

**Neighbourhoods for Healthy Kids:  
A child-centred investigation into the role of the built environment  
on child body size**

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A thesis submitted to  
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**Dedication:**

*For Abbie, Noah, Nic, Arjun, Sahan, Hazel, Zeke, Benji, Nova, Nena, Naomi, Marceline, Milan, Lagitupu, Leilani, Noah, Sophie and all the tamariki of Tāmaki Makarau, Aotearoa; may your neighbourhoods grant you opportunities for healthy, active and super-fun childhoods.*

## Table of Contents

|   |           |
|---|-----------|
| List of Figures.....  | 6         |
| List of Tables.....   | 7         |
| List of Appendices.....   | 8         |
| Abbreviations .....   | 9         |
| List of Publications Arising from Doctoral Thesis.....                          | 10        |
| Attestation of Authorship.....  | 11        |
| Acknowledgements.....   | 12        |
| Thesis Abstract .....   | 13        |
| Lay Person Summary.....   | 15        |
| Research Chapter Contributions.....   | 18        |
| <b>Chapter 1</b>  | <b>21</b> |
| <b>Introduction .....</b>   | <b>21</b> |
| Thesis Rationale .....  | 21        |
| Terminology: The Body Size of Children .....                                    | 22        |
| Critical Reflection on Child Body Size Terminology.....                         | 22        |
| Statement of Purpose .....  | 23        |
| Study Delimitations .....   | 24        |
| Personal Statement of Bias.....   | 25        |
| Thesis Organisation .....   | 27        |
| Significance and Originality.....   | 28        |
| Study Site.....   | 29        |
| Neighbourhoods for Active Kids (NfaK) Study and Independent Contributions ..... | 31        |
| <b>Chapter 2</b>  | <b>33</b> |
| <b>Literature Review .....</b>  | <b>33</b> |
| Introduction.....   | 33        |
| Child Body Size in New Zealand.....   | 33        |
| Deprivation .....   | 34        |
| Health Behaviours.....  | 36        |
| Health Behaviour: Physical Activity.....  | 36        |
| Health Behaviour: Diet .....  | 39        |
| Behaviour Change Interventions.....   | 41        |
| The Built Environment.....  | 43        |

|   |           |
|---|-----------|
| The Neighbourhood .....   | 44        |
| Physical Activity Built Environment .....   | 46        |
| Neighbourhood Destinations and Accessibility .....  | 47        |
| Walkability .....   | 47        |
| Distance to Parks .....   | 48        |
| Residential Density .....   | 49        |
| Nutrition Built Environment.....  | 49        |
| Food Outlets.....   | 50        |
| Advertising Unhealthy Food and Drink .....  | 52        |
| Children's Body Size and the Built Environment.....   | 54        |
| Summary.....  | 57        |
| <b>Chapter 3 58</b>   |           |
| <b>Methodology.....</b>   | <b>58</b> |
| Preface .....   | 58        |
| Theory .....  | 58        |
| The Socioecological Model of Health Behaviours.....   | 58        |
| <i>Hauora</i> (Health and Wellbeing).....   | 60        |
| Child-Centred Research.....   | 61        |
| The Theory of Affordances.....  | 62        |
| Knowledge Translation.....  | 63        |
| Technology.....   | 63        |
| Technology: Public Participation Geographic Information Software (PPGIS) Approaches to<br>Participatory Mapping ..... | 64        |
| Technology: Using Google to Investigate Built Environments .....  | 64        |
| Technology: Social Media .....  | 66        |
| <b>Chapter 4 68</b>   |           |
| <b>Viewing obesogenic advertising in children's neighbourhoods using Google Street View 68</b>                        |           |
| Preface .....   | 68        |
| Manuscript.....   | 69        |
| Abstract .....  | 69        |
| Introduction.....   | 70        |
| Background .....  | 72        |
| Methods of Approach to the Study.....   | 73        |
| Findings.....   | 80        |
| Discussion .....  | 83        |
| Conclusion.....   | 88        |

## **Chapter 5 89**

### **Neighbourhoods matter: Physical activity and nutrition built environments and the body size of children in Auckland, New Zealand..... 89**

|                   |     |
|-------------------|-----|
| Preface .....     | 89  |
| Manuscript.....   | 90  |
| Abstract .....    | 90  |
| Introduction..... | 92  |
| Methods.....      | 96  |
| Results .....     | 103 |
| Discussion .....  | 110 |
| Conclusion.....   | 116 |

## **Chapter 6 118**

### **Understanding children's neighbourhood destinations: Presenting the Kids-PoND framework ..... 118**

|                         |     |
|-------------------------|-----|
| Preface .....           | 118 |
| Manuscript.....         | 119 |
| Graphical Abstract..... | 120 |
| Abstract .....          | 121 |
| Background .....        | 122 |
| Methods.....            | 124 |
| Results .....           | 128 |
| Discussion .....        | 133 |
| Conclusion.....         | 138 |

## **Chapter 7 139**

### **Discussion 139**

|   |     |
|---|-----|
| Introduction.....   | 139 |
| Methodological Strengths and Contributions to Knowledge .....   | 140 |
| Chapter 4: Viewing obesogenic advertising in children's neighbourhoods using Google Street View.....  | 141 |
| Chapter 5: Neighbourhoods matter: Physical activity and nutrition built environments and the body size of children in Auckland, New Zealand. .... | 142 |
| Chapter 6: Understanding children's neighbourhoods: Presenting the Kids-PoND framework .  | 142 |
| Discoveries and Opportunities for Further Research.....   | 143 |
| Limitations and Implications for Future Research.....   | 148 |

|  |            |
|--|------------|
| Implications of this Body of Work..... | 154        |
| <b>Chapter 8</b>                       | <b>160</b> |
| <b>Conclusion</b>                      | <b>160</b> |
| <b>References</b>                      | <b>162</b> |

## List of Figures

|            |  |     |
|------------|--|-----|
| Figure A.1 | Screenshot, neighbourhoods for healthy kids, on YouTube. ....  | 15  |
| Figure A.2 | Children’s colouring-in. ....  | 17  |
| Figure 1.1 | Thesis organisation.....   | 28  |
| Figure 3.1 | A simplified socioecological model of health behaviour as it applies to<br>children’s body size .....  | 60  |
| Figure 3.2 | Te Whare Tapa Whā .....  | 61  |
| Figure 4.1 | Flow chart of processes involved in data collection.....   | 74  |
| Figure 4.2 | Kernel density maps for example schools in highly walkable<br>neighbourhoods .....   | 82  |
| Figure 4.3 | Kernel density maps for example schools in low walkable<br>neighbourhoods .....  | 83  |
| Figure 5.1 | Conceptual Model .....   | 95  |
| Figure 5.2 | Example of individual home and school area buffers that were<br>merged together to create a combined neighbourhood buffer,<br>counting the area of overlap only once ..... | 98  |
| Figure 5.3 | Structural equation model results and standard errors.....   | 109 |
| Figure 6.1 | Kids-PoND Framework.....   | 127 |
| Figure 6.2 | PPGIS neighbourhood destinations from children attending 1 primary<br>and 1 intermediate school, located in close proximity to each other,<br>in Auckland .....            | 133 |

## List of Tables

|           |  |     |
|-----------|--|-----|
| Table 1.1 | Recruitment and eligibility screening of child participants.....             | 32  |
| Table 4.1 | School and neighbourhood characteristics .....                               | 75  |
| Table 4.2 | Advertisements identified by category .....                                  | 78  |
| Table 4.3 | Categories combined for use in mapping .....                                 | 81  |
| Table 5.1 | Hypotheses and supporting literature .....                                   | 96  |
| Table 5.2 | Study variables .....  | 100 |
| Table 5.3 | Descriptive statistics of participants .....                                 | 104 |
| Table 5.4 | Descriptive statistics for observed variables by waist-to-height ratio ..... | 105 |
| Table 5.5 | Results from structural equation model .....                                 | 107 |



## List of Appendices

|  |     |
|--|-----|
| Appendix A. Amendment to AUT Ethics Committee 14/236 .....   | 200 |
| Appendix B. Google Street View Study Protocol .....  | 201 |
| Appendix C. GIS data sources used to calculate the physical activity and nutrition<br>built environment attributes ..... | 214 |
| Appendix D. Destinations, data sources, and weights of the NDAI-C .....  | 215 |

## **Abbreviations**

|           |  |
|-----------|--|
| BMI       | Body Mass Index                                    |
| DVD       | Digital Video Disc                                 |
| GIS       | Geographic Information System                      |
| GPS       | Global Positioning System                          |
| Kids-PoND | Kids Perceptions of Neighbourhood Destinations     |
| MELAA     | Middle-Eastern Latin-American African              |
| MVPA      | Moderate to Vigorous Physical Activity             |
| NfAK      | Neighbourhoods for Active Kids                     |
| NZ        | New Zealand  |
| PPGIS     | Public Participation Geographic Information System |
| SEM       | Structural Equation Model/ling                     |
| WtHR      | Waist to Height Ratio                              |

## List of Publications Arising from Doctoral Thesis

### Peer-Reviewed Journal Publications

**Egli, V.**, Zinn, C., Mackay, L., Donnellan, N., Villanueva, K., Mavoa, S., ... & Smith, M. (2018). Viewing obesogenic advertising in children's neighbourhoods using Google Street View. *Geographical Research*. <https://doi.org/10.1111/1745-5871.12291>

**Egli, V.**, Carlson, J., Mackay, L., Villanueva, K., Zinn, C., Donnellan, N., Forsyth, E., Smith, M., (Submitted October 2018). Neighbourhoods matter: Physical activity and nutrition built environments and the body size of children in Auckland, New Zealand. *Health & Place*.

**Egli, V.**, Villanueva, K., Donnellan, N., Mackay, L., Forsyth, E., Zinn, C., Kytta, M., Smith, M. (Under Review). Understanding children's neighbourhood destinations: Presenting the Kids PoND framework. *Children's Geographies*.

