed transcripts at the end of the suburban children's go-along interviews. Due to time and funding constraints, and respondent burden, it was not feasible to repeat the suburban sample interviews.

Lessons learnt from the suburban interviews led to some refinements for the inner-city data collection. Firstly, the interviews were conducted by expert senior academic researchers and secondly, home-based interviews were conducted prior to the go-along interview. This was to garner more in-depth information on places the children liked to go in their neighbourhood. This did not limit the interpretation of the findings in Chapter 5 for the following reasons:

The Kids in the City study (involving the suburban dataset drawn from youth researcher interviews) was a qualitative sample, so the number of participants was designed to achieve heterogeneity and saturation (i.e., no significant new content was emerging from interview data) (Mason, 2010, Glaser and Strauss, 2009, Fusch and Ness, 2015).

i. The selection of diverse study neighbourhoods (detailed in Chapter 1). Briefly, three inner-city school (schools were mid to high decile) and six suburban schools (2 were mid socio-economic status (mid decile); and 4 were low socio-economic status (low decile)) reflecting both a socio-demographically and geographically diverse sample selection.

ii. Though having a different sample size across areas (suburban =100; inner city= 40), this is a substantial sample size (as highlighted above) for a qualitative study and the dataset was extensive and the results obtained from the PhD candidates analysis in Chapter 5 did not have an impact on the level of information garnered from across the sample.

iii. Findings emerged that reflected differences and similarities in themes for suburban and inner-city neighbourhoods that would be expected. Overall, clear and consistent themes emerged across the dataset, indicating that sufficient depth was gained from the youth researcher interviews work to reflect adequately the participating children's perspectives.

iv. Themes that were unique to the type of neighbourhood emerged as would be expected, for example accompaniment status with a mobile phone was exclusively reported with some inner-city children but not reported by suburban children.

In future, a more robust training for the youth researchers would be beneficial, followed by regular data quality checks. This may highlight possible issues in interview conduct and provide opportunities to adapt research methods early in the process.

Geographical relocation

In a few instances, qualitative data revealed that some of the participating children (and parents) in the Kids in the City study had 'recently' relocated to their neighbourhood. Details on when the participants moved to the neighbourhood and when they started to attend the school was not known. By not having an exclusion criterion regarding length of residence (or a variable to control for this in analyses), it is possible that some bias may have been introduced. The child's previous behaviours were unknown and therefore it is possible those participants may have been highly motivated and already had a high level of active travel and independent mobility behaviour. Therefore, findings might not necessarily reflect the neighbourhood environment exposure but rather individuals' pre-existing behaviour patterns. Potential bias due to residential self-selection has been previously identified, particularly in cross-sectional studies and has been recognised as a primary limitation in built environment research (Diez Roux, 2004). Specific to prevalence of children's active travel, research has suggested that residential self-selection may be an important correlate to consider (Mammen et al., 2012) whereby families with more or less inclination towards active travel for their children might be drawn to live in particular locations (Veitch et al., 2017). Future research would benefit from measuring neighbourhood self-selection and length of residence in a neighbourhood, and controlling for these variables when examining associations between environments and behaviours.

Thesis limitations

The following limitations were identified in this thesis:

1. In Chapter 3, the adapted NZ-POST audit tool was used to collect the environmental public open space audit data for the main Kids in the City study. A more specific audit, the Children's Public Open Space Audit Tool (C-POST) (Crawford et al., 2008) may have been better applied for the creation of the POSAI tool. C-POST was developed to assess features of public open space, identified from previous literature, to be potentially important in influencing children's physical activity. C-POST, for example, had more detailed options of recreational facilities than the NZ-POST tool (Appendix I), including skate boarding facilities, BMX tracks, and indoor and outdoor swimming pools (Crawford et al., 2008). In this study the NZ-POST was the preferred tool to apply as it has been adapted and tested for use in the New Zealand setting whereas the C-POST had not. However, the development of the POSAI was an exploratory exercise to test a proof of concept tool that may be developed into a more generalizable measure. In time the POSAI may be adapted further to be more child specific. A possible next step is to create a POSAI tool that includes child- audited public open space data. To date, no internationally validated child-specific tool for auditing public open space exists.

2. The public open spaces which were audited were not necessarily spaces children accessed, for example long stretches of grass verge along main roads. Additionally, some children in the study lived outside the school zone, so it is possible that the public open spaces which they frequented were not in this study's catchment area.

3. Length of residence was not measured in the current study. Children residing in a particular neighbourhood for a longer time may have acquired greater environmental knowledge and familiarity with the neighbourhood. Length of residence may also impact parental licence for freedom due to increased

familiarity and social connections. Future studies should control for length of residence, or remove those who have recently moved to a neighbourhood from the sample prior to analysis.

4. Although neighbourhoods were stratified by geographic and socio-economic factors facilitating heterogeneity in the sample, this research was conducted in Auckland City only. Findings cannot therefore be extrapolated to other cities. It must also be noted that only a small number of schools within the city were examined.

5. In Chapter 4, individual child behaviours were considered in relation to public open spaces assessed at the neighbourhood level, rather than at the household level. The school was considered to be the hub of the neighbourhood and thus school zones were employed to delineate the neighbourhood. This approach will have reduced sensitivity and specificity in identifying relationships between individual behaviours and the neighbourhood environment. The concept of school catchment areas or zoning (as adopted in New Zealand) has a somewhat arbitrary geography, which can be influenced by economic factors, parental demands and other competing forces (Pearce, 2000). Zoning can be seen as administrative boundaries (e.g., school districts), that may not reflect the areas important to the individuals living within them (Clapp and Wang, 2006). This aligns with the concept of ecological fallacy (Robinson, 1950) where inferences about the nature of individuals are deduced from inferences for the group to which those individuals belong. Robinson showed that differing results could be obtained when the same data set is analysed at individual and aggregate levels.

6. In Chapter 5 the use of multiple researchers with varying degrees of interview experience (i.e., youth researchers and senior academic researchers) impacted the depth of data obtained. The high school youth researchers had limited

experience with interview and question probing techniques compared with the senior academic members that had a wealth of experience. This was evident (as discussed in Chapters 5 and 6 discussions) in the depth of information attained upon transcribing and analysis of the go-along interviews. Though some of the youth researchers did probe the child during the go-along, this was not consistent across all the youth researchers.

7. Study designs for Chapters 3 to 5 were cross sectional and therefore causality cannot be inferred. It could be that child behaviours and parental attitudes prevail regardless of the built environment to which the child is exposed.

Future directions

1. Development of the POSAI tool

The initial concept of the POSAI was seen as building block for potential future work in the development of the POSAI tool. Future work on the POSAI could be enhanced by adding more quantitative spatial built environment measures, including street connectivity and park accessibility around the neighbourhood public open spaces.

2. Comparative analysis between different built environments (e.g., suburban vs inner-city neighbourhoods)

Findings in Chapter 5 suggests that compared with suburban children, inner-city were allowed less independent mobility, however findings do not ascertain whether the difference in themes between the areas were due to the parental licences afforded or differences in the built environments. Future work could further answer this by comparing the frequencies of different themes across the following four groups: (1) suburban + high parental licence (2) suburban + low parental licence, (3) inner-city + high parental licence and (4) inner-city + low parental licence. Additionally future work could look differences between neighbourhood type by gender, age group, and ethnicity.

3. Policy implications

Like many cities globally, Auckland has experienced significant population growth. From 2006 to 2013, Auckland's population has expanded by 9% to over 1.4 million, of which over a third (36%) are children (Auckland Council, 2013b). Accordingly, urban intensification has been on the agenda for the governance of Auckland, as detailed in The Auckland Unitary Plan (Auckland Council, 2013a). This plan has a 30-year goal to make Auckland the world's most liveable city. Overall, the plan recommends a greater level of residential intensification in urban areas throughout Auckland to address the growing population growth. Challenges with urban intensification are to ensure public open spaces are protected and can adequately provide physical activity (formal and informal) opportunities across the population.

Findings from this research suggest that urban planning policy and practice, including building new, or improving existing, parks and green space, would benefit from taking children's perspectives into account As such engaging with the children in the go-along interviews drew attention to new emergent topics that would have otherwise been missed. The children provided first-hand information of their unique experiences in the built environment, as previously shown (Rehrer et al., 2011, Nansen et al., 2015, Race et al., 2017). By way of example, a major initiative launched by UNICEF (2010), The Child Friendly Cities, aims to guide cities and other local governance systems in the inclusion of children's rights in policies, laws, programmes, and budgets. This initiative stipulates that children are active agents and their voices and opinions need to be taken into consideration and contribute to decision making processes. Presently, only one city in New Zealand, Whangarei, is recognised as a Child Friendly City (UNICEF, 2010, Manaia Health PHO). Another four cities around New Zealand making progress

towards becoming child friendly cities, Waitemata Local Board, Auckland; Wellington City, Hutt City, and Christchurch City (UNICEF, 2010).

4. Companion devices

In view of the findings in this thesis, that some children were allowed to go out only if they carried a mobile phone, this research contributes twofold. Firstly, this research contributes to the limited research looking at use of companion devices as a form of communication between parents and their child(ren) when roaming in public open spaces, and secondly this research highlights the potential for future measurements of children's independent mobility to investigate the use of mobile devices and GPS technologies as a mode of accompaniment. GPS-based surveillance devices and mobile phones maybe the silent companion that helps increase children's independent mobility in this age group of children. As yet unpublished, Nansen et al. (2017) examined two qualitative studies exploring how children and parents perceive and use mobile phones to negotiate everyday mobility. The authors' findings reflect findings from this thesis; that is, research is needed to investigate the relationship between mobile phone use and children's independent mobility, particularly with children transitioning from primary school.

5. New Migrants

It has long been recognized that large cities can be places where cultural diversity flourishes. Cities like Auckland have seen a growth in new migrant populations, those that migrate for lifestyle, employment, educational or family reasons. Auckland is fast becoming a multi ethnic, multi-culture society with over 180 ethnicities residing (Auckland Council, 2012a). However, migrating to a new environment may mean adopting to the new rules/cultural practices of that environment and adjusting to their

new surroundings and accepting different people's parenting practices (Greves et al., 2007, Dowling, 2000, Mikkelsen and Christensen, 2009, Sime and Fox, 2014).

For example, where children may have had more freedom to actively travel and roam independently in their home country/region, this practice may have changed once moving to Auckland. Although it did not arise as a key theme, during analysis of the qualitative data in this thesis, some new migrant children reported more freedom to roam in their previous neighbourhood than they did in their current neighbourhood. The lack of research specifically investigating new migrant experiences in the context of independent mobility and public open space limits opportunities for comparisons with earlier research. A recent study in Scotland of first generation Eastern European migrants (Sime and Fox, 2014) found that children often thought that parents were less restrictive with boys when it came to playing outside or walking alone to local places, such as parks or libraries. In earlier research, Greves et al. (2007) reported that most of the adult participants in their study walked to school in their country of origin, yet only 13% of these participants' children walked to school in the USA. Barriers to allowing their child to actively transport to school included fear of their child's safety from violence from strangers, as cited from Greves et al. (2007).

"In America it's not safe for young children to walk–too much violence."

Together, these findings highlight a need to further explore independent mobility experiences of new migrant children and their families. With increasing migration internationally, understanding issues for families who migrate will become increasingly important to ensure optimal outcomes for all.

Conclusion

This thesis has contributed to further understanding the relationship between public open space attributes and independent mobility in primary and intermediate school aged children living in socio-economically and geographically diverse neighbourhoods. Relationships between children's independent mobility and neighbourhood public open spaces are complex and multifactorial, as per the adapted socio-ecological framework (Figure 7).

The application of the POSAI tool to examine public open space visitation and children's independent mobility across socio-economically and geographically diverse neighbourhoods has policy implications. By having one score for a neighbourhood's public open space, this may provide a useful measure that would aid policy makers and planners in decision-making regarding neighbourhood areas to prioritise for future (re)development. Further research is needed to develop the POSAI tool using the neighbourhood catchment around participants' residential address to gain a better understanding of children's independent mobility and public open space use in the local neighbourhood.

This thesis confirmed the value of children's agency in contributing to the planning and development of public open space environments to create a child friendly city that caters for the needs of children and provides public open spaces that are child friendly.

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Appendices

Public Open Spaces, Children's Independent Mobility

Moushumi Chaudhury, Melody Oliver, Hannah M. Badland, and Suzanne Mavoa

Contents

M. Chaudhury (✉) • M. Oliver
Human Potential Centre, Auckland University of Technology, Auckland, New Zealand
e-mail: moushumi.chaudhu@aut.ac.nz; melody.oliver@aut.ac.nz

H.M. Badland
McCaughey VicHealth Centre for Community Wellbeing Unit, Melbourne University School of Population and Global Health, University of Melbourne, Melbourne, VIC, Australia
e-mail: hannah.badland@unimelb.edu.au

S. Mavoa
McCaughey VicHealth Centre for Community Wellbeing Unit, Melbourne University School of Population and Global Health, University of Melbourne, Melbourne, VIC, Australia

SHORE and Whāriki Research Centre, School of Public Health, Massey University, Auckland, New Zealand
e-mail: suzanne.mavoa@unimelb.edu.au

Abstract

The health benefits of children engaging in at least 60 min of moderate-to-vigorous physical activity (MVPA) daily are well documented, including improved musculoskeletal health, cardiovascular risk profiles, and aerobic fitness and better psychological well-being. Many Western countries have indicated a decline in physical activity over recent decades.

Emerging research shows that children who engage in outdoor activities and travel to destinations using active modes (i.e., walking, cycling) accumulate higher levels of physical activity than those that do not. Over recent decades, research interest has focused on children's independent outdoor play and active travel to destinations within their neighborhood, including journeys to and from school without adult accompaniment.

Engaging in independent mobility has two important benefits for children. Firstly, engaging in non-formalized activity practices helps children attain daily physical activity recommendations, which in turn, generates significant health benefits. Secondly, independent mobility has an important role in fostering children's physical, social, emotional, cognitive, and spatial development; this carries into adult life.