### Conference Presentations

**Egli, V.**, Zinn, C., Mackay, L., Villanueva, K., Smith, M. Neighbourhoods for Active Kids Symposium: Using Google Street View to Capture Outdoor Advertising Around Schools. Critical Health Education Studies Conference May 2018: Queenstown, New Zealand

**Egli, V.**, Zinn, C., Mackay, L., Villanueva, K., Smith, M. Google Street View, a useful tool to document outdoor advertising around schools: limitations and implications for use. NZGS IAG Conference July 11-14 2018: 'Creative conversations, constructive connections', University of Auckland, Auckland, New Zealand

### **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 and outlined in the research chapter contributions), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Chapters four, five and six have been submitted (or are in the process of being prepared for submission) for consideration as separate papers for publication in international peer-reviewed journals. Each of these papers 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 preface for each paper.

---

2<sup>nd</sup> of November, 2018

## Acknowledgements

*“There are some things you can't share without ending up liking each other, and knocking out a twelve-foot mountain troll is one of them.” J.K Rowling (1997) Harry Potter and the Philosopher's Stone*

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## Thesis Abstract

**Background:** Neighbourhood built environments can promote or hinder health-promoting behaviours such as physical activity and dietary behaviours in children. The aim of this thesis was to contribute to a greater understanding of possible associations between physical activity and nutrition built environments and child body size. Child-centred methodologies and triangulation of multiple data sources may yield in-depth understanding of the relationships between these variables.

**Methods:** Cross-sectional data from children (aged 8 – 13 years) and primary and intermediate schools participating in the Neighbourhoods for Active Kids Study in Auckland New Zealand were used. Google Street View was used to map outdoor advertising around schools. Objective measures of the built environment were derived using Geographic Information Systems. Children's neighbourhood destinations, perceptions and preferences were captured using public participation geographic information systems (PPGIS). Children's physical activity was assessed using 7-day accelerometry and children answered an online survey on their dietary behaviours. Children's height, weight, and waist circumference were objectively measured by trained researchers. Knowledge translation efforts were employed throughout the research process.

**Analysis:** Structural equation modelling was used to assess associations between the built environment and physical activity and dietary behaviours and waist to height ratio (WtHR). The Kids-PoND framework for children's neighbourhood use and preferences was developed using content analysis from the PPGIS, based on the theory of affordances.

**Results:** 1102 children from 19 schools participated in this body of work. Google Street View shows promise for assessing obesogenic advertising in children's neighbourhoods. No association was found between the neighbourhood built environment and WtHR. A statistically significant inverse relationship between a positive physical activity built environment and a poor nutrition built environment was found. Children from neighbourhoods of high deprivation were more likely to have greater WtHRs. Children mentioned spending time with friends and purchasing and consuming unhealthy food as important activities in neighbourhood destinations.

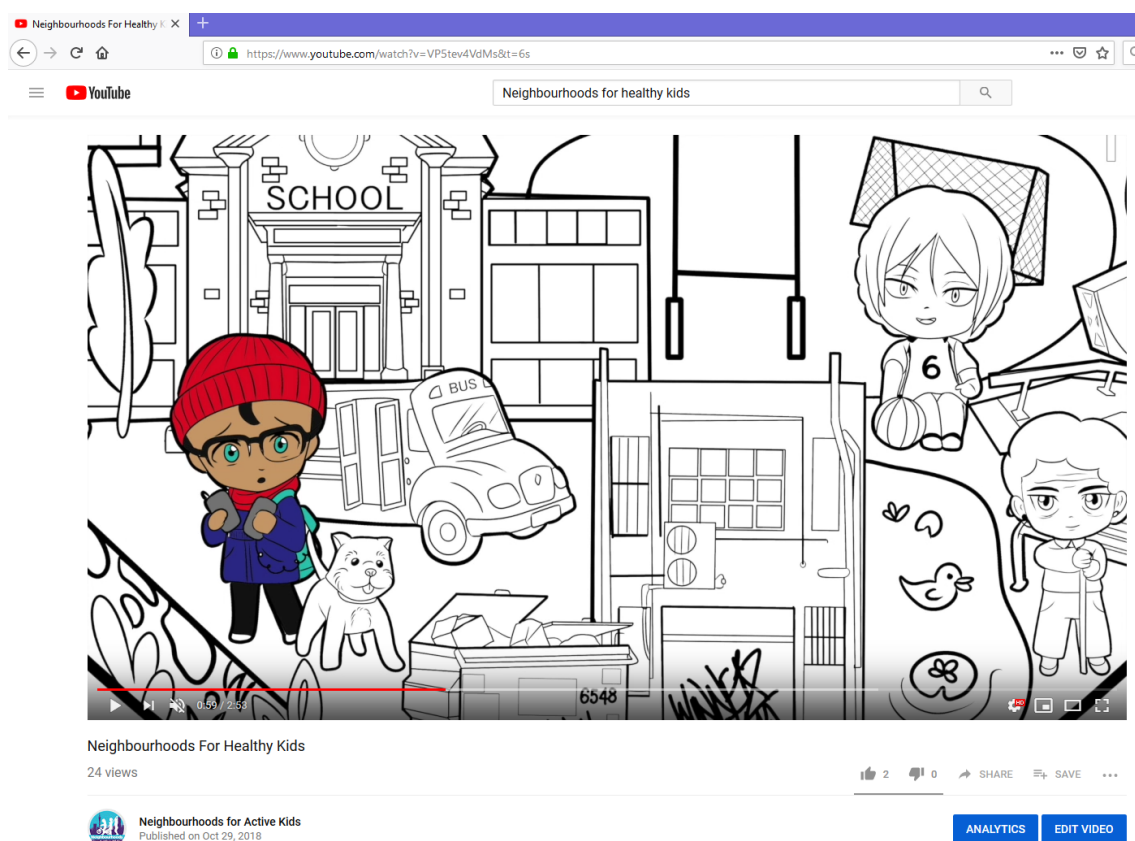
**Conclusions:** Neighbourhood built environments are associated with health-promoting behaviours in children. Quantitative modelling found no relationship between the neighbourhood built environment and children's WtHR. However, the significant, inverse

relationship between a positive physical activity-promoting environment and a poor nutrition environment, in combination with children's use and perceptions of neighbourhood destinations, has important implications for public health and urban planning. There is evidence that inequalities exist particularly for poorer nutrition environments in areas of high deprivation. Findings may indicate that promoting better physical activity built environments in the absence of concurrent restriction of poor nutrition environments may intensify health inequalities. Multi-level approaches, including environmental policies and practices to promote positive health behaviours in children may have a substantial positive impact on body size outcomes and help to reduce health inequalities. Research opportunities exist to build upon this body of work and further investigate the role of food purchasing behaviour in children's neighbourhoods and the role of social relationships on dietary behaviours.

## Lay Person Summary

The lay person summary for this thesis is in the form of a short, online video. Please visit [https://www.youtube.com/watch?v=FXXIVeEQ\\_IE](https://www.youtube.com/watch?v=FXXIVeEQ_IE) to view. Or put “Neighbourhoods for healthy kids” in the search box on YouTube, see Figure A.1 below. The text for this lay person summary is also provided below. Accompanying this video is a graphic suitable for distribution to schools, see Figure A.2 below. It is a colouring-in diagram and is designed to be printed at least A3. A smaller version has been included in this thesis below. Please note, the graphic is intended to be folded to form a heart shape.

Figure A.1 Screenshot, neighbourhoods for healthy kids, on YouTube



*“Do you ever wonder what impact neighbourhoods might have on kids’ health? Does where kids live, where they go to school and where they play, have a relationship with how much physical activity they get? or what unhealthy food they eat and drink? Let’s find out!*

*Over the years research has focused on neighbourhood built environments, things like roads, traffic, speed limits, walkways, cycleways and parks and how these things get kids moving or not. Recently there has also been research that has looked at the location of*



*unhealthy food outlets, things like fast-food chains, take-away restaurants and convenience stores, if they are located close to kids homes, or schools and how this influences what kids eat.*

*We all know that being active and eating healthy is good for us, but for kids in Aotearoa, New Zealand what we don't know is how neighbourhoods may influence their health. So, we reached out to kids and schools across Tāmaki Makaurau, Auckland to help us find out.*

*Just over 1000 children from 19 schools all over Auckland took part. We used Google Street View to map the number of unhealthy food and drink advertisements marketed to children in their neighbourhoods. We measured all the features of neighbourhoods that get kids moving, and all the things in neighbourhoods that encourage kids to eat unhealthily. We measured kids' overall physical activity, how many steps they took per day, and how much time they spent sitting or lying around. We also found out how often kids eat unhealthy food: things like lollies, chips, pizza and cake and how often they drink fizz, cola, cordial, juice and flavoured milk. We asked kids to map the places they go in their neighbourhood online, and to tell us what they liked or disliked about these places. We put all this information together and found some really cool results.*

*First off, neighbourhoods that were really good at getting kids moving, were also likely to promote unhealthy eating. We found that kids really liked going to parks: to play sport with their friends, ride their bikes, run and explore. But kids also liked going to the shops: to eat lollies and chips and hang with their friends.*