A growing body of evidence suggests that the use of public open spaces, including parks and green spaces, is associated with many health and well-being benefits of urban dwellers. Public open spaces are also recognized as important settings to promote physical activity and children's independent mobility, not only because of purpose-built infrastructure (e.g., playgrounds) but also as easily accessible destinations for unstructured activities such as walking, cycling, and informal outdoor play.

This chapter first provides an overview of children's independent mobility and thereafter synthesizes the literature related to public open spaces within the context of children's activity and independent mobility.

1 Introduction

1.1 Definition of Independent Mobility

The term independent mobility was conceptualized by Hillman and colleagues in the early 1990s, as the freedom to move around to destinations outside the home by active travel (e.g., walking and cycling) and engaging in outdoor play without an accompanying adult (Hillman et al. 1990; O'Brien et al. 2000). van Vliet (1983) described these destinations as the "fourth environment," being the setting outside the home, including playgrounds, and child-orientated institutions. Broadly, the investigation of children's independent mobility has fallen into three categories:

studies of parental license for children's independent mobility, accompaniment status, and "true" independent mobility. Parental license is conceptualized as parents allowing children the freedom to do certain activities without the presence of an adult. Hillman et al. (1990) study devised a set of behavioral indicators related to risks to children in the local environment. They examined the licenses and parental proxy reports for what children were allowed to do "on their own" including crossing roads, going to leisure places, coming home from school, and going out after dark and also what forms of transport they were approved to use independently by parents (i.e., walking, cycling, cycling on roads, buses). Hillman refined this to using "six licenses" as the basis for establishing the level of children's independent mobility afforded, as described above. The higher the number of parental licenses a child held, the higher the levels of children's independent mobility. Generally, children's independent mobility increased as children aged.

Accompaniment status has been defined as a child travels, be it with a parent, adult, sibling, peer, or alone, with "true" independent mobility considered as situations where the child travels without any accompaniment (Hillman et al. 1990; O'Brien et al. 2000). Although these definitions exist, Mikkelsen and Christensen (2009) suggested a more theoretical perspective is needed to define children's independent mobility. They identified that children navigating environments "on their own" and "alone" described the behavior, but the concept in itself was not defined. Their findings suggested that the concept of children's independent mobility should not be focused solely on the presence or absence of adults but should be broadened to include "invisible actors," such as peers, friends, pets, and animals. In particular, they found Danish suburban children entertained companionship with other children to and from school, and around their neighborhood, while mobility of rural children principally involved the family, pets, and animals. More recently, the use of telecommunication technology such as mobile phones has allowed parents to monitor their independently mobile children and is thus an additional factor to consider when defining children's independent mobility (Mikkelsen and Christensen 2009).

The terms "independent" and "mobile" have been interpreted in a variety of ways in health research to describe how these relate in childhood. Mikkelsen and Christensen (2009) argued that "independent" implies freedom of control/not dependent (on people or things). However this definition is unclear if it intends to focus on a power struggle between child and parent, dependence, or physical distance between parent and child at any given time. For example, a child attending an adult-controlled afterschool club, yet engaging in outdoor play with no direct adult supervision during this time, is considered to be independently mobile based on this construct. Pooley et al. (2005a) discussed how the word "mobility" can be characterized into three levels. Level one encompassed practical functions including those undertaken on a temporary basis such as journeys to school, shopping, and visiting friends. Level two included everyday mobility as a social function including interaction – allowing development of social networks, friendships, and local
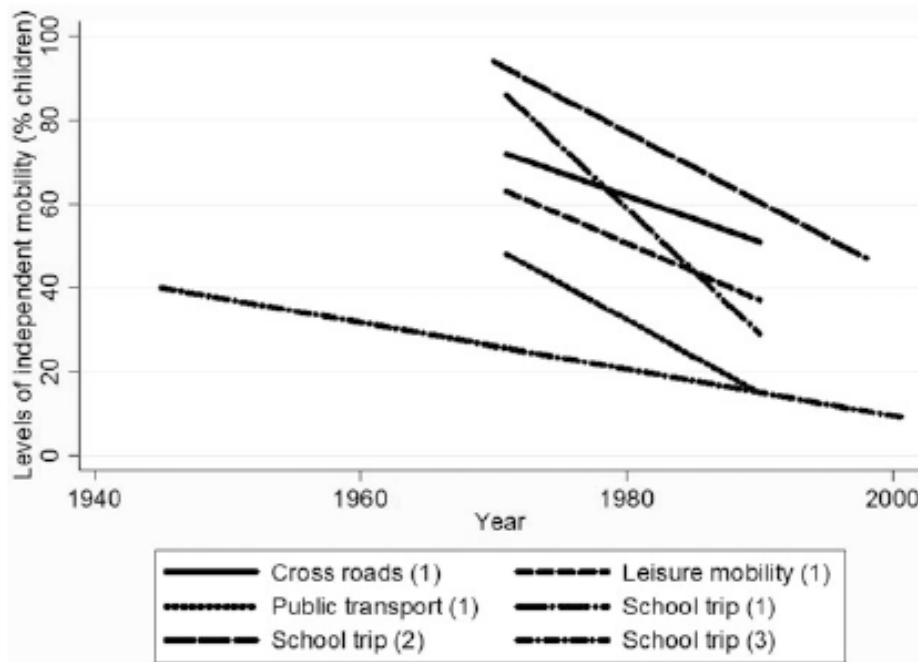
Fig. 1 Prevalence of independent mobility in children (% children over years 1940–2000). Notes: Cross roads = allowed to cross roads on own, leisure mobility = independent mobility during leisure time, public transport = allowed to use public transport on own, school trip = independent mobility to school. (*1*) Hillman 1990); (*2*) O'Brien et al. (2000); (*3*) Pooley (2005b) (Figure reprinted with permission; Badland and Oliver (2012))

proxy measure of children's independent mobility and thus was not an assessment of children's actual behaviors.

Through in-depth oral life-history interviews, Pooley et al. (2005b) compared children's journey to school in urban areas in England since the 1940s. For 10–11-year-olds born in the oldest cohort (1932–1941), 40 % traveled to school alone compared with 9 % in 10–11-year-olds born in the youngest cohort (1990–1991). Figure 1 shows this decline in children's independent mobility over 1940–2000.

Similar independent mobility trends have been reported in other countries, including Denmark, Finland, Norway, and the United Kingdom (Fyhri et al. 2011), Italy, and Australia (Shaw et al. 2013). Interestingly, studies from Finland and other Scandinavian countries have reported children engage in higher levels of children's independent mobility than children from other European countries, albeit overall decline has been observed over time (Kyttä 2004).

Many of the accounts of children's independent mobility and more recently the concept of walkability research have come from study notions of space, and of journeying from place to place across a number of interdisciplinary researchers (e.g., public health, urban planners, environmental psychology, social epidemiologists), looking at distances walked and maps of spatial ranges. However little attention has been drawn to alternative perspectives in particular from the view point of health geographers, for example, practices of walking itself. This could

further contribute knowledge on movement activities, different forms of embodiment, their relationship to health, and their places, experiences, agency, and cultures involved (Christian et al. 2012). As Horton and Evans (2013) suggest, this could be particularly important to know what happens during those distances walked and within those mapped ranges and how such practices matter.

Obesity/fatness is a major concern not only for public health researchers, and globally among policy maker, but across other multidisciplinary researchers. For example, among geographical research there is a shift in obesity policy and understanding obesogenic environments away from an individualistic model of obesity to a more ecological model at population level (Colls and Evans 2014).

1.3 Theoretical Framework

1.3.1 Socio-ecological Model

In determining what influences children's independent mobility, no specific behavioral model has been published that provides a theoretical framework for emerging research in this area (Mikkelsen and Christensen 2009). One of the most common models used in health promotion research to look at health behavior is the socio-ecological model (Stokols 1996). The socio-ecological model developed out of work of a number of prominent researchers (Glanz et al. 2008, pp. 468–469). The core concept of a socio-ecological model is that behavior has multiple levels of influences, including individual, social environment, physical environment, and policy. Original work on the socio-ecological model stems from Bronfenbrenner's work on ecological systems theory in the 1970's, which identifies five environmental systems with which an individual interacts. His work saw the influences on behavior as a series of layers, where each layer had a resulting impact on the next level (Bronfenbrenner 1994). All levels of the socio-ecological model impact on the behavior of the individual (Stokols 1996). As Stokols addresses, the socio-ecological approach integrates person-focused efforts to modify health behaviors with environment-focused interventions. While the components remain the same, the socio-ecological model needs to be tailored to suit particular behaviors and population groups within each level. Figure 2 features the basic socio-ecological model linking the individual with their social, physical, and political environments.

In light of the lack of a theoretical framework for children's independent mobility, Badland and colleagues have recently developed a conceptual multilevel framework to understand the multiple influences on the behavior (Fig. 3; Badland et al. 2016). Figure 3 highlights the relationships within the conceptual framework, for example, children's independent mobility behavior may be influenced by factors associated within the built environment, which in turn are influenced by environmental policies and social norms, and these relationships may be causational or bidirectional.

The focus on children's independent mobility by many social science researchers, over the last three decades, has concentrated mainly within urban neighborhood setting. Drawing conceptual-methodological frameworks from

Fig. 2 Illustration of model
made up of the individual,
social environment, physical
environment, and policy
components
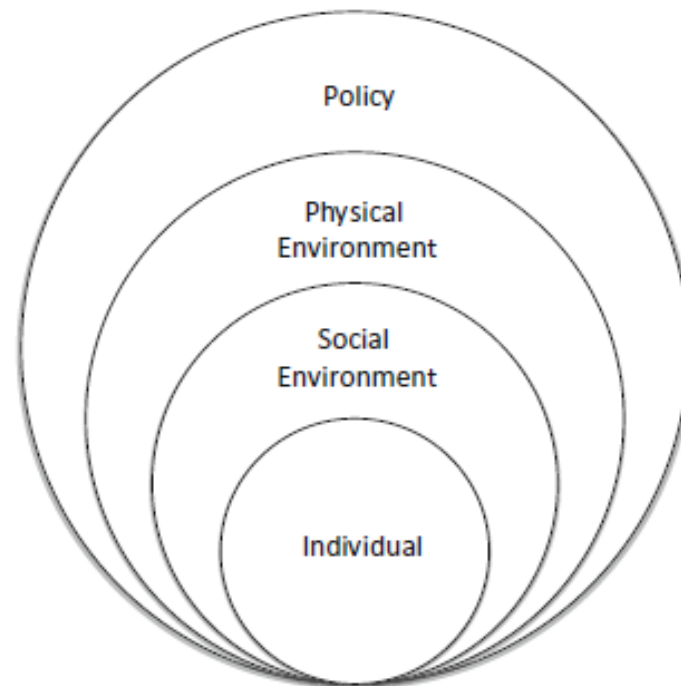
transport geography and environmental psychology has afforded research exploring
children and young people's everyday walking in diverse context including walking
routines, behavior, and patterns. Together with new terminologies and the devel-
opment of a number of techniques and technologies, researchers have contributed to
understanding children and young people's geographies (Trapp et al. 2012).

1.3.2 Societal Changes

Over the last few decades, a number of societal changes have likely influenced
children's independent mobility, including change in family structure, greater use
of structured childcare, increasing number of dual income and working households,
families living further away from schools and places of employment, and increased
and multiple car ownership per household (Fyhri et al. 2011). Also, parental
(O'Brien et al. 2000; Prezza et al. 2005) and children's (Hume et al. 2005) percep-
tions of safety in neighborhood risks, including stranger danger (Rudner 2012),
outdoor play (Veitch et al. 2006; Wen et al. 2009), and increased road traffic
(Hillman et al. 1990; Zwerts et al. 2010), are contributing factors that have
influenced children's independent mobility.

Fyhri et al. (2011) examined datasets from national travel surveys and other
types of available data and surveys for active travel and children's independent
mobility in the United Kingdom, Norway, Denmark, and Finland. Not all data
sources were directly comparable between the countries; however the same patterns
were found in all four countries. Data from the United Kingdom sample showed
that parental accompaniment for school travel increased among children aged 7–11
years from 78 % in 2002 to 86 % in 2008 (Department of Transport 2009). In the
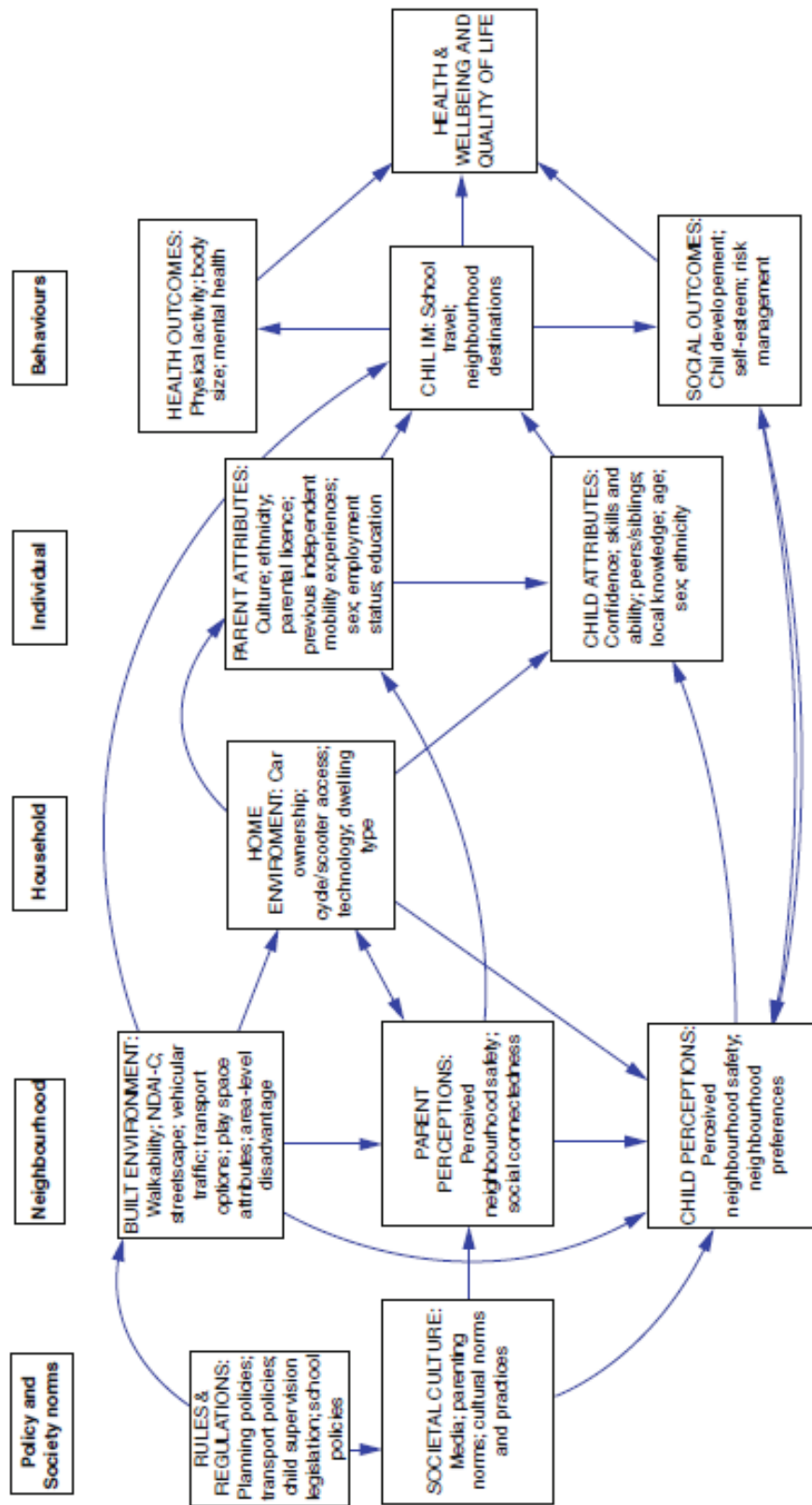
Fig. 3 Conceptual model development for children's independent mobility (Permission to reprint by Badland et al. (2016))