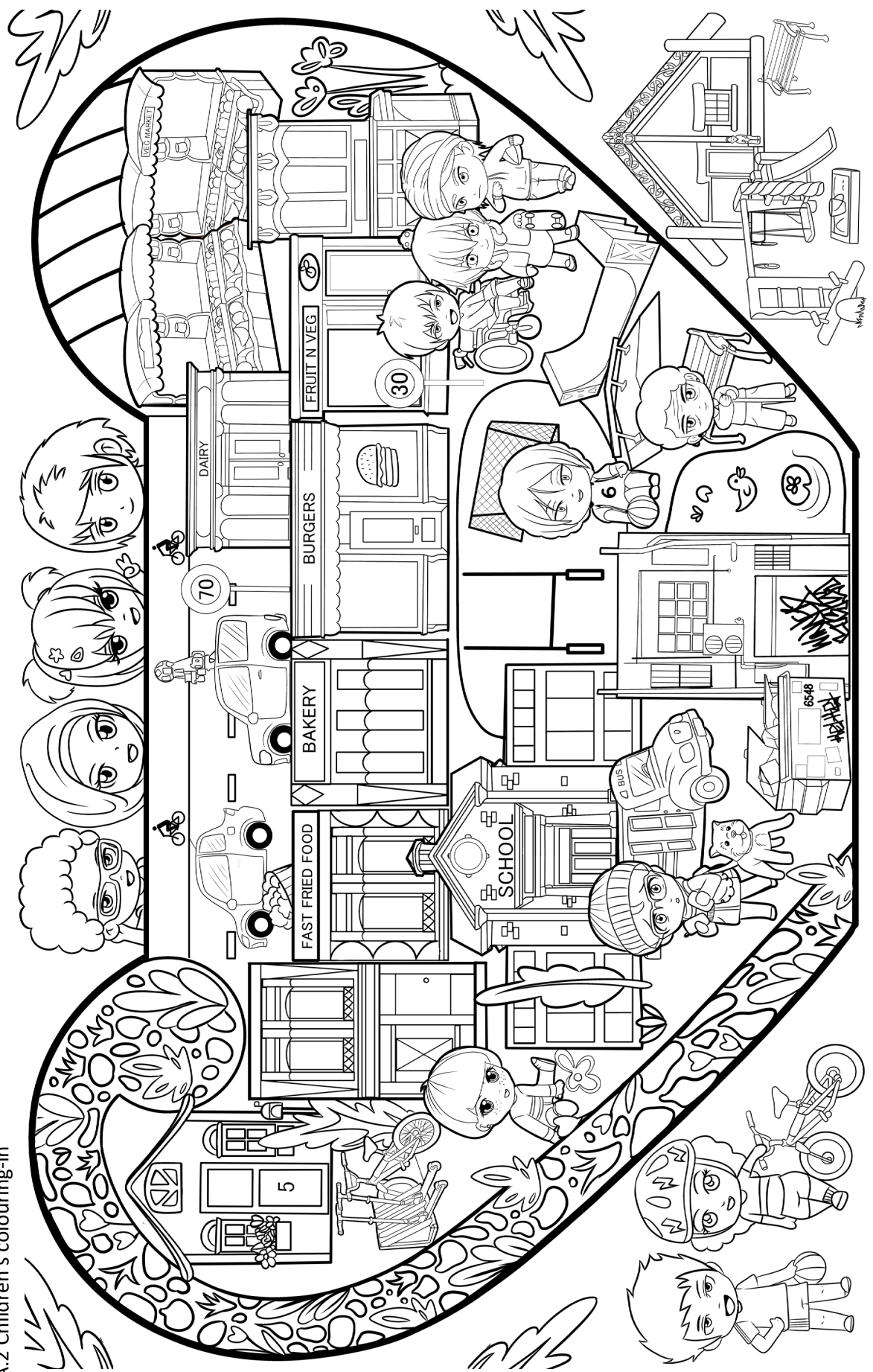
*Neighbourhoods are important to kids in New Zealand and they impact kids' health. Adults need to make sure that **all** neighbourhoods get kids moving and that they protect kids from advertising and marketing of unhealthy food and drink, especially in places kids go every day, and in the places, kids like to hang-out with friends. For more information please click on the link below Thanks to all the kids who took part."*

Credits:

Narrator: Abbie Mackay, age 12

Designer: Alex Heart, Shop Nine and Three Quarters

Figure A.2 Children's colouring-in



**NEIGHBOURHOODS**

that get kids moving and support  
healthy eating are important

**FOR HEALTHY KIDS**

## Research Chapter Contributions

Chapters four, five and six of this thesis are comprised of scientific papers that are published, or have been submitted and are awaiting editorial review, in international peer-reviewed journals. The academic contributions and specific role of the doctoral candidate for these research chapters were as follows:

Chapter 4: Viewing obesogenic advertising in children's neighbourhoods using Google Street View.

|                             |     |
|-----------------------------|-----|
| Victoria Egli .....         | 80% |
| Caryn Zinn .....            | 3%  |
| Lisa Mackay .....           | 2%  |
| Niamh Donnellan .....       | 2%  |
| Karen Villanueva .....      | 2%  |
| Suzanne Mavoa .....         | 2%  |
| Daniel Exeter .....         | 2%  |
| Stefanie Vandevijvere ..... | 2%  |
| Melody Smith .....          | 5%  |

Chapter 5: Neighbourhoods matter: Physical activity and nutrition built environments and the body size of children in Auckland, New Zealand.

|                               |     |
|-------------------------------|-----|
| Victoria Egli .....           | 80% |
| Jordan Carlson.....           | 4%  |
| Lisa Mackay .....             | 3%  |
| Niamh Donnellan .....         | 3 % |
| Euan Forsythe .....           | 2%  |
| Caryn Zinn .....              | 2%  |
| Karen Villanueva .....        | 2%  |
| Melody Smith nee Oliver ..... | 4%  |

Chapter 6: Understanding children's neighbourhood destinations: Presenting the Kids PoND  
framework

|                        |     |
|------------------------|-----|
| Victoria Egli .....    | 80% |
| Karen Villanueva ..... | 5%  |
| Niamh Donnellan .....  | 2%  |
| Lisa Mackay .....      | 2%  |
| Euan Forsyth .....     | 2%  |
| Caryn Zinn .....       | 2%  |
| Marketta Kyttä .....   | 2%  |
| Melody Smith .....     | 5%  |

### Introduction

*"Begin at the beginning," the King said, very gravely, "and go on till you come to the end: then stop." Lewis Carroll (1946) Alice in Wonderland*

#### Thesis Rationale

In New Zealand (NZ) childhood overweight and obesity is a public health concern, with rates of childhood overweight and obesity being higher for Māori, Pacific and those living in the most deprived areas (Ministry of Health, 2017a). Over the last 20 years, despite a plethora of interventions targeting childhood overweight and obesity, NZ continues to have one of the highest prevalence rates of childhood overweight and obesity globally (Ng et al., 2014). To date, interventions have focused primarily on individual behaviour change with little to no lasting impact on national statistics (Ministry of Health, 2017a). Despite the best efforts of medical practitioners, health promoters and researchers, prevalence rates remain high.

Opportunities to participate in healthy behaviours, specifically engaging in physical activity and eating a healthy diet, are facilitated by the environments that people are exposed to. Neighbourhoods play a role in physical activity (Cerin et al., 2017) and dietary behaviours (Carroll-Scott et al., 2013; Zick et al., 2009). The connections between these health behaviours and deprivation on child body size warrants further exploration, especially given the sizable disease burden attributed to overweight and obesity in the NZ population (Ng et al., 2014), its inequitable distribution (Ministry of Health, 2017a) and how body size tracks across the life-course (Aarestrup et al., 2016).

The factors contributing to overweight and obesity in children are complex and multidimensional. Neighbourhood environmental influences and health behaviours, including physical activity and diet, are important target areas for public health interventions and urban planning. Knowing what relationships exist and how variables relate to each other is important to guide targeted interventions and allocate scarce health resources.

The research is about children, their neighbourhoods, their health behaviours and their body size. It is therefore imperative that any research conducted with children is sensitive to this and goes beyond *Primum non nocere*, 'first, do no harm' and is also empowering for children, their

parents and communities. There is a need to know more about the relationship between children's neighbourhoods and body size. A research framework that is child-centred and allows space for children to voice their experiences and receive research information is an appropriate way to carry out this research.

### **Terminology: The Body Size of Children**

"The body size of children" is a term that encompasses all varied, body sizes in a neutral tone. This neutral and impartial term was chosen in order not to contribute to the stigmatisation of children whose bodies fall outside of what is considered a clinically 'healthy' body size, (Pont, Puhl, Cook, & Slusser, 2017). Stigmatising children causes harm and can negatively impact long-term quality of life (Pont et al., 2017). The aim of this thesis is to understand the role of neighbourhoods on children's excess body size and to do so in a way that is not stigmatising for children, families, schools, and communities. The term 'body size' has greater alignment with empowering children, schools and communities than 'too heavy for height', 'overweight', or 'obesity' (Medvedyuk, Ali, & Raphael, 2017) and is discussed further in Chapter 3 Methodology. Overweight and obesity are defined as an excess in adiposity or body fat mass (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007). When the terms 'overweight' or 'obesity' are used in this thesis they are contextualised as medical terminology and/or the words of the author to whom I am referring. In this research, body size will be measured via waist to height ratio (WtHR).

### **Critical Reflection on Child Body Size Terminology**

Academics, clinicians and public health practitioners are divided on the use of the term *childhood obesity*. At one end of the spectrum there are neoliberalists who have medicalised overweight and obesity, placing culpability at the level of the individual and their behaviour. At the other end are critical health scholars who argue the childhood obesity epidemic is socially constructed and that any form of research or awareness of child body size is dangerous (Moffat, 2010; D. Powell, 2018). This thesis acknowledges both sides and takes a middle course approach, bridging the divide between the two academic camps by focusing on the level of the neighbourhood built environment.

From altruistic motives and to generate funding for research and interventions, the words 'epidemic', and 'crisis' have been used to describe the increasing global prevalence of childhood overweight and obesity. This medicalisation of overweight and obesity has resulted in a pedagogical shift from overweight and obesity being considered a risk factor for the development of a range of noncommunicable diseases, to being a disease-state in itself (Gard,

2011). Furthermore, as epidemiologists tracked body size and endocrinologists and biomedical researchers sought to find a 'cure' for childhood overweight and obesity the result was interventions that were targeted to the level of the individual (Elfhag & Rössner, 2005). Compounding this neoliberalist ideology has been the influence of the media resulting in stigmatisation of larger body sizes (Holland, Blood, Thomas, & Lewis, 2015; Saguy & Almeling, 2008) and a lack of understanding about wider environmental influences, particularly deprivation and gender (Moffat, 2010). This has led to little acknowledgement of differing cultural perceptions of body size (Teevale, 2011) and the lived experience (Boero, 2007). Underweight, overweight and obesity are risk factors for the development of disease and are not diseases in and of themselves (Ezzati et al., 2002; Lopez, Mathers, Ezzati, Jamison, & Murray, 2006). Individual behaviours including physical activity and nutrition play an important role in body size outcomes; however, they are not the only influence. Individuals do not conduct physical activity and dietary behaviours in a bubble, they move around and eat food in 'real world' environments (Anderson, Wynter, Grant, Cave, et al., 2017).