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same age group, traffic danger (58 %), fear of assault/molestation (29 %), convenience (21 %), and distance to school (22 %) were the leading four reasons given by adults for accompanying children to school. In Norway, parents taking the same route to the workplace as their child's route to school was the main reason children were driven to school by car (58 %), followed by concerns of traffic safety (21 %) and the car being the fastest travel mode (18 %). In the Danish and Finnish studies, the main parental concerns for accompanying children to school were road traffic and fear of molestation from adults (Fotel 2007).

1.4 Active Transport

Active transport can contribute to children's independent mobility and encompasses traveling by non-motorized travel modes, such as walking, cycling, scootering, and skateboarding. There is a large body of evidence reporting the significant contribution of active transport to or from school (Cooper et al. 2005; Salmon et al. 2007) and other nonschool travel destinations (Mackett et al. 2005) in overall children's physical activity. Active travel to school has been shown to be an important source of physical activity in young children (Schoeppe et al. 2012). Walking is free and convenient and has been described as a "near-perfect exercise." Cooper et al. (2005) used accelerometry with Danish primary school-aged children to study walking, cycling, and motorized transport to school. The authors found walking to school was associated with higher levels of overall physical activity compared with motorized transport. Cycling was also associated with higher levels of physical activity, but only among boys. Furthermore, a national survey of the US youth has shown a steep decline from 1969 to 2001 (41–13 %) in children's active commuting to school, while motorized transport (by car) to school has increased in this period from 17 to 55 % (McDonald 2008; Shaw et al. 2013). Following on from Hillman's earlier work (Hillman et al. 1990), active transport from home to school among English children decreased between 1971 and 2010 (86–25 %) (Shaw et al. 2013). The decline in active transport has been observed in many countries in Europe and elsewhere (Fyhri et al. 2011). Although the US national survey data are not directly comparable to those presented by Fyhri et al. (2011), it is clear that the overall picture of active travel, particularly walking and cycling, is on the decline, and in contrast transport by vehicular modes has become a predominant form of personal mobility (van der Ploeg et al. 2008).

Apart from a "near-perfect exercise," active transport has been targeted as a way of increasing energy expenditure in children and combating rising levels of obesity in children (Harten and Olds 2004). There are also a number of positive health and social benefits from active transport including mental health, cognitive development self-esteem, improved behavior, and relationship building (Jan 2011). The decline in active transport is particularly well documented in relation to trips to school. The shift in active travel to school may be explained by a number of reasons, for example, parent's negative perception of the neighborhood, including

concerns of stranger danger and traffic safety, the increasing distances to schools, and time pressures (Oliver and Schofield 2010). Though globally on the decline, it should be acknowledged that children's active travel practices vary by country and geographic region.

Distance and trip duration, such as home to school journeys, are the main factors which influence whether one uses active and passive transport modes (Oliver and Schofield 2010). Furthermore, distinct differences can be found for walking and cycling, distance to location being greater for children who walk (Schlossberg et al. 2006), while increased trip duration may affect cycling more than walking (Ewing et al. 2004). Findings from studies in the early 2000s from the United Kingdom and Australia reported that distance to school was the main factor affecting the likelihood that a trip would be active (Black et al. 2001; Harten and Olds 2004). In Harten and Olds' (2004) study on Australian children aged 11–12 years, trip data were collected on two school days and one nonschool day. They reported that children made an average of one active trip per day, with median trip length of 0.63 km and the mean total distance per child per day being 0.61 km. In the Black et al.(2001) study of English children aged 5–10 years, 50 % of the trips to school were by active commute up to a distance of 2.0 km. Urban planning literature suggests that key destinations should be with 400–450 m (approximately 5 min walking) of residential areas and within 800 m of public transportation. In Metcalf et al. (2004) study of 275 younger English children (year one, aged 5 years), the median time taken to walk to school was 6min and the median distance accompanied actively travel distance was 0.7 km.

More recent studies are finding similar results to this early research. A recent review by Wong et al. (2011) identified 17 studies between 1960 and 2010, of which 15 studies reported negative associations between distance to school by either walking or cycling to school or both. No study reported a positive association between distance to school and active transport. McDonald (2007) reported a negative association with active school travel when the trips were short (i.e., less than 1.6 km); no associations were found for trips greater than 1.6 km. A summary from current literature provided conclusive evidence that increasing distance is negatively associated with active school travel (Wong et al. 2011). Promotion of active travel modes such as walking and cycling, with peers or independently in the built environment, has greater prospects if school catchment area is explicitly considered (Black et al. 2001). A handful of studies have measured children's independent mobility in the form of children's (unsupervised) active travel to various destinations (Page et al. 2009; Wen et al. 2009), and one study has looked at unsupervised outdoor play as an indicator of children's independent mobility (Floyd et al. 2011). Schoeppe et al. (2012)recently reviewed the associations between children's independent mobility and active travel. The systematic review reported a vast majority of active travel studies focused on children's transport behavior (active/motorized) to and from school. The review noted that only five studies examined active transport to nonschool locations, suggesting a gap in research that needs to be addressed.

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1.5 Associations Between Children's Independent Mobility and Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure. This behavior is not limited to sport and exercise, but it is classified as any activity that raises the heart. Children that engage in active transport behavior are more likely to be physically active overall and have higher levels of energy expenditure. The benefits of different types of physical activity differ across life stages. While morbidity and premature mortality increase into adulthood and older age, exposure to risk through inactivity begins in childhood. Participating in 60 min of moderate-to-vigorous physical activity daily in children has significant health benefits, including improved muscular and bone strength and aerobic fitness and reduced risk of adiposity (Strong et al. 2005). In addition, long-term benefits include reducing risk for chronic diseases such as cardiovascular disease, obesity, type 2 diabetes, high blood pressure, and some cancers (Banks et al. 2012) and improved mental health. Time spent outdoors by children is a consistent correlate of physical activity (Wen et al. 2009), and reductions in active travel and in children's independent mobility may be contributors to the decline in physical activity levels (Page et al. 2009).

1.6 Children's Independent Mobility Associations with Health and Social Outcomes

The benefits of children's independent mobility can be seen as twofold. Firstly, being independently mobile allows a child to engage in non-formalized physical activity, which has been shown to be important for children achieving daily physical activity requirements (World Health Organization 2010). Secondly, children's independent mobility has an important role in fostering children's physical, social, emotional, cognitive, and spatial development (Kyttä 2004). Additionally, engaging in children's independent mobility provides opportunities to develop life-long skills including social connectedness, to contribute to community social capital, and to make calculated judgments to safely navigate risky situations, such as crossing busy roads or encountering strangers (Rudner 2012).

1.7 Children's Independent Mobility and the Environment

The design of the neighborhood built environment can have an impact on children's independent mobility. In the review by Davison and Lawson (2006) which focused on the relationship between the built environment and children's physical activity, they reported a positive association with traffic density, speed, and local conditions such as crime rates. Similarly, one Australian study found that perception of unsafe round environments was negatively associated with walking and cycling among 10–12-year-olds (Timperio et al. 2004).

Attributes in the urban built environment may explain some of the changes documented in children's independent mobility behavior. Environmental features that may influence children's independent mobility include distribution, accessibility, aesthetics, and quality of destinations such as public open space, presence of green space/greenery (Giles-Corti et al. 2005a), size of public open spaces such as parks, perceived neighborhood safety (Pooley et al. 2005a; Rudner 2012), and increased motorized traffic (Hillman et al. 1990; Zwerts et al. 2010). More walkable neighborhoods (i.e., those with high street connectivity, residential density, and mixed use) have positive associations with walking activity among adults; however better street connectivity means more exposure to vehicular traffic, which may not be conducive for active travel behavior in children.

Evidence suggests that neighborhoods with parks, play areas, recreational facilities, pedestrian infrastructure, and sporting venues available facilitate higher active travel among children (Pont et al. 2009); these may also be appropriate locations to support children's independent mobility.

1.8   Definition and Importance of Public Open Space

Public space and public open spaces include parks, green spaces, plazas, sidewalks, shopping malls, community centers, and schoolyards. There are a number of subjective definitions of what constitutes a public space or public open space within the built environment literature with overlapping features as described. Furthermore public open spaces can include land space areas for playgrounds and "blue space" areas of water including rivers, canals, lakes, and reservoirs. Crucially, public open spaces are spaces freely accessible to all and may have multiple uses by multiple users, including sport and recreational opportunities. In this chapter, public open spaces have been defined as "parks and green space that can be freely accessed by the public" (Badland et al. 2010).

Public open spaces are recognized as important settings to promote physical activity engagement in the neighborhood built environment (Timperio et al. 2008). This is not only by use of purpose-built infrastructure (e.g., playgrounds) but because they operate as potential destinations to actively travel to and as destinations to travel through. Public open spaces may also confer health and well-being benefits by fostering social connectedness, communication skills, and friendship development (Lachowycz and Jones 2013; Sugiyama et al. 2008). Evidence also suggests that children's body mass index is lower when they have access to more green space (Lachowycz and Jones 2011).

Multidimensional physical characteristics of the neighborhood may contribute to various forms of activity engagement among youth in their immediate environment. The relationship between child and neighborhood environment needs to be further explored to add to the existing body of knowledge of what contributes or hinders children's independent mobility.

1.9   Public Open Space Use by Children

Simply providing green space in a neighborhood is not enough for individuals in the community; attention needs to take place in its design and qualities for it to be beneficial for all groups (Villanueva et al. 2013). Access to good quality green space has positive associations with physical and mental health and well-being (Francis et al. 2012). The use of green space also provides an area for social contact with others, freedom for play, and destinations to walk or cycle and engage in physical activity (Veitch et al. 2008). Access to appropriate facilities for physical activity and active play has been previously identified as a key determinant of activity participation (Sallis et al. 1993), and public open spaces need to be flexible to accommodate a diverse community and populations (Cabe Space 2004). What is not well known is how public open space availability, safety, and accessibility are conducive for children's independent mobility and children's active play. For example, safety features of a public open space have been identified as important contributors to their use. Lighting, dog fouling, graffiti, vandalism, and unmaintained areas all contribute to a perceived lack of safety, which reduces the use of green space in children and adolescents (Cabe Space 2004).

Availability and quality of public open spaces are used widely in health research to determine relationships among the physical environment, physical activity, and health. Availability and access to parks near home are associated with higher levels of physical activity in youth (Cohen et al. 2006). Quality of public green space is an important determinant of health and influences their use for children; key considerations include safety, toilets, drinking water, lighting, and pathways (Sallis et al. 1997; Veitch et al. 2006). Crawford et al.(2008), when looking at features of public open spaces in contrasting socioeconomic neighborhoods, found those in more disadvantaged areas had more amenities (e.g., toilets, drink fountains) and better shading from trees, walking and cycling paths, and lighting than public open spaces in more advantaged areas. Similar results have been reported elsewhere (Giles-Corti et al. 2003).

Park proximity, size, and features have been minimally investigated among children (Kaczynski and Henderson 2007). Giles-Corti et al. (2005a) indicated that among similar-sized parks, those public open spaces rated "higher quality" versus "lower quality" were more likely to attract users to engage in physical activity. Having good access to larger public open spaces was also associated with higher levels of walking in adults. Conversely, Kaczynski et al. (2008) reported size and distance of park were not significant predictors for use among adults, although specific features inside the park (e.g., paved trails) were positively related with use.

Though most public open space studies have focused on physical activity and active play, it is thought that attention needs to be paid to measuring children's independent mobility, an important contributor for daily physical activity. To date very few studies have attempted to relate environmental attributes to children's independent mobility in specific locations.

1.10 How Have Public Open Spaces Been Measured?

A number of direct observational methods have been employed in health research to code attributes of physical activity environments, and a summary of these can be found by Sallis (2009). The chapter discusses observational tools used to measure physical activity behavior in specific settings (e.g., schools, stairways) and auditing of specific environments.

Largely, direct observation audits have been used to audit public open spaces (parks and green space). Audit tool examples include the Bedimo-Rung Assessment Tool, Environmental Assessment of Public Recreation Spaces Tool, Community Park Audit Tool, and Public Open Space Audit Tool (Giles-Corti et al. 2005a). These inventories all vary in length and type of environmental information collected. Other tools collect data objectively on both individual and environmental levels, for example, System of Observing Play and Leisure Activity in Youth and System for Observing Play and Recreation in Communities. Details of these tools and resources can be found elsewhere (Active Living Research 2014).

Taylor et al. (2011) measured the quality of public open spaces using a new remote-assessment approach, Google Earth Pro. The study assessed the correlation between remote assessment of quality of public open spaces using Google Earth and direct observation using a shortened version of the Public Open Space Audit Tool. Fifty parks were selected to be assessed by the remote method and scores compared with some parks using Public Open Space Audit Tool. Strengths of the remote method were the speed at which audits could be completed, facilitating a larger number of environmental audits without the need of in-person visits. Limitations of this remote-assessment method were that some items could not be accurately scored due to obstructed view or poor resolution, particularly regarding aesthetic features. Additionally, satellite imagery data may not be current in some areas, as images may be up to 3 years old and thus not accounting for spaces where redevelopment has occurred. Advantages of these direct observation audits are that they are user-friendly tools to measure different environmental characteristics, with no participant bias, and they are easy to conduct. Disadvantages include the cost and need to train auditors, and depending on length of audit, it may be time consuming to collect the data.

1.11 What Is the Relationship with Children's Independent Mobility and Public Open Space

Within the built environment, places where a child engages in physical activity and active play are important to study to establish factors affecting youth physical activity (Ellaway et al. 2007; Giles-Corti et al. 2005b). Play areas are potentially important areas for children's mental, social, and physical health and for social contact with other children (Ellaway et al. 2007). There is limited data on the relationship between children's independent mobility and public open space as the majority of children's independent mobility studies have investigated physical

activity in school locations (including active travel to school), neighborhood streets, and parks (Grow et al. 2008). However, Giles-Corti and King (2009) suggest most individuals obtain physical activity from more than one context, which includes walking and cycling and free play.

Past research in children aged 10–12 years reported that absence of nearby parks and sports venues was related to decrease walking and cycling trips (Timperio et al. 2004). Children spent less time in engaging in sedentary activities (i.e., computer/e-games and watching television) when living near a larger-sized park with a water feature and/or whose parents reported greater satisfaction with park quality (Veitch et al. 2011). Similarly, Grow et al. (2008) showed that regardless of age, living closer to a larger public park and public open spaces increased the likelihood of being active.

It is also possible that sex differences exist for utilizing public open spaces. Some studies have indicated that in youth, boys tend to roam more freely and independently in public open spaces in their neighborhood than girls (Page et al. 2009; Villanueva et al. 2012; Wen et al. 2009). Villanueva et al. (2012) examined how far children traveled from home within the neighborhood; parental perceptions reported in favor of boys being more able to safely negotiate traffic conditions better than girls. Stronger association between access to green space and physical activity has been found for boys (Page et al. 2009; Villanueva et al. 2012). For example, in a cross-sectional study by Page et al. (2009), in the neighborhood, boys aged 10–11 years reported higher children's independent mobility compared to girls.

1.12   What Is the Relationship with Public Open Space and Area-Level Disadvantage

The relationship between individual and environmental characteristics in influencing health and health-related behaviors is well established in literature (Strategic Review of Health Inequalities in England 2010). Living in a disadvantaged neighborhood compared to living in a more advantaged neighborhood has been linked to poorer health outcomes in individuals (including children), with higher rates of chronic disease, and associated risk factors such as obesity (Diez-Roux 2001). This has been shown for total and coronary heart disease mortality (Diez-Roux et al. 1997), coronary heart disease prevalence and risk factors (Smith et al. 1998), and depression (Yen and Kaplan 1999). Macintyre (2007) described this as "deprivation amplification." These variations in health are explained as compositional (individual level) and contextual (area level) (Diez-Roux 2001; Macintyre 2007).

Conflicting evidence exists where some populations exposed to more green environments report lower levels of health inequalities (Mitchell and Popham 2008), and several studies in New Zealand have shown that socioeconomically deprived urban communities have better access to parks (Badland et al. 2010; Pearce et al. 2008). Yet other research suggests communities in more disadvantaged

neighborhoods have poorer green space availability than more affluent neighborhoods (Estabrooks et al. 2003). Nevertheless, access, location, and quality are important attributes for determining public open space use within a neighborhood. In contrast, Richardson et al. (2010) suggest the availability of public green space in New Zealand may not be as an important determinant of health as found elsewhere.

The Strategic Review of Health Inequalities in England 2009 Marmot Report advocated that there should be green space within 4 min of every family home (2010). Using international data, the report found a significant lack of green spaces and play spaces for children in disadvantaged neighborhoods. Other empirical research suggests that the relationship between area-level disadvantage and public open space access varies nationally.

Studies of the locations of children's outdoor playgrounds have found them more common in and closer to poorer areas in Scotland and the USA (Cradock et al. 2005; Ellaway et al. 2007). However in Australia, Crawford et al. (2008) found no difference in number of playgrounds and recreational facilities between higher and lower disadvantaged neighborhoods, and most of their participants (aged 8–9 years) lived about 300 m to their closest public open space. Veitch et al. (2008) addressed the importance of park proximity to home within Australian neighborhoods. They reported that children living in low socioeconomic outer-urban neighborhoods had to travel a greater distance to access local parks for active free play compared with higher socioeconomic areas. Together, this work highlights the conflicting findings presented thus far.

In addition, researchers have looked at the quality of parks and playgrounds for children's play with regard to their safety and availability by area-level disadvantage (Cradock et al. 2005; Curtice et al. 2005; Ellaway et al. 2007; Ellaway et al. 2001). Ellaway et al. (2001) reported people who lived in poorer areas of Glasgow were more likely to report a lack of safe places for children to play in their neighborhood. Similarly in 2005, a Scotland-wide study found 45 % of people living in deprived areas compared to 4 % of those in affluent areas reported a problem with the availability of safe places for children to play (Curtice et al. 2005). Cradock et al. (2005) found that in Boston, USA, young people from poorer areas lived closer to playground facilities than those in more advantaged areas; however the playground equipment in poorer areas was unsafe and poorly maintained. The quality of public open space for influencing children's use is also important. Badland et al. (2010) analyzed public open spaces in 12 urban neighborhoods in New Zealand and found no difference in quality of public open space by area-level deprivation; however public open space safety score was greater in more disadvantaged areas compared with least disadvantaged areas. However, this study did not look at the association between quality of public open space and individuals' use of public open space.

A 2007 Scottish study investigated the provision of outdoor play areas for children in relation to area disadvantaged per 1000 total population. The results of the study pointed toward more play areas being available in more disadvantaged areas compared with less disadvantaged areas (Ellaway et al. 2007). Similar findings were reported in a Danish study (Karsten 2002); however this study did

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not assess the quality and use of the playgrounds. An Australian study revealed a reduction in active travel to school (by foot and cycle) among 9–13-year-olds between 1985 and 2001 in contrasting neighborhoods. In higher socioeconomic areas, this reduction was 50 %, while in lower socioeconomic areas active travel declined by 77 % among children (Salmon et al. 2007).

It is not yet clear whether quality, quantity, or a measure of both is most important for public open space use; several studies have started to investigate these associations with various health outcomes. One Australian study explored the relationship between quality and quantity of public open space attributes and mental health among adults. The authors found that quality of public open space within a neighborhood was more important than quantity (Francis et al. 2012). This warrants further investigation as to the relationship of quality and quantity together with public open space by neighborhood disadvantage among children has not been examined.

2   Conclusion

1. The evidence of the potential health and well-being benefits of public open spaces have increased immensely over the last decade along with the growing research interest in public open space in the urban built environment.
2. Most public open space studies have focused on physical activity and active play; more attention needs to be paid to measuring children's independent mobility, an important contributor of daily physical activity.
3. The evidence base linking public open space attributes with children's independent mobility is limited, for example, mobility in specific locations, and to date very few studies have explored this relationship.
4. Multidimensional physical characteristics of the neighborhood may contribute to various forms of activity engagement among youth in their immediate environment. The relationship between child and neighborhood environment needs further exploration.

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Appendix B. Using the Public Open Space Attributable Index tool to assess children's public open space use and access by independent mobility

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Using the Public Open Space Attributable Index tool to assess children's public open space use and access by independent mobility

M. Chaudhury[a*], M. Oliver[a], H. Badland[b], N. Garrett[c] and K. Witten[d]

[a]Human Potential Centre, Auckland University of Technology, Auckland, New Zealand; [b]McCaughey VicHealth Community Wellbeing Unit, The University of Melbourne, Melbourne, Australia; [c]Biostatistics Unit, Auckland University of Technology, Auckland, New Zealand; [d]Social and Health Outcomes Research and Evaluation, SHORE and Whariki Research Centre, School of Public Health, Massey University, Auckland, New Zealand

This study examined associations between public open space (POS) attributes and children's use, and independent mobility to, POS in Auckland, New Zealand. Overall 240 children aged 9–12 years and their parents/caregivers participated. Data were sourced from child travel diaries and parent telephone interviews. The Public Open Spaces Attributable Index (POSAI) assessed POS quality and quantity. Associations were examined between age, sex, ethnicity, parental licence of freedom score, and POSAI with: (1) child trips to POS and (2) independently mobile trips to POS. Children made a total of 68 trips to POS over a seven-day period; 35 of these were independently mobile. Child ethnicity was related to child trips to POS. Independent trips to POS differed by ethnicity and parental licence of freedom. This research utilised a new tool, the POSAI, to examine associations of POS use and independent mobility in children living in urban neighbourhoods.

Keywords: active travel; audit tool; built environment; neighbourhoods; New Zealand

Introduction

Children's independent mobility (CIM) is an integral part of a child's 'growing up' experience in their local neighbourhood environment. CIM is described as the freedom to move to destinations outside the home environment by active travel (i.e. walking, cycling) and engage in outdoor play without adult supervision (Hillman, Adams, and Whitelegg 1990). Benefits of CIM include fostering children's physical, social, emotional, cognitive, and spatial development (Kyttä 2004). Engaging in CIM can also help children develop skills for safely navigating risky situations, such as crossing busy roads or encountering strangers, and can contribute to greater community social capital (Rudner 2012).

Over the last 40 years CIM has declined across a wide range of industrialised nations (Fyhri et al. 2011; Shaw et al. 2013; Schoeppe et al. 2015). Long-term trend data from England showed that in 1971, 86% of parents allowed their primary-school aged children to travel home from school alone; by 1990 this had declined to 35%, and in 2010 this percentage had further reduced to 25% (Shaw et al. 2013). Increased parental concerns of children's safety when in outdoor environments (e.g. stranger danger and road safety) have likely contributed to this

*Corresponding author. Email: moushumi.chaudhury@aut.ac.nz

decreasing prevalence (Carver, Timperio, and Crawford 2008; Fyhri et al. 2011). In addition, the intensification of cities has contributed to a loss of suitable public open space (POS) in neighbourhoods for unsupervised travel and play (Ergler, Kearns, and Witten 2013). POS refers to a range of spaces including green spaces (e.g. public park, reserves, and planted areas), natural vegetation (e.g. woodlands, grass verges), blue spaces (e.g. waterways, rivers, wetland and coast), and grey spaces (e.g. civic squares, streets, transport corridors) (Regional Public Health 2010). Here, we focussed on POS that were freely accessible to the public. Some of the POS examined did also have privately owned facilities that incurred a fee for use attached. However, in these instances, they were always associated with green space that provided free of charge opportunities for children to engage in other activities, for example, sports field, playground, and walking trail. POS in this examination was delimited and defined as freely accessible parks, reserves, and green spaces (including those containing wetlands) located in urban neighbourhoods. Herein these spaces will be referred to as POS.

Amongst youth and children, POS provide opportunities to engage in physical activity and destinations to actively travel to (Floyd et al. 2011; Veitch et al. 2014). These settings also provide areas to relax, foster social connectedness, improve mental health and well-being, and promote friendship development (Maas et al. 2006; Sugiyama et al. 2008; Lachowycz and Jones 2013). Evidence suggests that children who have contact in areas of natural vegetation (e.g. bushland, woodlands, and forest) experience a number of benefits, such as enormous play, adventure, and exploration benefits (Freeman et al. 2015). Exposure to natural vegetation provides additional opportunities for children to interact with nature and enhance their physical prowess through activities including swimming, climbing trees, running, and chasing (Freeman et al. 2015). At present, evidence suggests children's independent travel to areas of natural vegetation is limited. One recent Norwegian study (Skar et al. 2016) reported that children aged between 6 and 12 years spent more time in nature with adult supervision than without, suggestive that parental directives are key drivers of whether children are able to visit these areas independently.

A recent study of Australian youth aged 8–15 years examined the associations between physical features in the neighbourhood environment and CIM to a number of local neighbourhood destinations, including POS (Christian, Klinker, et al. 2015), demonstrating independent travel decreased with increased distance to POS. Similarly another study found less than a third of adolescents used the closest park; reasons for choosing other parks (beyond proximity) included other features within the parks, such as the presence of a skate park, walking paths, barbeques, picnic table, public access toilets, lighting around courts and equipment and number of tress (Edwards et al. 2015). Previous studies have also shown that living closer to POS, irrespective of size, is positively associated with CIM (Mackett et al. 2007; Alparone and Pacilli 2012; Christian, Zubrick et al. 2015). Villanueva et al. (2013) found amongst Australian children aged 10–12 years, girls' CIM was higher if they perceived their closest POS from their residence as being safe. For boys, the likelihood of CIM increased if they perceived that their closest POS had fun and interesting 'things to do'.

However, simply locating POS in neighbourhoods does not guarantee their use. Design, quality, population-appropriateness, and maintenance of the POS have been shown to encourage or discourage POS use (Villanueva, Pereira, et al. 2013). For example, adult and child focus group findings from the Child's Play study in Australia (Wood, Martin, and Carter 2010) showed POS that were inadequately or poorly maintained were used less than their well-maintained counterparts. Similar findings have been found elsewhere (Bedimo-Rung, Mowen, and Cohen 2005).

There is a growing body of literature examining different aspects of POS (e.g. proximity to home, size, quality) in relation to their use; however, to date this research has primarily focussed on adult physical activity outcomes (Ord, Mitchell, and Pearce 2013; Koohsari et al. 2015).