### **Statement of Purpose**

This thesis seeks to understand the role of neighbourhood built environments on children's (aged 8 – 13 years) body size in Auckland, New Zealand. It generates new insights into the role of the physical activity and nutrition built environments on children's body size, while also accounting for the potential mediating health behaviours of children's physical activity and unhealthy eating habits. This research also explores children's perceptions of neighbourhood destinations and seeks to disseminate knowledge back to participants in a way that is appropriate and engaging for children, schools and communities.

The specific objectives of this research were:

- (1) To develop and investigate the utility of a new way to measure nutrition advertising for inclusion in future modelling of the nutrition built environment (Chapter 4).
- (2) To determine possible associations between neighbourhood built environment factors and children's body size, adjusting for physical activity and eating behaviours (Chapter 5).
- (3) To contextualise the results of quantitative modelling (Chapter 5) through an investigation into children's perceptions of neighbourhood destinations, allowing them to voice the important influences in their environment (Chapter 6).



## Study Delimitations

Parameters specific to this body of work are as follows:

- 1) The focus of this thesis is on individual and environmental factors that may contribute to excess child body size. While it acknowledges the wider influences on excess child body size, it does not include a detailed investigation into the influence of epigenetics, family, peers, social norms, or individual factors that arise from psychological or medical co-morbidities.
- 2) When interpreting the results in light of other research in the field, care must be taken as not all measurements are consistent across studies. In this study, waist to height ratio (WtHR) was used as a body size measure. Other common methods for calculating body size in children may be used; these include body mass index (BMI), waist to hip ratio, and BMI standard deviation score (BMI SDS - a standardised measure of BMI for children). The rationale for this approach is discussed in more detail in Chapter 5.
- 3) In this study age was determined by school year. As a result, precise date of birth was not captured and therefore it was not possible to calculate body size using BMI SDS.
- 4) This study was cross-sectional; therefore, the results cannot be used to determine causation.
- 5) This study was conducted in the Auckland region, and as such results may not be generalisable to other regions in NZ. Specifically, this is due to the unique socio-demographic and cultural make up of Auckland. See section on Study Site below.
- 6) The dietary behaviour data were drawn from child self-reports of unhealthy dietary behaviours rather than in-depth, objective measures (e.g., of portion sizes, nutrient profiles, etc.). Children were asked about portion sizes during piloting of the survey and it was clear children were unable to report portion sizes. Therefore, indicator questions regarding frequency of consumption of unhealthy foods and frequency of purchasing food on the way to and from school were used in place. The results of the pilot research showed children were able to recall this information. Nonetheless, the implications are that the data collected can only be used to indicate broad estimates of unhealthy dietary behaviours. The use of weighed food records, 24-hour food recall, detailed diet histories or wearable image capture devices would have captured dietary behaviours in greater detail (Burrows, Martin, & Collins, 2010) however that would have increased participant burden significantly and reduced feasibility of the study.
- 7) Physical activity was measured with accelerometers worn for 7 days at the waist. Waist placement of accelerometers do not capture stationary (e.g. cycling) or load bearing activities well. Accelerometers were also removed for water-based activities; therefore,

swimming and water sports would also have been missed. The results give a snapshot of children's physical activity and must be interpreted with caution. It is likely the results under-estimate children's overall time spent in moderate to vigorous physical activity.

- 8) The environmental features of neighbourhood built environments were limited to those theorised to relate to key outcomes based on previous literature. It is possible other features of the environment contributed to both the physical activity built environment and nutrition built environment but were not measured.

### **Personal Statement of Bias**

As a researcher it is important to acknowledge the biases that are inherent in our research. While the extent of disclosure required by nutrition researchers specifically is often debated (Ioannidis & Trepanowski, 2018; Nestle, 2016), I will take a conservative approach and disclose all possible potential influences on personal bias that I was aware of during the course of thinking about, undertaking, writing up and disseminating the research contained within this body of work.

### **Financial**

I received a domestic student doctoral fee-waiver for part of this thesis from the Faculty of Health and Environmental Sciences at Auckland University of Technology. The Neighbourhoods for Active Kids study, under which research sits, was funded by the Health Research Council of New Zealand (grant number 14/436). I did not experience any bias or conflict of interest on financial grounds.

### **Nutrition**

Recently, Ioannidis and Trepanowski (2018) argue that the personal dietary preferences of nutrition researchers must be acknowledged in addition to financial ones as allegiance bias, advocacy and activism also become part of the role of nutrition researchers. Therefore, I acknowledge that I try to eat a vegetarian diet. Some term this type of diet 'plant-based', however there is no universal consensus on the definition of that term (Williams & Patel, 2017). My dietary preferences do not pose a conflict of interest in this research. One of my supervisors, a New Zealand Registered Dietician, is an advocate of the Low Carb Healthy Fat diet (Schofield, Zinn, & Rodger). Her biases have influenced the development of this thesis by encouraging critical questioning of government and industry nutrition recommendations (Henderson, Zinn, & Schofield, 2017).

When not working or writing this thesis, I volunteer for The Animal Sanctuary (<https://animalsanctuary.co.nz/>) where I play a lead role in the rescue, rehabilitation and rehoming of battery hens. I have seen first-hand the damage caused by factory-farming on the environment and on the animals involved. It is my opinion that large multi-national corporations, specifically those that manufacture ultra-processed, energy dense, nutrient poor food and drink, make profits while animals and the environment suffer. It is likely that my desire to see factory-farming outlawed in NZ, on the grounds of environmental damage and animal welfare, influences my negative perception towards these corporations including, but not limited to, fast-food companies. I acknowledge I view them in a negative light, however I undertook all possible efforts to remain objective and look only at what the data reported.

### **Physical Activity**

Growing up as a child in suburban Sydney, Australia I was free to roam around my neighbourhood. I remember building 'cubbys' in the bush and walking almost 2km each way to get to and from school. I am not fortunate enough to have children of my own and so cannot comment or be personally biased towards parental perceptions of neighbourhood safety and child independent mobility. As an adult I lived in Switzerland for a few years where I enjoyed commuting via an incredibly efficient public transport system, as well as excellent cycling and walking infrastructure. Today, living on the outskirts of Auckland, I make short trips in my neighbourhood on foot or by bike, however longer trips occur in the car. I try to be as physically active as I can. However, in the final stages of writing this thesis I was sedentary. I would like to actively commute more and am often frustrated that the infrastructure in my neighbourhood doesn't support it. During this research I was aware of my personal sense of frustration at the lack of appropriate active transport infrastructure and efforts were made to be as objective as possible when interpreting physical activity and built environment literature as well as the results of my research.

### **Personal Background**

I was raised in Australia, in a household where things were considered black or white. During my undergraduate and master's studies in the early 2000's I saw life through a scientific and biomedical lens. Since then I have learned that life is rarely black and white and to see the world through the full colour spectrum it contains. Using the terms and definitions described by Crotty (1998), I currently position myself as a post-positivist and constructionist researcher. In other words, I value scientific research and the scientific foundation of all things - even those I cannot see, feel and touch. I also accept that as humans we each construct our view of the world based

on our experiences and perceptions of it; and that this too is not static, but ever changing as we age, develop, and learn from our experience of being in the world.

### **Thesis Organisation**

This thesis explores the built environments of varied and diverse neighbourhoods in Auckland, NZ and how they relate to the body size of children. This thesis centres around Chapter 5 'Neighbourhoods matter: Physical activity and nutrition built environments and the body size of children in Auckland, New Zealand'.

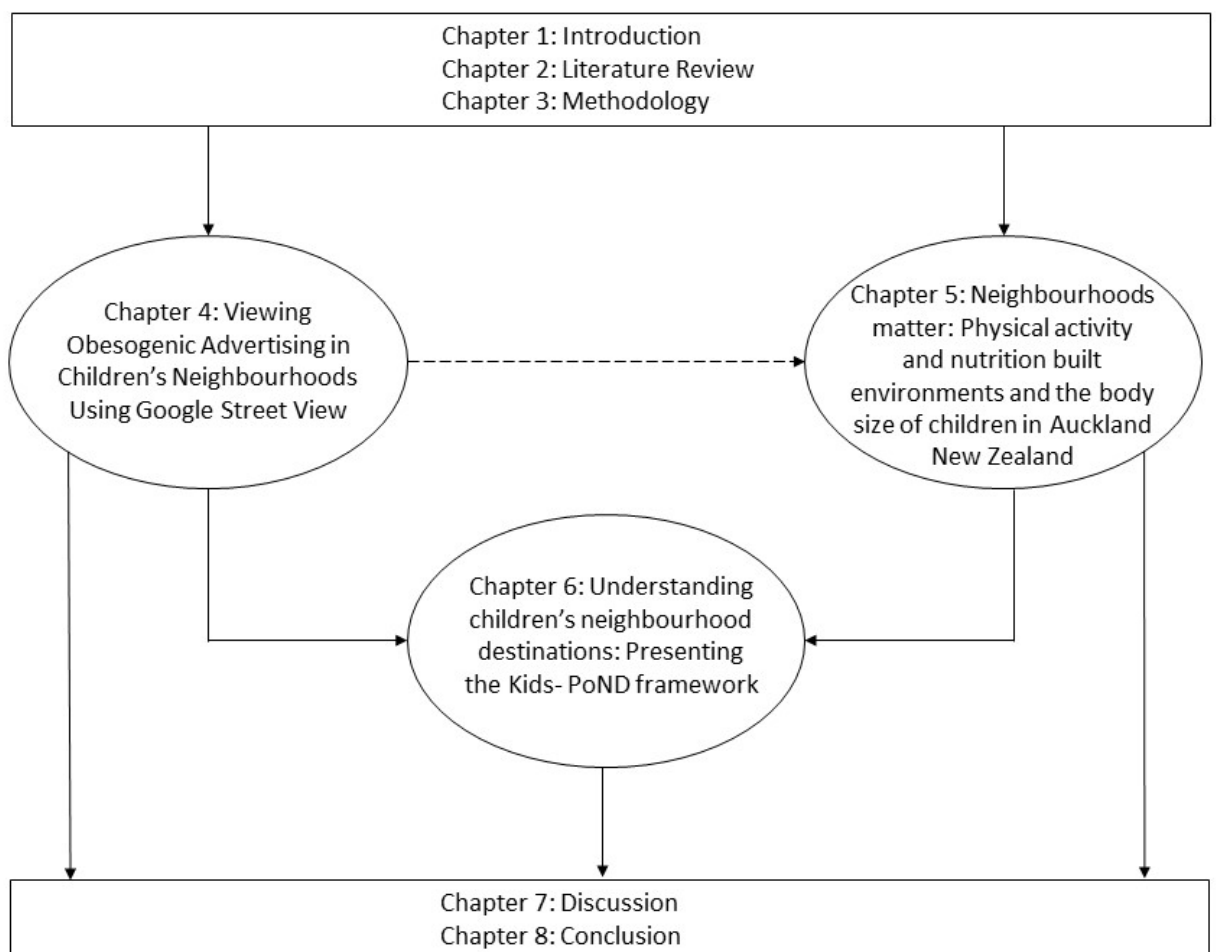
The rationale for undertaking the study is presented above, followed by a literature review in Chapter 2. Further review of the literature is provided in Chapters, 4, 5 and 6 as they specifically relate to each individual study, therefore some sections included in the literature review may be repeated later in the thesis. Chapter 3 outlines the philosophy and theory underpinning this thesis as well as the key tools used to conduct the body of work. Chapter 4 presents the first study, 'Viewing Obesogenic Advertising in Children's Neighbourhoods Using Google Street View'. The rationale for this study arose from the literature review, whereby understanding the role of outdoor food marketing (conceptualised as a component of the nutritional built environment) on children's health behaviours and body size was identified as a knowledge gap. The information from this study was intended to be included as a single item contributing to the latent variable 'Nutrition Built Environment' in Chapter 5, and reasons for the decision not to include it are detailed in the preface to this chapter, in Figure 1.1 below; this is indicated by a dotted line. In Chapter 5, structural equation modelling is employed to examine quantitatively pathways between environmental features, health behaviours, and children's body size. This robust approach yielded new insights regarding links between health behaviours and children's body size. However, understanding the context of these relationships from a child's perspective was lacking. This knowledge was considered essential drawing from the child-centred philosophy of this thesis, and recognising the opportunity to add depth to the quantitative modelling. Thus, Chapter 6 allows children to voice the reasons why neighbourhood destinations are important to them, adding depth and providing important context that further crystallises the findings of Chapters 4 and 5. In Chapter 7 the key findings from all three studies are discussed and critically analysed in line with other research in the field, and implications for future research, urban planning and public health are presented. Finally, Chapter 8 summarises the findings of this thesis and the novel contributions to knowledge achieved in this body of work. The flow between the chapters contained in this thesis is illustrated in Figure 1.1. Arrows indicate the direction of influence.