Giles-Corti et al. (2005) showed that, after accounting for size, POS rated 'higher' versus 'lower' quality were more likely to attract users to engage in physical activity across all age groups. Conversely, Kaczynski, Potwarka, and Saelens (2008), reported size of, and distance to, POS were not significant predictors for use among adults, although specific features inside the POS (e.g. paved trails) were positively related with use.

Previous studies examining environmental quality attributes of POS and physical activity-related outcomes have applied separate measures of quality and quantity, and primarily focused on adults. The unique contribution of this paper is to apply a POS measure that combines both quality and quantity to investigate children's use of POS. Applying such a combined measure can help elucidate if the physical attributes and size of a POS are important factors in determining children's use of and travel behaviours to POS. Therefore, the aim of this study is to determine if POS quantity and quality, as assessed using the newly developed Public Open Space Attributable Index (POSAI), is associated with POS use and CIM for children living in urban neighbourhoods in Auckland, New Zealand. We hypothesise that POS which score higher on the POSAI (i.e. larger size and better environmental quality of the POS) will be associated with higher levels of POS use by children and accessed by CIM.

Methods

Kids in the city study design

Data were drawn from the Kids in the City Study (KITC). This was a cross-sectional study designed to examine the association between urban design attributes and CIM in Auckland, New Zealand's largest city. In brief, children attended one of nine participating schools eight primary (elementary) schools (years 0–6) and one intermediate school (years 7–8), from socioeconomically diverse neighbourhoods across Auckland. Parents/caregivers of participating children completed a researcher-assisted Computer Administered Telephone Interview (CATI) to report on child, parent and household demographics, and parental licence. Area-level population census data were collected between 2011 and 2012 (Statistics New Zealand 2007).

POSAI environmental audits were undertaken between May and June 2012, and between October and November 2013. Detailed study design for the KITC study (Oliver et al. 2011) and the POSAI development (Chaudhury et al., in preparation) can be found elsewhere. For this examination, data were extracted for all children attending the eight primary schools ($n = 240$, aged 9–12 years). Data for children attending the intermediate school were excluded, as it was likely that different CIM behaviours and parental licences existed between the school types and age groups. Ethical approval was granted by the respective research institutes (AUTEC 07/126; MUHEC 10/091; and UAHPEC).

Measurement

Children's demographic information

Data collected from the parent CATI included information on the child's sex, date of birth, and ethnicity.

CIM and trips to POS

CIM was measured using travel diaries for seven consecutive days. For each day of the measurement period, children were provided a paper travel diary to self-complete in the evening and following morning. Time, origin, destination, mode of travel (e.g. walking, cycling, motorised

vehicle, and scootering), and accompaniment status were collected for each journey undertaken during the measurement period. To maximise travel diary compliance and accuracy, diaries were checked and confirmed each weekday of data collection with the child by a member of the research team. This included going through in detail the previous day's diary activities sequentially; including the trip destination, travel mode of each trip, time and accompaniment status of the child (Oliver et al. 2011; Badland et al. 2015).

All destinations children reported travelling to in the travel diaries were classified into primary domains (e.g. education) and sub-domains (e.g. primary schools) based on the Neighbourhood Destination Accessibility Index – Child (NDAI-C, Badland et al. 2015). The 'parks' (sub-domain) variable of interest was classified under the 'recreation' primary domain in the NDAI-C and identified for use here. Only in some instances specific POS visited by the child was reported by the child. In most instances the child only reported the destination, such as 'park', 'playground', or 'sports field'. Data were extracted from the travel dairies for the total number of trips made to POS and the total number of trips made to POS that were independent (i.e. without adult supervision) by children.

Parental licence of freedom

The parental licence of freedom score was derived from five questions asked of parents/caregivers (via the CATI) about 'licences' afforded to their child to go to particular destinations or play on their own, without adult supervision. Parents rated their responses for each of the statements using a 5-point Likert scale ranging from 'strongly agree' to 'strongly disagree'. Parental licence affordances asked about travelling to the following destinations: school, friends' houses, shops, organised activities, as well as play without adult supervision. This measure is based on the original work by Hillman, Adams, and Whitelegg (1990). A principal component analysis (PCA) was used to generate the parental licence of freedom score. PCA scores were rescaled to range between 1.0 (lowest freedom) and 10.0 (highest freedom). The parental licence of freedom score was split into quartiles to allow the examination of non-linear associations with the binary outcomes.

School neighbourhood POS selection

Neighbourhood identification

To capture built environment variability, schools within the greater Auckland region were identified using a matrix of high/low school decile rating and high/low neighbourhood walkability (Frank et al. 2010) and destination accessibility (Witten, Pearce, and Day 2011). School decile is an indicator of socio-economic status of residents within a school's catchment area; decile ranged from 1 (the 10% of schools with the highest proportion of students from low socio-economic areas) to 10 (the 10% of schools with the lowest proportion of students from low socio-economic areas) (Ministry of Education 2013). In this study sample, the school deciles ranged from 1 to 7.

Delineating the school neighbourhood catchment

'School neighbourhood catchments' were generated around the eight state primary schools. Where available (six schools), established school zones (Ministry of Education 2011) were used to define the school 'neighbourhood' catchment. This was favoured rather than utilising the arbitrary Euclidean or road network boundary around schools (e.g. 800 m scale). In New Zealand, children who live in the defined catchment of a state school are guaranteed a place at

that school. Geographic boundaries of the school zones were obtained from the Ministry of Education website (http://nzschools.tki.org.nz/). In the instances where no school catchment existed (two schools), a Euclidean buffer of 1200 m generated from the school's x, y coordinates was applied. This was the median buffer value for schools with defined catchments. Neighbourhood size (m^2) was calculated using Geographic Information Software (GIS) (ArcInfo 9.1 (ESRI, Redlands, CA).

POS identification and auditing

POS that intersected or fell within the school neighbourhood catchments were identified for auditing. Spaces excluded from auditing were grass verges and green spaces on roundabouts (traffic circles). In total, 146 GIS-derived POS were identified across the eight school neighbourhood catchments, of which 88 (60%) comprised of parks, and reserves that could be readily accessed. The remaining 40% were those POS that were deemed unsuitable or spaces not conducive for children's use, such as roadside grass verges, roundabouts, POS in busy intersections near main roads, and some overgrown fields. A few POS were large established reserves/parks, but at the time of auditing major refurbishments by the local council meant they were cordoned off from use, and therefore were unable to be audited.

Where POS intersected a school neighbourhood catchment, the additional POS area (i.e. the POS area outside the school neighbourhood catchment) was calculated and added to the total school neighbourhood size. The reason for this is that a potential user would likely use the entirety of a POS rather than stopping at a synthetic buffer boundary, particularly in small- to medium-sized POS.

POS were physically assessed by trained auditors using the New Zealand Public Open Space audit tool (NZ-POST) (Badland et al. 2010). This was adapted from the validated 49-item Public Open Space Audit Tool (POST) (Giles-Corti et al. 2005). The NZ-POST included 41 items across four subscales; activities (2 items), 'environment (17 items), 'amenities' (17 items), and safety (5 items) (detailed below), and excluded the following 4 POST items: size of water feature, evidence of grass watering, accessibility for dogs, and types of roads.

Scoring responses differed by the item being assessed as follows: (1) Items with a dichotomous outcome, for example, presence or absence of playground, were assigned 0 = not present, or 1 = present; (2) Items with a graded outcome, for example, approximate number of trees, were assigned a score ranging from 0 to 1; < 50 trees = 0.33, 50–100 trees = 0.66; > 100 trees = 1. Higher scores in all instances indicated better quality. Details can be found elsewhere (Chaudhury et al., in preparation; Badland et al. 2010).

Measures

POS attributable index

The POSAI is an environmental audit tool that assesses both POS quality and quantity. In brief, the 'quality' of POS was determined by the NZ-POST (Badland et al. 2010). The NZ-POST features a series of four subscale scores (activities, environmental quality, amenities, safety) and a composite score derived from the sum of the items. As mentioned previously, the total area for selected POS was calculated using GIS. A standardised measure of POS space was applied in the analyses. Detailed information on the development of the POSAI measure is described elsewhere (Chaudhury et al., in preparation).

To combine the quality and quantity components, PCA was used to calculate the index variable for each school neighbourhood catchment. PCA techniques are increasingly being applied

when trying to address relationships between multiple built environment features (Yan et al. 2010; Broberg, Salminen, and Kyttä 2013). PCA creates fewer dimensions, which can simplify further analysis in a meaningful way (Broberg, Salminen, and Kyttä 2013). Accordingly, individual variable weightings derived from PCA were used to calculate the index score for each school neighbourhood catchment. Neighbourhood level POSAI scores were dichotomised as high or low using the median score for all POS within the given neighbourhood. Descriptive information for the POSAI score was examined by school decile.

Data analyses

Bivariate logistic regression analyses adjusted for cluster effects were undertaken to determine associations between the school, potential child and parent predictor factors (age, sex, ethnicity, parental licence of freedom score, POSAI score) with: (1) any trips to a POS; and (2) any independently mobile trips to a POS. Factors significantly associated with any trips to POS at p-value ≤ 0.20 in the bivariate analyses were then simultaneously considered in a multivariate model (Sun, Shook, and Kay 1996). Non-significant factors (p-value > 0.05) were removed from the multivariate model in a stepwise manner to attain the final models. Analyses were undertaken using SPSS v22.0 (SPSS Inc., Chicago, IL) and SAS v9.4.

Results

Inter-rater reliability testing of the NZ-POST reported three of the four subscales (activities ICC $=$ 0.91; environment ICC $=$ 0.95; amenities ICC $=$ 0.98), and overall POS score (NZ-POST ICC $=$ 0.95) as having acceptable reliability (Landis and Koch 1977). The safety category (ICC $=$ 0.22) was shown to have fair reliability (Landis and Koch 1977) and therefore was omitted as a separate subscale analysis, but was deemed suitable for inclusion in the overall POSAI.

On average, there were fewer POS in lower decile areas compared with higher decile areas. Compared with the lowest decile school areas, the one school area rated as high decile had double the number of POS (18 compared with 9). On average, POSAI scores were lower in the most disadvantaged areas than more advantaged neighbourhoods. However, POSAI scores varied substantially both within school neighbourhood catchments and within deciles. For example, the average POSAI score for the lowest decile schools (decile 1) was 14.52, with a range of 4.98–30.87. This compares with a range of POSAI scores from 5.89 to 39.69 for higher decile areas (deciles 4–7; data on request).

A total of 254 children aged 9–12 years participated in the KITC study of the total sample. Of these, complete travel diary and parent CATI data were available for 240 children (94%). All the children living in and out of the school neighbourhood catchments were included in the analyses ($n = 172$ -in zone; $n = 67$ out of zone). In total 3234 trips from home to a destination were identified from the travel diaries, of which 68 (2.10%) trips were made to POS (hereafter 'any trips') and 35 (1.08%) were made independently mobile to POS. Table 1 presents descriptive data for participants included in the analyses, by 'any trips' and 'independently mobile' trips to a POS over the last seven days.

Results from the bivariate analyses for any trips made to a POS are presented in Table 2. Ethnicity of the child and the POSAI score were related to any trips to POS at $p < .20$ and therefore were considered simultaneously in a multivariate model. When considering these variables together, only ethnicity ($p \leq .0001$) remained significantly associated with children making any trips to POS. Māori (OR 1.54; 95% CL 0.47, 5.06) and Samoan (OR 1.34; 95% 0.67, 2.70) children had around 1.5 and 1.3 greater odds, respectively, of making any trips to POS compared with children of European ethnicity.

Table 1.   Summary of descriptive data of children by POS use and any independently mobile trips to park.

Variable	N	Any trips to a POS during last seven days		Any IM trips to a POS during the last seven days	
		Yes n (%)	No n (%)	Yes n (%)	No n (%)
Sex					
Female	136	32(23.5)	104(76.5)	17(12.5)	119(87.5)
Male	104	36(34.6)	68(65.4)	18(17.3)	86(82.7)
Age					
9	54	14(25.9)	40(74.1)	4(7.4)	50(92.6)
10	163	47(28.8)	116(71.2)	29(17.8)	134(82.2)
11–12	23	7(30.4)	16(69.6)	2(8.7)	21(91.3)
Ethnicity					
European	53	16(30.2)	37(69.8)	7(13.2)	46(86.8)
Indian/Asian/other	62	13(21.0)	49(79.0)	2(3.2)	60(96.8)
Māori	30	12(40.0)	18(60.0)	6(20.0)	24(80.0)
Samoan	38	14(36.8)	24(63.2)	11(28.9)	27(71.1)
Other Pacific islander	45	10(22.2)	35(77.8)	7(15.6)	38((91.0)
Parental licence of freedom (quartile)					
1 (Lowest)	66	13(19.7)	53(80.3)	4(6.1)	62(93.9)
2	50	17(34.0)	33(66.0)	11(22.0)	39(78.0)
3	54	15(27.8)	39(72.2)	9(16.7)	45(83.3)
4 (Highest)	56	18(32.1)	38(67.9)	9(16.1)	47(83.9)
POSAI score					
Low	131	44(33.6)	87(66.4)	23(17.6)	108(82.4)
High	109	24(22.1)	85(78.0)	12(11.0)	97(89.0)

Table 2.   Bivariate logistic regression[a] analysis of variables with any trips to a POS.

Variable	N	OR	95% CI	*p*-value
Sex				.10
Female	136	Reference		
Male	104	1.72	(0.91, 3.27)	
Age				.91
9	54	Reference		
10	163	1.16	(0.34, 3.98)	
11–12	23	1.25	(0.46, 3.43)	
Ethnicity				<.0001
European	53	Reference		
Indian/Asian/Others	62	0.61	(0.28, 1.33)	
Māori	30	1.54	(0.47, 5.06)	
Samoan	38	1.39	(0.67, 2.70)	
Other Pacific island	45	0.66	(0.22, 1.95)	
Parental licence of freedom score (quartiles)				.74
1 (Lowest)	66	Reference		
2	50	2.10	(0.48, 9.17)	
3	54	1.57	(0.50, 4.88)	
4 (Highest)	56	1.93	(0.58, 6.46)	
POSAI score				.06
Low	131	Reference		
High	109	1.68	(0.98, 2.90)	

[a]Bivariate logistic regression adjusted for school effects.

Table 3.   Bivariate logistic regression[a] analysis of variables with any independently mobile trips to a POS.

Variable	N	OR	95% CI	*p*-value
Sex				.14
Female	136	Reference		
Male	104	1.47	(0.88, 2.44)	
Age				.03
9	54	Reference		
10	163	2.71	(1.12, 6.52)	
11–12	23	1.19	(0.21, 6.85)	
Ethnicity				.003
European	53	Reference		
Indian/Asian/others	62	0.20	(0.05, 0.83)	
Māori	30	1.48	(0.25, 8.71)	
Samoan	38	2.60	(1.17, 5.78)	
Other Pacific islanders	45	1.15	(0.41, 3.21)	
Parental licence of freedom score (quartiles)				<.0001
1 (Lowest)	66	Reference		
2	50	4.97	(2.03,12.17)	
3	54	2.67	(1.48, 4.80)	
4 (Highest)	56	2.83	(1.14, 7.01)	
POSAI score				.27
Low	131	Reference		
High	109	0.58	(0.22, 1.51)	

[a]Bivariate logistic regression adjusted for school effects.

For CIM trips to a POS, bivariate analyses revealed significant associations with age, ethnicity, and parental licence of freedom $p < .20$ (Table 3). After stepwise elimination of non-significant variables ($p > .05$), ethnicity ($p = .003$) and parental licence of freedom score ($p \leq .0001$) remained significantly associated with likelihood of children making any independently mobile trips to a POS. Children with higher parental licence had greater odds of travelling independently to a POS, though this trend was not linear. Children in the second quartile (OR 4.97; 95% CI 2.03, 12.17) had the greatest odds of travelling independently to a POS. Compared with children of European ethnicity, children of Samoan ethnicity were more likely to make trips to POS independently (OR 2.60; 95% CI 1.17, 5.78).

Discussion

Over the last decade research exploring associations between built environment features and health outcomes and behaviours has grown (Giles-Corti et al. 2005; Koohsari, Badland, and Giles-Corti 2013; Christian, Zubrick et al. 2015; Hunter et al. 2015). This study applies for the first time, the POS Attributable Index (POSAI), an innovative tool that combines measures of POS quality (environmental attributes) and quantity (size of POS) with child behaviours. This tool can be useful for modelling relationships between POS and health outcomes. The primary aim of this study was to determine if a combined measure of POS quality and size, able to be assessed using the POSAI, was associated with POS use and travelling independently to POS in a sample of children living in urban neighbourhoods. To date no one has used a combination of these two POS measures in one index and, further, this has not been tested with behaviours in a child population.

When examining relationships between the POSAI with total trips to POS and CIM trips to POS, a significant association was found with ethnicity. Children of Samoan descent were more

likely to travel independently when compared with those from European descent. A possible explanation as to why children of Samoan or Māori descent were more likely to travel independently could be because these ethnic groups tend to have a higher proportion of single parent families (Social Policy Evaluation and Research Unit 2015). Additionally, in the Auckland, New Zealand context, neighbourhoods with higher Pasifika ethnicities may have more extended family living in close proximity (Poland et al. 2007; Schluter, Carter, and Kokaua 2007), therefore active travel maybe be independent of adults, but instead undertaken with other siblings and child/adolescent relatives (Carroll et al. 2013). At present only a small number of studies have looked at child's ethnicity and active travel to destinations (Yelavich et al. 2008; Mendoza et al. 2010). More studies are needed to further understand this phenomenon.

One such systematic review by Pont et al. (2009) examined environmental correlates of active transport in children aged 5–18 years. They found a positive relationship between children of minority ethnic backgrounds (Hispanic, Asian, Māori, Pacific Islander, or other) and children's active travel. Two studies by de Bruijn et al. (2005) (the Netherlands) and Yelavich et al. (2008) (New Zealand) found that children from recent immigrant background were between two and half to three times more likely to use active transport than those who did not have an immigrant background. However, we were unable to verify these results with our data as generational immigration was not assessed.

Earlier findings from a sub sample of the KITC examined children's active travel (Tav'ae et al. 2012) showed the odds of a child of 'Other Pacific Island' ethnicity (i.e. Tongan, Niuean, Cook Island Māori), excluding Samoan, walking both ways to school were 6.1 times greater than those of a child of 'European/Asian/Other' ethnicity ($p = .001$). Both Tav'ae et al. (2012) and the present study are based on small sample sizes, however these travel behaviour patterns by ethnicity are similar to national survey data. Nationally representative data for New Zealand show that Pacific children have relatively high levels of active transport (such as walking to school), although they participate less than other groups in organised leisure and sport (Ministry of Health 2003). More broadly, other work examining children's spatial mobility in urban settings in the UK, found that minority ethnic children were more restricted in their use of urban space compared with white children, though the magnitude of the differences were not reported (O'Brien et al. 2000). Further in-depth exploration may be warranted to look at ethnic differences in CIM and associated variables across different geographic contexts.

It is worth noting that although the POSAI score was not statistically significantly associated with any trips to POS, the *p*-value was only just above the 5% significance level for the bivariate analyses ($p = .0506$ not reported) and had a *p*-value of .08 if considered for additional inclusion in the multiple variable model. This indicates the POSAI has potential relevance to the modelling of open space usage for children and may be significant for a larger study. Study results show that when POSAI was high (indicating higher quality and larger sized POS), the odds of any trip made to a POS was almost half that of when the POSAI was low. This was a curious finding, especially in light of existing literature. Previous studies have shown that better quality (e.g. aesthetics) POS, as assessed by direct observational audits, are associated with higher POS use and increased activity amongst children (Veitch et al. 2006; Timperio et al. 2008). Veitch et al. (2012) collected observational data including pre- and post-POS improvements. They found that improvement of 'internal' features resulted in an overall increase in POS use (i.e. walking and physical activity) across all age groups. A Canadian study (Kaczynski, Potwarka, and Saelens 2008) found associations with physical activity and park features, but not with size or distance. The findings of this study did not suggest that better quality or larger POS influenced any trips or independently mobile trips to POS. In our sample the mean number of trips made to POS was 2 (range 1–6 trips) and mean CIM trips made to POS was 1 (range 0–5 trips) in the seven-day period. However, in the final multivariate variable analyses, the POSAI reported no association for

any trips to POS ($p = .06$), although this was borderline. We suggest our findings could be an artefact of the small number of children in the study. It is possible that environmental features such as size, distance of local parks to home may have a bigger influence on CIM than POS quality. As such the importance of park proximity, size and environmental quality attributes of neighbourhood POS for CIM at present remains relatively unknown (Christian, Klinker, et al. 2015).

Children with a higher parental licence had greater odds of travelling independently to a POS. However, the trend was not linear, with the second quartile having the highest odds of children making independent trips to a POS.

This paper hypothesised that a higher POSAI score would be positively related to increased levels of CIM to the POS. Our findings did not support the hypothesis. POS with a lower POSAI score suggest children were more likely to make CIM trips to that POS. This finding could be due to the low number of trips made to POS within the sample; therefore caution needs to be exercised when interpreting the findings from these data. International studies with adults have shown that those living in a more socioeconomically disadvantaged neighbourhood are more likely to report walking for transport than those living in more advantaged neighbourhoods (Cerin, Leslie, and Owen 2009; Turrell et al. 2013). Likewise New Zealand data on children of low socio-economic status are likely to walk to school than those of a higher socio-economic status (Ministry of Health 2003). As such it is possible that confounding in terms of area-level disadvantage existed in the current study. We examined the prevalence and proportion of POS rated as high or low by school decile (socio-economic status). While substantial variation in POSAI scores was observed within neighbourhoods and deciles, findings did show some evidence of a greater number of POS and higher quality POS in higher versus lower decile areas. These findings may be an artefact of the study design, as the higher decile schools were all located close to the central city. A different outcome may have resulted if suburban higher decile schools had been included in the study. We found that child ethnicity was associated with any trips and CIM trip made to POS, specifically children of Samoan ethnicity were more likely to make independently mobile trips to POS.

Sugiyama et al. (2010) investigated Australian adults' recreational walking. They found that presence of a large, high-quality park within walking distance of one's home was more important in promoting recreational walking for health benefits than the presence of an open space within a shorter distance. Previous studies have reported mixed findings. For example, Veitch et al. (2006) found that children visited parks with the most appealing aesthetics and attributes rather than the closest green space. It is possible that lower quality POS were located closer to the child's home, therefore they were more likely to visit them independently.

Strengths and limitations

This study has several limitations. Although 3234 trips in total were made by children, only a small proportion of the trips were made to POS, and even fewer were made independently. This study is delimited to POS visited within the school neighbourhood catchments the children attended. It is highly possible that children visited POS out of this predefined boundary, as over a third of children in the KITC study lived outside the school neighbourhood catchments. With this in mind, the use of individual neighbourhood boundaries for each child would likely be a more sensitive approach for capturing POS visits in this sample. The findings from this study are limited by the cross-sectional design, therefore causality cannot be assumed. Despite these limitations, this study had several strengths. First, it included a large number of POS objectively audited from socio-economically and ethnically diverse urban neighbourhoods (Brannon et al. 2013; Schoeppe et al. 2014). Second, one component of the tool (derived from the NZ-POST) has previously demonstrated acceptable reliability for use in the New Zealand setting. In addition, we applied statistical rigour to develop the POSAI. For example, a range of geographic areas may

be employed across a single study, yet the POSAI can account and standardise for differences in study area size. Further strengths include the high level of travel diary completion (Oliver et al. 2011).

Conclusion

This research sought to utilise a new innovative tool, the POSAI, a combined measure of quality and quantity to examine associations between POS and CIM in urban neighbourhoods in children. The POSAI tool did not show significant associations with any trips or for independent trips in children to POS. Children of Samoan ethnicity were more likely that children of other ethnic groups to make independently mobile trips to their neighbourhood POS. Children with a higher parental licence have greater odds of travelling independently to a POS though this trend was not linear. The key findings from this examination indicate there are possible ethnic differences in children's independent mobility and active travel to POS. Future studies in this discipline call for more contextual-based qualitative research to include a focus on ethnicity to examine differences in children's own experience in an urban setting.

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Appendix C. AUT approval for Kids in the City study: Chapters 3-5

AUT
UNIVERSITY

MEMORANDUM
Auckland University of Technology Ethics Committee (AUTEC)

To:	**Melody Oliver**
From:	**Madeline Banda** Executive Secretary, AUTEC
Date:	18 October 2010
Subject:	Ethics Application Number 10/208 **Children's mobility and physical activity in higher density urban neighbourhoods: objective measurement of activity, independent mobility, and built environments.**

Dear Melody

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 13 September 2010 and that on 15 October 2010, I approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 8 November 2010.

Your ethics application is approved for a period of three years until 15 October 2013.

I advise that as part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 15 October 2013;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/research/research-ethics/ethics. This report is to be submitted either when the approval expires on 15 October 2013 or on completion of the project, whichever comes sooner;

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are reminded that, as applicant, you are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

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.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 8860.

On behalf of the AUTEC 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

From the desk of ...
Madeline Banda
Executive Secretary
AUTEC

Private Bag 92006, Auckland 1142
New Zealand
E-mail: ethics@aut.ac.nz

Tel: 64 9 921 9999
ext 8044
Fax: 64 9 921 9925
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Appendix D. MUHEC approval for the Kids in the City study: Chapters 3-5

MASSEY UNIVERSITY
ALBANY

16 August 2010

Associate-Professor Karen Witten
SHORE/ Whariki Research Centre
Centre for Social & Health Outcomes Research & Evaluation
P O Box 6137
Wellesley Street
AUCKLAND

Dear Karen

HUMAN ETHICS APPROVAL APPLICATION – MUHECN 10/053
"Children's mobility and physical activity in higher density urban neighbourhoods"

Thank you for your application. It has been fully considered, and approved by the Massey University Human Ethics Committee: Northern.

Approval is for three years. If this project has not been completed within three years from the date of this letter, a reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Ralph Bathurst
Chair
Human Ethics Committee: Northern

Appendix E. UAHPEC approval for the Kids in the City study: Chapters 3-5

Office of the Vice-Chancellor
Ethics & Biological Safety Administration

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

Level 3, 76 Symonds Street
Auckland, New Zealand

Telephone 83711 / 87830
Facsimile 64 9 373 7432

The University of Auckland
Private Bag 92019
Auckland Mail Centre
Auckland 1142
New Zealand

UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE

15 October 2010

Professor Robin Kearns
School of Environment

Re: Ethics Application from Massey University

At the meeting on 13 October 2010, the Committee considered your request for ratification of the ethics approval from Massey University project titled "Children's mobility and physical activity in higher density urban neighbourhoods".

The Committee resolved to ratify the ethics approval from Massey University. You can continue the research subject to approved protocols.

Lana Lon
Executive Secretary
University of Auckland Human Participants Ethics Committee

Appendix F. Example of seven day travel diary

Appendix G. Semi structured go-along walking interview questions

Go along interview questions
[General Q]
1. What are some of the places you like and don't like in this area/neighbourhood?

   Probes: What places around here do you go with your friends?
   Where do your friends live around here?
   What places around here do you go with your family?

So where are we going to go today?
Why have you picked this walk?

[At a specific place]
2. Okay so this is [...] – can you tell me a bit about [this place]?

   Probes: What things do you like about it? Dislike about it?
   Do you come here a lot? When do you come here? (after school, weekends etc)
   Who do you come here with? – alone, others?

3. Are there places around here that you don't like going to or going past? (only ask if it comes up)

   Probe: Tell me about that place? Why is that? How do you feel when you go there?
   Alone/with others?
   If they don't go there why not?

4. Are there places you like to go/things you like to do that your parents won't let you go/do on your own?

   Probe: What about with friends or siblings? Why do you think they don't want you to there?
   How do you feel about that?