### Significance and Originality

A key methodological strength of this body of work is the child-centred approach to exploring associations between the neighbourhood built environment and child body size, where quantitative numerical data and open-ended responses are incorporated from a multitude of sources including children, researchers and spatial data, modelled using GIS. This is the first body of work to investigate the relationship between neighbourhood built environments and child body size, drawing conclusions from both quantitative modelling and children's perceptions while also focusing on appropriate child-centred knowledge translation throughout the research process.

Chapter 4 is the first study to document the issues associated with using Google Street View to assess outdoor advertising. At the time of publication, it was the first study to quantify unhealthy food and drink advertising around schools in NZ. Internationally it is the first to investigate links between school walkability and neighbourhood level deprivation with outdoor advertising.

Figure 1.1 Thesis organisation



Chapter 5 was the first study to use structural equation modelling in the analysis of relationships between built environments and body size. Internationally it is the first to explore the neighbourhood built environment and associations with child body size using individualised neighbourhood buffer boundaries. Furthermore, it is also the first to include food purchasing behaviour as a component of dietary behaviour in the nutrition built environment - dietary behaviour - body size relationship. Specific to the NZ context, it is the first to account for the potential mediating influence of individual health behaviours and deprivation on the relationship between neighbourhood built environments and child body size. The findings of this Chapter contribute to the knowledge base by being the first to find a significant inverse relationship between a positive physical activity promoting built environment and a poor nutrition built environment.

Chapter 6 provides unique insights, such as the importance of spending time in neighbourhood destinations with friends and consuming unhealthy food and drink at the shops. These findings further contextualise the results of Chapter 5 and would likely not have emerged without a child-centred approach. The Kids-PoND framework presented in this Chapter is the first child-centred, place-based framework to be developed based on the theory of affordances.

### **Study Site**

This research was conducted in the area of Tāmaki Makarau/Auckland. Māori are the indigenous people of Aotearoa/New Zealand and they use the name Tāmaki Makarau for the area also known as Auckland. Tāmaki Makarau literally translates as *“Tamaki - the bride sought by a hundred suitors”* referring to the fertile volcanic soil of the land suitable for growing crops, and the coastlines to the East and West abundant with seafood. Tāmaki Makarau/Auckland, hereafter referred to as Auckland, is the largest city in Aotearoa, hereafter referred to as New Zealand (NZ), with a population of approximately 1.5 million people; roughly a third of all New Zealanders usually reside in Auckland, and approximately 21% of those are aged under 15 years (Statistics New Zealand, 2013).

The Auckland metropolis is situated on an isthmus between two natural harbours. It is a city of contrasts with high density city living, sprawling housing developments and traditional beachside settlements all fringed by harbours dotted with islands, subtropical rainforests and fertile farm land (Gu, 2010). Auckland is composed not only of contrasts in land use type but of contrasts of wealth. The results from the most recent census reveal that Auckland contains the

richest areas in New Zealand, and the poorest, often juxtaposed in close geographic proximity to each other (Exeter, Zhao, Browne, & Lee, 2016).

Auckland is busy and diverse with large numbers of immigrants from the Pacific and Asia (Auckland Council, 2014). The city is vibrant and multi-cultural, with 39% of all immigrants in NZ usually residing in Auckland (Statistics New Zealand, 2013; Tse, 2017). In NZ, ethnicity refers to the ethnic group people feel a belonging to and is a measure of cultural affiliation rather than biological race or ancestry (Statistics New Zealand, 2004). In NZ people can belong to more than one ethnicity and thus it is common for ethnicity statistics to reach cumulative sums over 100%. According to the 2013 census, 59% of people living in Auckland reported being of European ethnicity, 23% Asian, 15% Pacific peoples, 11% Māori, 2% Middle Eastern, Latin American and African, and 1% other ethnicity (Statistics New Zealand, 2013). This is in contrast to the rest of NZ which has a much greater proportion of people reporting European ethnicity (74%) and less reporting Pacific (7%) and Asian (11%) ethnicities.

Auckland is the most highly populated area in NZ, covering 4939 square kilometres including offshore islands (Auckland Council, 2016). Population density, a general measure of housing intensity, varies considerably in Auckland, both within and across local government areas. The Auckland average population density is 1020 people per 1km squared, however this can increase to 10,915 in some parts of Central Auckland (Auckland Council, 2014). Some of the variation in Auckland's population density can be accounted for by methodological limitations. When calculating population density Auckland Council incorporates the entire land area, irrespective of what proportion of the land area is zoned for residential use (Auckland Council, 2014; Maré, Coleman, & Pinkerton, 2011).

Approximately 21% of the population in Auckland are children aged 0 – 15 years (Statistics New Zealand, 2013). It is mandatory in NZ for children to be enrolled in school by six years of age and it is common for children to start school around their fifth birthday. The schooling system comprises 13 years in total. Most children attend publicly-funded state schools, where financial contributions from parents can include uniforms, some text books and stationery as well as external activities like school excursions, but do not normally include fees for education (Witten, McCreanor, Kearns, & Ramasubramanian, 2001). In NZ, schools are more than just places children go to learn; they function as central hubs for dissemination of local knowledge and information and play an important role in community cohesion (Witten et al., 2001). Likewise, out of official school hours, school grounds often function as public open spaces and when

permitted become additional parks, playgrounds, function halls and community resources (Nielsen, Taylor, Williams, & Mann, 2010).

### **Neighbourhoods for Active Kids (NfAK) Study and Independent Contributions**

This research will include some data from the Neighbourhoods for Active Kids (NfAK) study. My independent contributions to the NfAK study and Chapters 4, 5 and 6 are as follows:

- 1) I was part of the team of trained researchers that went into schools to collect data.
- 2) I led the modelling for one of the key outcomes of the research (see Chapter 5). This involved completing a literature review, conceptualising the SEM modelling framework, developing a study-specific database, undertaking analyses, interpreting results, and preparing and submitting a manuscript for publication.
- 3) In Chapter 6, I conceptualised a new framework that complements the aims of the NfAK study. This aligned with the NfAK research but was new and additional to the original scope of work.
- 4) For the study presented in Chapter 4, I conceptualised a complementary study to measure the outdoor advertising around the schools. This was not part of the original NfAK study. I conceived the idea, planned the project, developed, tested, and refined the methodology for data collection and interpretation, developed a training manual, trained researchers, and led all aspects of this piece of work.

Detailed information regarding methods and variables specific to each empirical study are outlined in their respective chapters.

NfAK is a cross-sectional study conducted in Auckland, NZ between March 2015 and November 2016. Participants were children attending school in Years 5 to 8. Children were recruited through intermediate (junior high) schools (years 7-8, approximate ages 11-12 years) and a contributing primary (elementary) school (years 5-6 only, approximate ages 9-10 years) across nine neighbourhoods. Detailed information regarding the NfAK study design and methodology can be found in the study protocol by Oliver, McPhee, et al. (2016). Eligibility for inclusion in NfAK can be seen in Table 1.1 over the page.



Table 1.1 Recruitment and eligibility screening of child participants

|                               | n    | %    | Cumulative % |
|-------------------------------|------|------|--------------|
| Eligible, include participant | 963  | 38.0 | 38.0         |
| Non-consent                   | 1040 | 41.0 | 79.0         |
| Non-eligible                  | 21   | 0.80 | 79.9         |
| School ID 22 and 23*          | 510  | 20.1 | 100          |
| Total invited participants    | 2534 | 100  | 100          |

\*These additional two schools were recruited using a different criterion than the NfAK protocol (i.e., did not fit with the matrix described below) but are still included in the analysis. Further detail on inclusion criteria can be found in the preface for Chapter 6.