CHECK Qs at the end
- What is your favourite place to go in the neighbourhood?
- Are there other places you like to go too that we didn't go to today?
- Are there other places that you would like to go too but can't? Why not/How come?
- What place do you dislike the most around here?
- What is the best thing about living in your neighbourhood?
- If you could change one thing about your neighbourhood, what would it be?
- What do you think would make your neighbourhood a better place for you/children?

Useful probes to keep the conversation going: Can you tell me more about that?

General neighbourhood conversation
What do you usually do after school?
How do you get home from school? Do you go with friends? Fun/not fun?

Kids in the City

Q1

Please select the interview language

- English
- Chinese
- Samoan

Q2

Kia ora, my name is NAME thank you for agreeing to be interviewed for our study. Can I check that your child is {#ChildName} and that {#She} goes to {#School}?

- Yes, all correct
- No, this isn't right (wrong name, school or gender)

IF 'NO, THIS ISN'T RIGHT':

Q3

Child's name: {#ChildName}
Child's school: {#School}
Child's gender: {#Sex}

What is incorrect?

- The child's name
- The child's school
- The child's gender

Q4

What is your child's actual name?

Q5

What school does {#ChildName} actually go to?

Q6

Is {#ChildName} male or female?

- Male
- Female

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- Don't know DON'T READ
- Refused DON'T READ

LOOP: AGESEXLOOP

RESTRICT TO NUMBER GIVEN IN Q11

1. first child
2. second child
3. third child
4. fourth child
5. fifth child
6. sixth child
7. seventh child
8. eighth child
9. ninth child
10. tenth child

Q12

What age is the {@AgeSexLoop} (not including {#ChildName})?

- Less than 1 year
- 1 year
- 2 years
- 3 years
- 4 years
- 5 years
- 6 years
- 7 years
- 8 years
- 9 years
- 10 years
- 11 years
- 12 years
- 13 years
- 14 years
- 15 years
- 16 years
- 17 years

Don't know DON'T READ
- Refused DON'T READ

Q13

What gender is your {@AgeSexLoop}?

- Male
- Female
- Don't know DON'T READ
- Refused DON'T READ

END LOOP(AGESEXLOOP)

Q14

Does {#ChildName} live with you full time?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q14 IS 'NO':

Q15

How many days per week does {#ChildName} live with you?

(0 - 7)

Q16

Where else does {#ChildName} usually stay?

- Same suburb
- Different suburb
- Don't know DON'T READ
- Refused DON'T READ

Q17

How many adults, including yourself, live in your household?

(1 - 100)

Q18

How many cars are available to your household?

- One
- Two
- More than two
- None
- Don't know DON'T READ
- Refused DON'T READ

Q19

How often is a car available for picking up and dropping off children?

- Always
- Sometimes
- Never
- Don't know DON'T READ
- Refused DON'T READ

Q20

How long has {#ChildName} been going to {#School}?

YEARS

(0 - 20)

Q21

How does {#ChildName} usually get to school?

- Walk
- Car
- Cycle
- Bus
- Taxi
- Train
- Other (please say):
- Don't know DON'T READ
- Refused DON'T READ

Q22

How does {#ChildName} usually get home from school?

- Walk
- Car
- Cycle
- Bus
- Taxi
- Train

Other (please say):
- Don't know DON'T READ
- Refused DON'T READ

Q23

Are there any alternatives that {#ChildName} sometimes uses to get to or from school?

- Walk
- Car
- Cycle
- Bus
- Taxi
- Train
- Other (please say) :
- No other way
- Don't know DON'T READ
- Refused DON'T READ

LOOP: REASONSFORTRANSTYPE

1. The distance from home to school
2. Easy for you
3. His/her health and fitness
4. Concerns about road traffic danger
5. The amount he/she has to carry
6. Encouraging his/her independence
7. Encouraging him/her to be around friends
8. Someone available to accompany him/her
9. Spending time with him/her
10. To quickly get to after school activities

I am going to read out a list of factors that some parents consider important when deciding how their child gets to school. Can you please tell me if the item I read out is very important/important/a little bit important/or not important at all for you when deciding how {#ChildName} gets to school.

Q24

{@ReasonsForTransType}

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

END LOOP(REASONSFORTRANSTYPE)

IF THE SAME ANSWER WAS GIVEN FOR Q21 AND Q22, ASK:

CAN CHOOSE 1 - 3 ANSWERS

You've said {#ChildName} usually gets to and from school by {#QTS}. What are the main reasons {#She} goes by {#QTS}?

- Distance from home to school
- Safety -- traffic
- Safety -- strangers
- Easy -- convenient
- Child's health/fitness
- Encourage child's independence
- Someone to go with them
- Bullying
- Time with parent
- Time with friends
- Amount they have to carry to school
- Other (specify):
- Don't know DON'T READ
- Refused DON'T READ

IF DIFFERENT ANSWERS WERE GIVEN FOR Q21 AND Q22, ASK:

CAN CHOOSE 1-3 ANSWERS

Q25

You've said {#ChildName} usually gets to school by {#QTS}. What are the main reasons {#She} goes by {#QTS}?

- Distance from home to school
- Safety -- traffic
- Safety -- strangers
- Easy -- convenient
- Child's health/fitness
- Encourage child's independence
- Someone to go with them
- Bullying
- Time with parent
- Time with friends
- Amount they have to carry to school
- Other (specify) :Don't know DON'T READ
- Refused DON'T READ

Q26

236

You've said {#ChildName} usually gets home from school by {#QFS}. What are the main reasons {#She} goes by {#QFS}?

- Distance from home to school
- Safety -- traffic
- Safety -- strangers
- Easy -- convenient
- Child's health/fitness
- Encourage child's independence
- Someone to go with them
- Bullying
- Time with parent
- Time with friends
- Amount they have to carry to school
- Other (specify):
- Don't know DON'T READ
- Refused DON'T READ

IF THE SAME ANSWER WAS GIVEN FOR Q21 AND Q22, ASK Q27-Q30:

IF DIFFERENT ANSWERS WERE GIVEN FOR Q21 AND Q22, ASK Q27-Q33:

Q27

How important would you say this reason ({#ReasTrans}) is when deciding how {#ChildName} gets {#ToFrom} school?

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

Q28

How important would you say this reason ({#ReasTrans}) is when deciding how {#ChildName} gets {#ToFrom} school?

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

Q29

How important would you say this reason ({#ReasTrans}) is when deciding how {#ChildName} gets {#ToFrom} school?

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

Q30

How important would you say this reason ({#ReasTrans}) is when deciding how {#ChildName} gets {#ToFrom} school?

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

Q31

How important would you say this reason ({#ReasTrans}) is when deciding how {#ChildName} gets {#ToFrom} school?

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

Q32

How important would you say this reason ({#ReasTrans}) is when deciding how {#ChildName} gets {#ToFrom} school?

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

LOOP: OTHERTRANSREASONS

1. FirstReason
2. SecondReason
3. ThirdReason

Q33

Are there any other reasons you consider when deciding how {#ChildName} gets to school?

- Yes (specify): No
- Don't know DON'T READ
- Refused DON'T READ

Q34

How important would you say this other reason is when deciding how {#Childname} gets to school?

Other reason was... {#OtherReasonsForTransType}

- Very Important
- Important
- A little bit important
- Not important
- Don't know DON'T READ
- Refused DON'T READ

END LOOP(OTHERTRANSREASONS)

Q35

Does {#ChildName} usually go to school by {#XSelf} or with someone else?

- By {#XSelf}
- Someone else
- Don't know DON'T READ
- Refused DON'T READ

IF Q35 IS 'SOMEONE ELSE', ASK:

Q36

Who is usually with {#ChildName}?

- Parent/guardian
- Younger brother/sister
- Older brothers/sisters
- Another adult
- Childminder
- Other children
- Don't know DON'T READ
- Refused DON'T READ

Q37

Does {#ChildName} usually come home from school by {#XSelf} or with someone else?

- By {#XSelf}
- Someone else
- Don't know DON'T READ
- Refused DON'T READ

IF Q37 IS 'SOMEONE ELSE', ASK:

Q38

Who is usually with {#ChildName}?

- Parent/guardian
- Younger brother/sister
- Older brothers/sisters
- Another adult
- Childminder
- Other children
- Don't know DON'T READ
- Refused DON'T READ

Q39

If {#ChildName} usually goes to school by car, is this journey part of a longer trip?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q39 IS 'YES', ASK:

Q40

Where else do you or {#ChildName} go on the trip?

- Work
- Another school
- Preschool
- Other (please specify) :Don't know DON'T READ
- Refused DON'T READ

Q41

If {#ChildName} usually comes home from school by car, is this journey part of a longer trip?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q41 IS 'YES', ASK:

Q42

Where else do you or {#ChildName} go on the trip?

- Work
- Another school
- Preschool
- Other (please specify):
- Don't know DON'T READ
- Refused DON'T READ

LOOP: DESTINATIONS

1. friends' houses by {#XSelf}.
2. local shops by {#XSelf} during the day
3. local shops by {#XSelf} after dark
4. organised activities by {#XSelf} at somewhere like a local sports club, church or recreational centre

Q43

Does {#ChildName} go to {@Destinations}?

- Always
- Often
- Sometimes
- Never
- Don't know DON'T READ
- Refused DON'T READ

IF Q43 IS 'ALWAYS', 'OFTEN' OR 'SOMETIMES', ASK:

Q44

How old was {#ChildName} when {#\.She} was first allowed to go to {@Destinations}?

(1 - 20)

IF Q43 IS 'NEVER', ASK:

Q45

At what age would you allow {#ChildName} to go to {@Destinations}?

(1 - 20)

END LOOP(DESTINATIONS)

Q46

Does {#ChildName} go by {#XSelf} on the bus/train?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q46 IS 'YES', ASK:

Q47

How old was {#ChildName} when he or she started to go on buses/trains by {#XSelf}?

(1 - 20)

IF Q46 IS 'NO', ASK:

Q48

At what age would you allow {#ChildName} to go on buses/trains by {#XSelf}?

(1 - 20)

Q49

Does {#ChildName} have a bike?

- Yes
- No

- Don't know DON'T READ
- Refused DON'T READ

IF Q49 IS 'YES', ASK:

Q50

Is {#ChildName} allowed to bike on streets by {#XSelf}?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q49 IS 'NO', ASK:

Q51

At what age would you allow {#ChildName} to cycle on streets by {#Xself}?

(1 - 20)

LOOP: WHEREWHYLOOP

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6

Are there any particular places in your neighbourhood where you'd be worried about {#ChildName} going by {#XSelf}?

Q52

Where:

Q53

Why:

END LOOP(WHEREWHYLOOP)

Q54

What would make your neighbourhood a better place for {#ChildName} to walk by {#XSelf}?

Q55

When {#ChildName} plays outside without an adult, where does {#She} play?

- In the garden
- At a friend's
- In a communal area (in sight of the house)
- In a communal area (not in sight of the house)
- On the street (in sight of the house)
- On the street (not in sight of the house)
- In parks or playgrounds (in sight of the house)
- In parks or playgrounds (not in sight of the house)
- In another location, not in sight of the house
- Don't know DON'T READ
- Refused DON'T READ

Q56

How important is it to you to encourage {#ChildName} to spend time with friends? READ

- Very important
- Important
- A little bit important
- Not important at all
- Don't know DON'T READ
- Refused DON'T READ

What are the main ways you encourage {#ChildName} to spend time with friends?

Q57

First way

Q58

Second way

Q59

How important is it to you to encourage {#ChildName} to be independent? READ

- Very important
- Important
- A little bit important
- Not important at all
- Don't know DON'T READ
- Refused DON'T READ

What are the main ways you encourage {#ChildName} to be independent?

Q60

First way

Q61

Second way

Q62

How long have you lived at your current address? YEARS

(0 - 100)

IF Q62 IS LESS THAN 5, ASK:

Q63

In the last five years how many times have you moved?

(0 - 50)

Q64

Why do you live in this neighbourhood? DON'T READ BUT CODE ALL THAT MATCH WHAT THEY SAY

Interviewer note: If respondent says they bought or rented a house, ask why they chose this neighbourhood and code this response.

- For work
- Good education
- Friends/family nearby
- Better or more affordable housing/rental
- With similar population groups
- Good and safe neighbourhood.
- Handy to shops and other amenities
- Pregnancy related reason
- I like the local lifestyle
- My spouse/partner/family have a house here
- Other (please specify) :Don't know DON'T READ
- Refused DON'T READ

The next few questions are about your neighbourhood. Firstly, I am going to read out a number of statements.

LOOP: SOCIALRELATIONS

1. There are safe places for children to play in our neighbourhood
2. It's a good place to bring up children
3. I feel safe walking down my street after dark
4. I worry about the number of crimes committed in our neighbourhood
5. Graffiti and vandalism are problems
6. Roaming dogs are a problem in our neighbourhood
7. It's a good place to buy a home
8. Bullying is a problem in our neighbourhood
9. There are a lot of families with young children living in our neighbourhood

Q65

Thinking about your neighbourhood, could you please tell me if you strongly agree, agree, neither agree nor disagree, disagree, strongly disagree with the statement:

{@SocialRelations}

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree
- Don't know DON'T READ
- Refused DON'T READ

END LOOP(SOCIALRELATIONS)

LOOP: SECONDSOCIALRELATIONS

- People are willing to help
- Neighbours watch out for kids
- It's a close knit neighbourhood
- I could borrow $10 from a neighbour
- If there is a problem with neighbours we can deal with it
- The neighbours cannot be trusted
- People will take advantage of you
- People you don't know will greet you or say hello to you
- People of different backgrounds don't talk to each other

Q66

Thinking about your neighbourhood again, could you please tell me if you strongly agree, agree, neither agree nor disagree, disagree, strongly disagree with the statement:

{@SecondSocialRelations}

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree

- Strongly disagree
- Don't know DON'T READ
- Refused DON'T READ

END LOOP(SECONDSOCIALRELATIONS)

LOOP: THIRDSOCIALRELATIONS

1. Parents in this neighbourhood know their children's friends
2. Adults in this neighbourhood know who the local children are
3. There are adults in this neighbourhood that the children can look up to
4. Parents in this neighbouhood generally know each other
5. You can count on adults in this neighbourhood to watch out that children are safe and don't get in trouble

Q67

Again thinking about your neighbourhood, please tell us if you strongly agree...strongly disagree with the following statement:

{@ThirdSocialRelations}

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree
- Don't know DON'T READ
- Refused DON'T READ

END LOOP(THIRDSOCIALRELATIONS)

These next few questions are about you and your family again

Q68

Do you live in a...?

- House
- Flat (in a house or block)
- Apartment
- Other (specify):
- Don't know DON'T READ
- Refused DON'T READ

IF Q68 IS 'APARTMENT', ASK:

Q69

Is your apartment larger than 4 storeys high?

- Yes, more than 4 storeys
- No, less than 4 storeys
- Don't know DON'T READ
- Refused DON'T READ

Q70

From your {#Home}, do you have access to...?

- Your own garden
- Shared outdoor area
- Nearby park
- Don't know DON'T READ
- Refused DON'T READ

Q71

Can you tell me if you...? READ

- Own your own home
- Rent with others or by yourself
- Live with parents
- Board with people (not with parents/family members)
- Other (specify)
- Don't know DON'T READ
- Refused DON'T READ

Q72

Could you please tell me which ethnic group you identify with: e.g. Maori, Samoan, New Zealand, European, or something else I can key in?

- Maori
- Samoan
- Cook Island
- Niuean
- Tongan
- Tokelauan
- Fijian
- Tuvaluan
- NZ European/Pakeha/New Zealander
- Australian
- British
- Other European (e.g. Dutch Croatian German)
- American/Canadian
- Asian (e.g. Chinese Taiwanese Filipino)
- Indian

- South African
- Other (specify):
- Don't know DON'T READ
- Refused DON'T READ

Q73

Is there any other ethnic group you identify with?

- Maori
- Samoan
- Cook Island
- Niuean
- Tongan
- Tokelauan
- Fijian
- Tuvaluan
- NZ European/Pakeha/New Zealander
- Australian
- British
- Other European (e.g. Dutch Croatian German)
- American/Canadian
- Asian (e.g. Chinese Taiwanese Filipino)
- Indian
- South African
- Other (specify): No other ethnic group
- Don't know DON'T READ
- Refused DON'T READ

Q74

Do you work/study outside the home?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q74 IS 'YES', ASK:

Q75

Full time or part time?

- Full time
- Part time
- Don't know DON'T READ
- Refused DON'T READ

Q76

Do you have a partner?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q76 IS 'YES', ASK:

Q77

Does your partner work outside the home?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

Q78

Does your partner study outside the home?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

Q79

Does your partner work full time or part time?

- Full time
- Part time
- Don't know DON'T READ
- Refused DON'T READ

Q80

Finally, I'd like to ask you about your travel to school when you were {#ChildName}'s age.

Firstly, did you go to school in the same area/suburb as {#ChildName}?

(e.g. Manurewa)?

- Yes
- No

Sample updated

Child: {#ChildName}
School: {#School}
Gender: {#Sex}.

Q7

Okay, now we can start. The interview will take about 10-20 minutes – is this a good time to do it? IF NO MAKE APPOINTMENT

- Yes

Q8

Firstly, what is your relationship to {#ChildName}?

- Mother
- Father
- Grandmother
- Grandfather
- Caregiver
- Other (specify)
- Don't know DON'T READ
- Refused DON'T READ

Q9

CODE GENDER of interviewee.

IF UNSURE ASK Sometimes we cannot tell fropeople's voices whether they are male or female, so I have to ask you

- Male
- Female
- Refused DON'T READ

Q10

What is {#ChildName}'s date of birth?

Enter either a name for the month part, or use the US format MM-DD-YYYY, or the international format YYYY-MM-DD.

Q11

How many other children under 18 live in your household?

- No others
- 1

Don't know DON'T READ
- Refused DON'T READ

Q81

Where did you go to school? (Suburb if in Auckland; city if in NZ; otherwise country)

Q82

When you were the same age as {#ChildName} is now, how did you go to school?"

- Walk
- Car
- Cycle
- Bus
- Taxi
- Train
- Other (please say):
- Don't know DON'T READ
- Refused DON'T READ

Q83

Did you go by yourself?

- Yes
- No
- Don't know DON'T READ
- Refused DON'T READ

IF Q83 IS 'NO', ASK:

Q84

Who usually accompanied you?

- Parent/guardian
- Younger brother/sister
- Older brothers/sisters
- Another adult
- Childminder
- Other children
- Don't know DON'T READ
- Refused DON'T READ

Q85

Compared to the distance {#ChildName} travels to school now, how far did you have to go at the same

Appendix I. Features, categories and scores of POS variables assessed in the NZ-POST

	Category	Score
Activities at POS		
Type of usage	Passive only	0
	Active informal	1
	Active formal	1
Types of activities (summed)	Tennis	1
	Soccer	1
	Football	1
	Netball courts	1
	Cricket	1
	Baseball/softball	1
	Walling (paths)	1
	Cycling	1
	Fitness circuit	1
	Basketball/netball hoops	1
	Hockey	1
	Athletics	1
	Rugby	1
	Children's playground	1
	Other	1
Environmental quality at POS		
Presence of beach/ricer foreshore	No	0
	Yes	1
Presence of water features	No	0
	Yes	1
Type of water features (summed)	Lake	1
	Pond	1
	Water fountain	1
	Stream	1
	Other	1
Presence of aesthetic features	No	0
	Yes	1
Types of aesthetic features (summed)	Statues	1
	Gazebos/rotundas	1
	Sculptures	1
	Ducks/swans	1
	Bridge	1
	Rocks/stones	1
	Other	1
Number of trees	0 trees	0
	1-50 trees	0.33
	>51-100 trees	0.66
	>100 trees	1
Placement of trees (summed)	Perimeter, some sides	0.5
	Random placement throughout POS	0.5
	Perimeter, all sides	1
	Along walking paths	1
Presence of gardens	No	0
	Yes	1

(continued)

	Category	Score
Presence of walking paths/cycleways (summed)	None	0
	Walking paths	1
	Designated dual paths	1
Shade along paths	Very poor	0
	Poor	0.25
	Medium	0.5
	Good	0.75
	Very good	1
Placements of paths (summed)	Perimeter, some sides	0.5
	Perimeter, all sides	1
	Diagonal, radial	1
	Path around water/visual feature	1
Evidence of graffiti	No	0
	Yes	1
Vandalism evident	No	0
	Yes	1
Presence of litter	No	0
	Yes	1
Amenities available at POS		
Presence of children's playground equipment	No	0
	Yes	1
Type of children's play equipment (summed)	Slide	1
	Climbing equipment	1
	Hanging bars/rings	1
	Seesaws/rockers	1
	Bridges/tunnels	1
	Activity panels	1
	Cubby houses	1
	Others	1
Playground surfaces	Sand	1
	Grass	1
	Gravel/pebbles	0.5
	Woodchips	0.5
	Rubber	1
Shade over playground	No cover shade	0
	Partial cover/shade	0.5
	Total Cover/shade	1
Presence of BBQ	No	0
	Yes	1
Presence of picnic tables	No	0
	Yes	1
Presence of car parking bays	No	0
	Yes	1
Presence of public access toilets	No	0
	Yes	1

	Category	Score
Presence of kiosk/café	None	0
	Weekends only	0.33
	Weekdays only	0.66
	7 days/weeks	1
Access to public transport	No	0
	Yes	1
Presence of rubbish bins	No	0
	Yes	1
Presence of dog litter bags	No	0
	Yes	1
Presence of water sources accessible for dogs	No	0
	Yes	1
Presence of drinking fountains	No	0
	Yes	1
Safety at POS		
Presence of lighting	No	0
	Yes	1
Placement of lighting (summed)	Perimeter, some side	0.5
	Perimeter, all sides	1
	Around courts, building, equipment	1
	Along paths	1
	Random throughout POS	1
Visibility of surrounding roads	Roads cannot be seen from centre of POS	0
	Roads partially visible from centre of POS	0.5
	Roads clearly visible from the centre of POS	1
Presence of surrounding houses	Houses cannot be seen from centre of POS	0
	Houses partially visible from centre of POS	0.5
	Houses clearly visible from centre of POS	1
Number of surrounding houses	0 houses	0
	1-5 houses	0.33
	5-10 houses	0.66
	>10 houses	1
Area of POS unable to see houses	No	0
	Yes	1
Presence of pedestrian crossing without signals (zebra crossing)	No	0
	Yes	1
Presence of pedestrian crossing with signals	No	0
	Yes	1

Notes: POS= public open space

Appendix J. Summary of total and overall scores of environmental attributes, standardised public open space area, and percentage public open space area in the Kids in the City school neighbourhood catchments

	Descriptive Statistics					
Summary scores for total environmental attributes and area measures[1] (N)	**Range**	**Minimum**	**Maximum**		**Mean** **St**	**Std. Deviation**
School A (8)						
Total Activity Score	7.00	0.00	7.00	1.75	0.94	2.66
Total Environment Score	4.50	5.00	9.50	6.87	0.51	1.45
Total Amenity Score	13.16	0.00	13.16	5.39	1.92	5.43
Total Safety Score	4.50	2.50	7.00	4.54	0.60	1.71
Total public open space Score	29.08	7.58	36.66	18.56	3.69	10.44
Shape proportion	0.05	0.00	0.05	0.01	0.01	0.02
Shape area standardised	1.68	-0.41	1.27	-0.05	0.20	0.57
School B (14)						
Total Activity Score	4.00	0.00	4.00	1.36	0.41	1.55
Total Environment Score	9.17	6.33	15.50	9.43	0.86	3.20
Total Amenity Score	10.83	0.00	10.83	4.08	0.90	3.38
Total Safety Score	5.00	2.25	7.25	4.77	0.44	1.64
Total public open space Score	20.33	10.83	31.16	19.63	1.87	7.00
Shape proportion	0.05	0.00	0.05	0.01	0.00	0.01

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Shape area standardised	2.02	-0.41	1.61	-0.12	0.14	0.54

School C (10)

Total Activity Score	8.00	0.00	8.00	2.20	0.80	2.53
Total Environment Score	10.00	4.83	14.83	9.97	0.91	2.88
Total Amenity Score	15.49	0.00	15.49	5.68	1.75	5.53
Total Safety Score	9.75	2.00	11.75	5.63	0.86	2.73
Total public open space Score	29.16	8.33	37.49	23.47	3.12	9.86
Shape proportion	0.21	0.00	0.22	0.04	0.02	0.07
Shape area standardised	3.18	-0.37	2.81	0.20	0.31	0.97

School D (4)

Total Activity Score	3.00	0.00	3.00	1.25	0.75	1.50
Total Environment Score	1.50	4.83	6.33	5.46	0.31	0.63
Total Amenity Score	9.83	1.00	10.83	5.67	2.45	4.90
Total Safety Score	3.66	4.00	7.66	5.29	0.82	1.63
Total public open space Score	10.83	11.33	22.16	17.66	2.70	5.41
Shape proportion	0.01	0.00	0.01	0.01	0.00	0.01
Shape area standardised	0.14	-0.41	-0.27	-0.35	0.03	0.06

School E (15)

Total Activity Score	9.00	0.00	9.00	1.93	0.70	2.71
Total Environment Score	12.17	5.33	17.50	9.09	0.91	3.52
Total Amenity Score	13.49	1.00	14.49	5.91	1.05	4.06
Total Safety Score	5.75	0.75	6.50	3.65	0.46	1.80
Total public open space Score	35.24	10.41	45.65	20.58	2.39	9.25

Shape proportion	0.03	0.00	0.03	0.01	0.00	0.01
Shape area standardised	0.74	-0.41	0.33	-0.27	0.06	0.22

School F (11)

Total Activity Score	9.00	0.00	9.00	2.73	0.85	2.83
Total Environment Score	7.42	4.83	12.25	7.13	0.62	2.06
Total Amenity Score	14.83	1.00	15.83	8.21	1.64	5.44
Total Safety Score	4.00	1.75	5.75	3.88	0.36	1.20
Total public open space Score	33.25	8.83	42.08	21.94	3.07	10.18
Shape proportion	0.03	0.00	0.03	0.00	0.00	0.01
Shape area standardised	1.19	-0.41	0.78	-0.19	0.10	0.34

School G (8)

Total Activity Score	6.00	0.00	6.00	2.13	0.85	2.42
Total Environment Score	16.17	7.33	23.50	12.70	2.03	5.75
Total Amenity Score	19.49	0.00	19.49	9.83	2.18	6.16
Total Safety Score	8.00	0.00	8.00	4.16	0.99	2.80
Total public open space Score	39.83	8.00	47.83	28.81	5.10	14.41
Shape proportion	0.14	0.00	0.14	0.03	0.02	0.05
Shape area standardised	5.90	-0.40	5.50	0.76	0.74	2.10

School H (18)

Total Activity Score	9.00	0.00	9.00	2.33	0.62	2.61
Total Environment Score	19.50	4.00	23.50	9.83	1.15	4.89
Total Amenity Score	19.50	0.00	19.50	5.79	1.34	5.69
Total Safety Score	6.50	1.75	8.25	5.05	0.45	1.93

Total public open space Score	38.34	9.49	47.83	23.00	2.87	12.19
Shape proportion	0.13	0.00	0.13	0.01	0.01	0.03
Shape area standardised	5.91	-0.41	5.50	0.08	0.33	1.38
OVERALL TOTALS FOR EIGHT SCHOOL CATCHMENT AREAS[2]						
Total Activity Score	9.00	0.00	9.00	2.02	0.26	2.40
Total Environment Score	19.50	4.00	23.50	9.11	0.42	3.92
Total Amenity Score	19.50	0.00	19.50	6.15	0.54	5.11
Total Safety Score	11.75	0.00	11.75	4.57	0.21	1.99
Total public open space Score	40.25	7.58	47.83	21.85	1.10	10.32
Shape proportion	0.22	0.00	0.22	0.01	0.00	0.03
Shape area standardised	5.91	-0.41	5.50	0.00	0.11	1.00

[1,2]NZ-POST measures include activities, environmental, amenity and safety. GIS derived measures shape proportion (percentage of public open space area) and standardised area

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