Neighbourhoods were selected through utilisation of a matrix to maximise variation in socioeconomic and neighbourhood built environment characteristics. Selection criteria were employed by construction of neighbourhood-level child specific, built environment measures. Specifically, these included diversity in destination accessibility, walkability, and school decile. The density of destinations that may be important to children was measured using the Neighbourhood Destination Accessibility Index – Child described in detail by Badland, Donovan, Witten, Oliver, and Chaudhury (2015). A child-specific measure of walkability that included the extent to which it is easy to get around by walking or cycling, including both walking paths and street connectivity, was also used (Giles-Corti et al., 2011). School decile was used as an indicator of area level socioeconomic status. In NZ, every school is given a decile rating from 1 -10 as a measure of the socioeconomic position of a school's student community relative to other schools throughout the country. A school with a decile rating of 1 reflects a low socio-economic community, and a decile rating of 10 reflects a high socio-economic community (Ministry of Education, 2016). While school decile is an imperfect measure of community socioeconomic deprivation (Exeter et al., 2016), it functions as a basis for government funding, with schools from low socio-economic communities receiving proportionally more funding per student than schools from communities of high-socioeconomic status (Ministry of Education, 2016).

The information collected with children includes: body size, accelerometry, interactive mapping and a PPGIS survey. Additional information including child ethnicity and school decile, was obtained through the New Zealand Ministry of Education (Education Counts, 2018). GIS measures were calculated using datasets obtained from Land Information New Zealand and Auckland Council and geocoded participant addresses.

### Literature Review

*“The more that you read, the more things you will know. The more that you learn, the more places you’ll go.” Dr. Seuss (1978) I Can Read With My Eyes Shut!*

#### Introduction

Research suggests that neighbourhoods, specifically physical activity and nutrition built environments, may influence children’s physical activity, nutrition behaviours, and body size. It is acknowledged that physical activity and diet are not the whole sum of the child body size equation, however they are the focus of this thesis. Physical activity built environments either constrain or promote individual physical activity. Likewise, the accessibility of food outlets selling unhealthy food and drink combined with advertising for these products normalises consumption and might influence dietary behaviour. This chapter provides a review of the current evidence on neighbourhoods and children’s health, specifically body size, with a focus on neighbourhood definition and deprivation, physical activity built environments and nutrition built environments. Background information on the measurement tools used in this study to describe and capture physical activity and nutrition built environments is also detailed.

#### Child Body Size in New Zealand

Globally and in NZ the growing body size of children is a public health concern (S. Kelly & Swinburn, 2015). In NZ prevalence of overweight and obesity varies by ethnicity, deprivation and age. In the 2016/17 NZ Health Survey 19.9% of Asian children were classed as overweight or obese compared with 61.1% of Pacific children and 43.8% of Māori children (Ministry of Health, 2017a). There is evidence that Māori and Pacific people have different body compositions for a given body mass as compared with other ethnic groups in NZ, (J. S. Duncan, Duncan, & Schofield, 2010; Rush et al., 2004) with the resulting implications that overweight and obesity may be overestimated in these populations. However, research is divided – for example, Taylor et al. (2010) in a study of over 1500 adults, concluded that having a different BMI or waist circumference cut-off for people of Māori and Pacific descent is not warranted. Like other indigenous people worldwide, Māori are disproportionately affected by excess body weight (I. Anderson et al., 2016). There are additional differences too, where Māori children who were malnourished and underweight as infants (0-2 years) are more likely to become overweight or

obese later in life, than Māori children who were a healthy weight as infants (Grant, Wall, Yates, & Crengle, 2010). Differences in body size are also known to be associated with deprivation (Grow et al., 2010). After adjusting for age, sex and ethnicity, children living in the most deprived areas of New Zealand are five times more likely to be obese than children living in the least deprived areas (Ministry of Health, 2015). Age differences in overweight and obesity status are also observable in NZ children, with increased likelihood of overweight and obesity occurring linearly as children grow up (Hodgkin, Hamlin, Ross, & Peters, 2010).

Being underweight, overweight or obese in childhood and adolescence is associated with adverse health consequences over the life-course (Abarca-Gómez et al., 2017). Obese children are five times as likely to be obese adults (Simmonds, Llewellyn, Owen, & Woolacott, 2016), and children who go on to be obese adults have increased risk of a range of diseases including type 2 diabetes, hypertension, heart disease and respiratory diseases as well as sociopsychological conditions such as negative self-esteem, behavioural problems, anxiety and depression (Abarca-Gómez et al., 2017). The economic costs of overweight and obesity are sizable. The most recent estimates suggest overweight and obesity cost NZ \$686 million in annual health care costs (or 4.5% of the total health care expenditure) (Lal, Moodie, Ashton, Siahpush, & Swinburn, 2012).

## **Deprivation**

In NZ the observable and demonstrable differences in the level of social and material disadvantage in communities is termed 'deprivation' (Clare Salmond & Crampton, 2012). The comparative difference between communities of low deprivation and communities of high deprivation is social inequality. Links between deprivation and overweight and obesity are complex. However, the social inequalities in overweight and obesity prevalence are consistently present across all Organisation for Economic Co-operation and Development (OECD) countries, despite being culturally, demographically and politically varied (Devaux & Sassi, 2011).

The link between deprivation and poor health outcomes has been known since Dr Johann Frank in 1790, lecturing to a group of graduating medical physicians, attributed the 'Mother of Diseases' to 'People's misery' – or their deprivation (Sigerist, 1941). Deprivation and inequitable distribution of wealth are known to influence overall health outcomes for populations (Lobstein et al., 2015) and their role in the environment-child body size relationship in NZ warrants further investigation. Deprivation in NZ is commonly measured by using area-level measures that capture a range of factors e.g., household income, education levels, access to transportation

and services. These measures include the New Zealand Deprivation Index 2013 (NZDep2013) (Atkinson, Salmond, & Crampton, 2014), Index of Multiple Area-Level Deprivation (IMALD) (Exeter et al., 2016), and school deciles (Ministry of Education, 2016).

NZDep2013 estimates the comparative socioeconomic deprivation of an area (Atkinson et al., 2014). The NZDep2013 is simple to administer and thus a useful tool for governments and health departments (Salmond & Crampton, 2012). Data are calculated at the meshblock level from the NZ census. Meshblocks are the smallest geographical units where data is captured by Statistics NZ. NZDep2013 provides ordinal scale ranges from 1 to 10, where 1 represents the areas with the least deprived scores and 10 the areas with the most deprived scores. These scores are composite from a number of deprivation indices including: income, communication, employment, qualifications, owned home, support, living space and transport (Atkinson et al., 2014). NZDep2013 has been shown to be applicable across all ethnic groups in NZ with good validity (Salmond, Crampton, & Atkinson, 2007). It was first developed in 1994 from data collected in 1991 (Salmond, Crampton, & Sutton, 1998) and has been regularly updated to reflect the current situation in NZ (Atkinson et al., 2014). The NZDep2013 is the measure of neighbourhood level deprivation used in this study.

School decile ratings in NZ give each school a 1-10 ranking (1= low, 10= high) indicating the extent to which the school draws its students from low socioeconomic communities (Ministry of Education, 2016). This means a decile 1 school comes from the 10% of schools in NZ with the highest proportion of students from highly deprived communities. Conversely, a decile 10 school comes from the 10% of schools with the lowest proportion of these students. School deciles are used predominantly for government allocation of funding and cannot be used as a sole indicator of area level deprivation (Ministry of Education, 2016).

Another area level measure of neighbourhood deprivation for NZ has recently been developed, the Index of Multiple Area Level Deprivation (IMALD). It is expected that the IMALD will soon replace NZDep2013 as the common deprivation measure in public health and urban planning research in NZ (Exeter et al., 2016). The IMALD, developed by Exeter et al. (2016) uses data from national health, social, education, police and geospatial databases as well as NZ census data to analyse seven domains of deprivation: income, employment, crime, housing, education and geospatial access. The IMALD uses zones, rather than traditional mesh blocks or census area units. Zones comprise approx. 500-1000 people with an average of 730 people per zone. They have been tested against mesh blocks and census area units and findings showed more

consistent units for analysis, with less variability in regard to homogeneity of populations, while still being compact enough to provide adequately detailed data (Zhao & Exeter, 2016).

In NZ area-level deprivation across ethnicities is not equally distributed. According to most recent estimates, Māori and Pacific children are more likely to reside in areas of high deprivation than NZ European and Asian children (Marriott & Sim, 2015). Health outcomes are also not normally distributed by ethnicity, with Māori and Pacific children being more likely than NZ European children to suffer poor health consequences associated with deprivation, including but not limited to: infectious skin diseases (Hobbs et al., 2017), rheumatic fever (Gurney, Stanley, Baker, Wilson, & Sarfati, 2016), otitis media (Anderson, Wynter, Grant, Stewart, et al., 2017) and dental caries (Shackleton et al., 2018).

Neighbourhood built environments also vary by deprivation. Nutrition built environments have been clearly shown to vary by area level deprivation. In the USA (Cooksey-Stowers, Schwartz, & Brownell, 2017), UK (Maguire, Burgoine, & Monsivais, 2015) and Australia (Thornton, Lamb, & Ball, 2016) it is common for greater access to unhealthy food outlets, like fast food restaurants to occur in more deprived neighbourhoods than in less deprived neighbourhoods (Sushil, Vandevijvere, Exeter, & Swinburn, 2017). Differences between physical activity built environments and deprivation are less clear (Schüle & Bolte, 2015) and this is likely due to differences in study design and location.

### **Health Behaviours**

Children's body size is influenced by a range of factors, including physical activity and diet. Engaging in recommended levels of physical activity and eating a healthy diet are associated with maintenance of a healthy weight as well as good overall health and wellbeing outcomes (Janssen et al., 2005). Defining 'sufficient' levels of physical activity for children has been conceptualised using a number of different metrics, most commonly time spent in moderate-vigorous physical activity, time spent sedentary or number of steps taken per day. Likewise, consumption of unhealthy foods, those that are highly processed and nutrient poor, such as sugar sweetened beverages, and other junk foods like chips, lollies and cakes, have been shown to contribute to excess body weight, as well as a range of poor health outcomes.

### **Health Behaviour: Physical Activity**

Physical activity is an important health behaviour that is connected to a range of health outcomes including, but not limited to, body size (Strong et al., 2005). While it is true that dietary

behaviours play a greater role on body size outcomes than physical activity (Malhotra, Noakes, & Phinney, 2015), the dietary behaviour - physical activity relationship is inextricably intertwined. Research with children shows engaging in regular physical activity is related to a range of psychological factors that may also impact in body size indirectly; specific examples include the effect of regular physical activity on positive mood (Poitras et al., 2016), self-esteem (Slutzky & Simpkins, 2009), self-efficacy (Miller, Ogletree, & Welshimer, 2002) and identity (Allender, Cowburn, & Foster, 2006). This is worth considering as psychological factors have also been linked to body size in a systematic review of studies on children and adolescents (Sanders, Han, Baker, & Cobley, 2015). However, aside from the connection between symptoms of depression and lower rates of physical activity (Zahl, Steinsbekk, & Wichstrom, 2017), the directionality of causation has yet to be comprehensively and definitively determined (Bryan et al., 2017; Sallis, Prochaska, & Taylor, 2000). Given the tangled connection between physical activity and body size, knowing what it is, how it is measured and how much it is recommended for children is important for child health researchers to understand.

The most recent NZ physical activity report card showed that 7-39% of children and young people participate in 60 minutes of MVPA per day, while 9-61% of children and young people watch less than 2 hours of screen time per day (Smith et al., In Press). Different regulatory health and sporting bodies provide different physical activity minimum recommendations for children at different age groups. For children aged 5-17 years, the New Zealand Ministry of Health and Sport New Zealand recommends 60 minutes of moderate to vigorous physical activity (MVPA) every day of the week (Ministry of Health, 2016; Sport New Zealand, 2012). These recommendations are based on the activity patterns of children, where children usually participate in short bouts of MVPA followed by a period of rest (Bailey et al., 1995). Concurrently a reduction in sedentary time is also recommended (Ministry of Health, 2016; Sport New Zealand, 2012). The New Zealand Ministry of Health specifically recommends reducing screen time to less than 2 hours per day, and encouraging less sitting and more light physical activity (Ministry of Health, 2017c).

As it is difficult to quantify 'less sitting and more light physical activity' (Ministry of Health, 2017c) step counts can be a useful tool to measure average physical activity levels throughout the day. According to a recent systematic review, the optimal step count for children is 12,000 steps per day (Tudor-Locke et al., 2011), with associations between step count and adiposity also being well established (Miguel-Berges, Reilly, Aznar, & Jiménez-Pavón, 2018). However, NZ based research suggests this step count is too low and recommends 16,000 steps/day for boys and

13,000 steps/day for girls as optimal cut-off points (Duncan, Schofield, & Duncan, 2007). Furthermore, findings reveal overweight children have significantly lower overall step counts than their non-overweight peers and that recommended step counts to reduce adiposity in children should be 1000 steps/day higher than the aforementioned recommendations (J S Duncan et al., 2007).

Across the life course it is important to engage in minimum recommendations of physical activity to obtain and maintain good overall health (Strong et al., 2005; Warburton, Nicol, & Bredin, 2006; World Health Organization, 2010). In addition to the physical benefits to growth and motor development (Hills, King, & Armstrong, 2007), physical activity also influences bone mineral density (Boot, de Ridder, Pols, Krenning, & de Muinck Keizer-Schrama, 1997), blood glucose profiles (Anderson, Wynter, Treves, et al., 2016), and blood pressure in children (Andersen et al., 2006). Research has also reported additional benefits to academic performance and social relationships among children who participate in the above recommendations for physical activity (Donnelly et al., 2016; Poitras et al., 2016).

While the benefits of engaging in physical activity are well known, researchers are faced with practical measurement issues and challenges in obtaining objective physical activity data. This research focuses on objective physical activity data, however it is acknowledged that there is a broad field of physical activity measurement methods such as subjective adult-centric approaches, such as parent report and children's self-report (Sirard & Pate, 2001). Part of the standard protocol to wearing accelerometers requires participants to also complete a compliance log, noting non-wear time and this adds to participant burden. Additionally, focus group research shows that while children find it fun to wear accelerometers, hip placement is often reported as uncomfortable (Guerrero, Hoffmann, Munroe-Chandler, & Hall, 2016). Alternative accelerometer placement locations have been investigated such as on the wrist (Fairclough et al., 2016) and thigh (Fortune, Lugade, & Kaufman, 2014), as well as using a medical adhesive tape to directly attach the accelerometers to the skin (Schneller et al., 2017). Issues with objectivity and compliance occur regardless of the method used. Hip mounted accelerometers don't capture cycling activities or load carriage, so they are unable to provide data on energy expenditure. Placing accelerometers on the wrist may be more comfortable for children, however this prominent placement likely reminds them to move more thus reducing objectivity of the data collected. Likewise, while thigh placement of accelerometers has been shown to provide the greatest accuracy for walking, fidgeting and jogging (Lugade, Fortune, Morrow, & Kaufman, 2014) attachment issues exist and allergic reactions to tapes used to

adhere accelerometers on the skin have been reported (Stanton, Guertler, Duncan, & Vandelanotte, 2014), as well as increased likelihood of accelerometers ‘falling off’ particularly when attached to the back (Schneller et al., 2017). Results of studies using accelerometers, must therefore be interpreted with caution, noting that the data may likely overestimate the usual amount of movement for a given period, and due to limitations from poor compliance to both wear time and logs, account for missing data.

### **Health Behaviour: Diet**

A healthy diet, including one rich in fruit and vegetables, is associated with reductions in all-cause mortality, cancer and cardiovascular disease risk (Aune et al., 2017), while a diet high in energy dense, nutrient poor, ultra-processed foods and frequent consumption of sugar-sweetened beverages is linked with increased likelihood of excess body size and ill health (Janssen et al., 2005; Malik, Pan, Willett, & Hu, 2013; Vernarelli, Mitchell, Rolls, & Hartman, 2015). In NZ, the recommendations for a healthy diet are more complex than those for physical activity. The physical activity recommendations included in the NZ Ministry of Health 2012 nutrition guidelines specify nine recommendations for healthy eating for children and young people (aged 2 – 18). These are: 1) eating a variety of foods from each of the four food groups (cereals, vegetables and fruits, dairy, meats) each day; 2) eat to maintain a healthy body size; 3) consume snacks and drinks that are low in fat, low in sugar and low in salt; 4) drink plenty of water throughout the day, including low-fat milk but limit sugar sweetened and fizzy drinks; 5) alcohol is not recommended; 6) eat with family often; 7) encourage children to be involved in food purchasing, growing and preparation; 8) store and prepare food safely; 9) participate in minimum recommendations of physical activity (Ministry of Health, 2012).

The Ministry of Health (2012) guidelines for children and young people are the most up-to-date nutrition recommendations for this population group in New Zealand. They have been modelled off the adult population dietary guidelines developed in the 1980s, based on the national dietary guidelines in the USA and UK with the aim to reduce cardiovascular disease through a reduction in dietary fat intake (Harcombe et al., 2015). These guidelines have since gone on to function as easy-to-understand information on healthy eating for a varied and culturally diverse population and are used as the basis for dietary guidance dispensed in both public health and clinical settings. However, the evidence base for the current US, UK and NZ dietary guidelines for adults has received criticism, specifically regarding the promotion of low-fat foods and a diet based mostly on carbohydrates (Beck, Heyman, Chao, & Wojcicki, 2017; Henderson et al., 2017; Teicholz, 2015). These criticisms are not specifically targeted at the guidelines for children and



young people however the key concepts also apply. Furthermore there is no specific reference to junk food, take away food, chips, cakes, lollies or sweets in the guidelines, despite the significant evidence associating consumption of these products with poor health outcomes in both adults and children (Rosenheck, 2008).

In the Ministry of Health (2012) guidelines, item 3 recommends children eat snacks and drinks that are low in fat, sugar and salt. However, a relatively high degree of food literacy is needed to understand what this means in practice. Food literacy refers to the everyday practicalities of knowledge and understanding related to healthy eating (Vidgen & Gallegos, 2014). How many snacks should children have per day? What is 'low'? Does this mean children should be eating lots of snacks a day, but not eat fruit, because fruit has too much sugar? The recommendation encouraging snacking in children does not appear to be based on evidence and indeed recent research shows snacking leads to excess body size, particularly in children (Rodenburg, Kremers, Oenema, & van de Mheen, 2014). Likewise not all types of fat have the same impact on the body; some fats from fish are likely to protect against CVD and others such as trans-fat promote it (Michas, Micha, & Zampelas, 2014). Additionally, there are aspects that are particularly important to children's health that do not feature in the guidelines; notable examples include dietary fibre (Reddy, 2018) and iron (Abbaspour, Hurrell, & Kelishadi, 2014). An additional important field of nutrition research, with potentially great impact on dietary guidelines includes the influence of gut health and the microbiome (De Filippo et al., 2010; Kau, Ahern, Griffin, Goodman, & Gordon, 2011). Also important to note is the benefit to health from social aspects of eating, as well as cultural and religious influences. For children eating meals with family members often results in a decreased likelihood of overeating, as well as an increased likelihood of eating a healthy meal containing vegetables (Teevale & Kaholokula, 2016).

Studies of food literacy and consumers' understanding of food labels indicate that large proportions of the adult population have difficulty interpreting food labels to look for information regarding fat, sugar and salt content (McLean & Hoek, 2014; Volkova & Ni Mhurchu, 2015). Research has yet to be conducted with children to quantify their understanding of food labels, however it is known that children are greatly affected by junk food marketing and show preference for unhealthy food and drinks that are marketed directly to them (Ogba & Johnson, 2010; Sadeghirad, Duhaney, Motaghipisheh, Campbell, & Johnston, 2016). Comprehension and everyday application of healthy eating guidelines for children may be increased if item 3 was replaced with a more specific statement of limiting consumption of junk food, chips, sweets,

cakes, lollies and other ultra-processed food, however further research to determine this is required.

Children are exposed to advertising for unhealthy food and drink on their screens (Kelly, Vandevijvere, Freeman, & Jenkin, 2015), in food outlets (Signal, Stanley, et al., 2017), in schools (Signal, Stanley, et al., 2017), during physical education classes (D. Powell, 2014), and outdoors in their local neighbourhoods (Egli et al., 2018; Vandevijvere, Malloy, Hassen de Medeiros, & Swinburn, 2018). The majority of food and drink products that are marketed to children are energy dense, ultra-processed and unhealthy (Cairns, Angus, Hastings, & Caraher, 2013; Signal, Stanley, et al., 2017). Therefore, it is unsurprising that children's food preferences are heavily influenced by marketing and advertising (Boyland & Whalen, 2015; Sadeghirad et al., 2016). Children are known to influence the food purchasing behaviour of parents (Hartmann, Cash, Yeh, Landwehr, & McAlister, 2017; G. Wilson & Wood, 2004), however less is known about what children purchase, where they purchase food and if the purchasing behaviour is independent or accompanied by a parent or guardian. The location of unhealthy food outlets near schools has been linked to lunchtime food purchasing behaviour and consumption (Seliske, Pickett, Rosu, & Janssen, 2013) and the within school food environment (Walton, Pearce, & Day, 2009). Additionally, studies report that nutrition built environments with more opportunities for purchasing unhealthy food result in increased likelihood of having excess body size (Zick et al., 2009). However, the link between unhealthy food outlet location and unhealthy food purchasing behaviour and consumption in children is understudied.

### **Behaviour Change Interventions**

Worldwide and in NZ, there is much support from governments, clinicians and schools for behaviour change interventions designed to increase physical activity, reduce sedentary time and improve healthy eating in children (Lewis, Napolitano, Buman, Williams, & Nigg, 2017; Reis et al., 2016). Behaviour change interventions are defined as coordinated activities that are designed to change precise behaviour patterns (Michie, van Stralen, & West, 2011). These are often targeted to the micro-level of the individual child or school (Mead et al., 2017) and in some cases family and community (Anderson, Wynter, Grant, Cave, et al., 2017) with great variations in success (Mead et al., 2017). Behaviour change interventions targeted to the individual level usually focus on individual motivation and capability; that is, having the incentive and ability to make decisions to implement the knowledge and skills needed to make the desired behaviour change (Michie et al., 2011). Recently a cluster randomised control trial of a school-based physical activity and dietary behaviour modification intervention of 9 and 10 year olds found

*“despite a theoretically informed and extensively piloted intervention that achieved high levels of engagement, follow-up, and fidelity of delivery, we found no effect of the intervention on preventing overweight or obesity”* (Lloyd et al., 2018, p. 5). This important study illustrates the need for child overweight and obesity prevention programmes to move beyond the dogma of individual responsibility for health behaviours to include wider systematic approaches including a focus on environments. Behaviour change interventions targeted to the macro-level of the environment are those that occur at the level of community, organisation and wider national policy levels (for more information on these different levels please refer to the section on the socioecological model in Chapter 3).

Of relevance to nutrition behaviour is the idea of ‘individual choice’ and individual responsibility for food consumption. This idea is mirrored in physical activity, with notions of ‘individual responsibility’ and public and clinician perceptions of people with excess body weight as ‘lazy’ (Brownell et al., 2010; Schwartz, Chambliss, Brownell, Blair, & Billington, 2003). These ideologies of ‘choice’ and ‘individual responsibility’ are greatly influenced by the prevalence of neoliberalist dogma and laissez-faire economic markets that cumulate in government and clinician promotion of behaviour change interventions targeted to the level of the individual (Otero, Gürcan, Pechlaner, & Liberman, 2018) (Neoliberalism is discussed in detail in Chapter 3). These beliefs have been predominantly based upon the Health Belief Model (Becker, 1974) and Social Cognitive Theory (Bandura, 1986). Despite the prevalence of these beliefs and the many and varied health behaviour interventions targeted to the level of the individual, prevalence rates of both adult and child overweight and obesity in countries with widespread neoliberalist economies remain high (Abarca-Gómez et al., 2017; Davies, 2016).

A recent Cochrane systematic review has shown that behaviour change, including both diet and physical activity interventions, targeted to the level of the individual report only small, short-term benefit to body size outcomes (Mead et al., 2017). In addition to this small reported effect size is publication bias. Publication bias occurs across all fields of science where studies that yield positive results are more likely to be written up, successfully published and thus eligible for inclusion in systematic reviews, than studies where the intervention showed no result or a negative outcome (Franco, Malhotra, & Simonovits, 2014). In an attempt to capture studies that may show no result, clinical trial registers are included in Cochrane reviews (Mead et al., 2017), however the majority of childhood obesity interventions do not contain a true control group and/or are conducted in community settings (Mead et al., 2017; van Sluijs, McMinn, & Griffin, 2007). The result of this is all childhood obesity interventions are unlikely to be included in the

Clinical Trials Registry. Of note is the fact that none of the studies included in both the 2007 and 2017 systematic review of childhood obesity interventions accounted for deprivation (Mead et al., 2017; van Sluijs et al., 2007).

Falling outside the scope of these reviews is the childhood obesity randomised control trial Whānau Pakari, conducted in Taranaki, NZ (Anderson, Wynter, Grant, Cave, et al., 2017). This community-based intervention showed a reduction in BMI SDS score for overweight child participants and displayed improvements in cardiovascular fitness and self-reported quality of life. Unlike previous childhood obesity intervention studies, Whānau Pakari also accounted for deprivation (Anderson, Wynter, Grant, Cave, et al., 2017). As individual-level behaviour change interventions do not consistently show beneficial results (Anderson et al., 2015; Mead et al., 2017), a wider investigation that includes interventions targeted to the level of the environment is needed.

It may be that built environment interventions offer greater promise for sustained behaviour change compared to interventions targeted to the individual because they offer greater reach, and maintenance at the population level. The reach, efficacy, adoption, implementation, maintenance (RE:AIM) framework, developed by Glasgow, Vogt, and Boles (1999), provides a useful framework for evaluating health behaviour modification interventions. The benefit of built environment interventions is they reach all people who are exposed. Additionally, the maintenance of any health behaviour change is more likely to be sustained long-term in built environment interventions. This is contrary to individual-level interventions where changes in behaviour are seen during the intervention period and commonly accompanied by recidivism after the intervention period ends.

Opportunities exist for investigation into the potential for multi-component behaviour change interventions that include interventions at both the individual and environmental levels. This is discussed in more detail in Chapter 8. However, before multi-component, multi-level behaviour change interventions are investigated, there is a need for greater understanding of the potential influence of the neighbourhood built environment on child body size.

### **The Built Environment**

Public health research has documented relationships between urban built environment factors and population health since John Snow removed the handle of the Broad Street water pump in 1849 (Musa et al., 2013). Built environments are the living spaces created and modified by

people. They include homes, schools, workplaces, recreation areas, business areas, services and roads (Srinivasan, O'Fallon, & Dearry, 2003). Built environment factors have been acknowledged as playing an intervening role in population obesity prevalence through their effect on physical activity (Gilliland et al., 2012; F Li et al., 2008; Sandy, Tchernis, Wilson, Liu, & Zhou, 2013) and dietary behaviours (Lamb, Thornton, Olstad, Cerin, & Ball, 2017; Pitt, Gallegos, Comans, Cameron, & Thornton, 2017). Swinburn, Egger, and Raza (1999) termed these environments that promote overeating, including consumption of energy dense, nutrient poor, processed food and sugar-sweetened beverages, and discourage physical activity, *obesogenic*.

Neighbourhood built environments are important because children spend a greater proportion of time in their neighbourhood than adults (Sellström & Bremberg, 2006). While adults may live in one neighbourhood and drive to another, children's mobility is more limited (Malone, 2013). Children interact to a larger extent with their neighbourhood, have more social connections and exchanges within them and have the potential to be more affected by them (Schoeppe et al., 2015). A systematic review of multi-level studies determined that built environment interventions in deprived neighbourhoods can reduce overall health risks to children (Sellström & Bremberg, 2006). The research contained within this thesis seeks to generate greater understanding of the neighbourhood built environment features that influence the body size of New Zealand children. There is an expectation that results will be used to inform future urban design, community public health interventions and policies and government regulations at both local and national levels.

Neighbourhood built environments, specifically the physical activity built environment and nutrition built environment, as well as different methods of defining and measuring them, are discussed below.

### **The Neighbourhood**

The neighbourhood built environment has been shown in systematic reviews to influence physical activity levels of adults (Curl, Kearns, Macdonald, Mason, & Ellaway, 2018; Kärmeniemi, Lankila, Ikäheimo, Koivumaa-Honkanen, & Korpelainen, 2018) and children (Faulkner, Buliung, Flora, & Fusco, 2009; MacMillan et al., 2018; Smith, Hosking et al., 2017). Research is also beginning to demonstrate links between the built environment and diet, specifically with a focus on food outlets (Thornton, Crawford, Lamb, & Ball, 2017; Thornton et al., 2016; Timperio, Crawford, Leech, Lamb, & Ball, 2018; Vandevijvere, Sushil, & Swinburn, 2016) and advertising

(Sainsbury, Colagiuri, & Magnusson, 2017). Neighbourhoods are important for children because of their relationship with promoting or constricting health behaviours.

The location of schools within neighbourhoods is also important to consider. Research has shown that more centrally located schools, i.e., those that are located in town centres, near amenities and with a relatively equal radius to housing areas, are likely to have a greater proportion of children who walk to/from school than schools located on the outskirts or urban fringes of neighbourhoods (Kim & Lee, 2016). In NZ some schools have strict catchment zones, meaning that children must reside within a designated area around the school to be eligible to enrol (Education Counts, 2018). The zoning of schools is another issue for consideration for researchers, specifically in regard to transportation options, deprivation, equity and freedom of parental choice (McCulloch, 1991; Rehm & Filippova, 2008). In addition to facilitating active transport, schools are important sites for physical activity accumulation both in and out of school (Bürge, Tomatis, Murer, & de Bruin, 2016). Research by Bürge et al. (2016) indicates that all schools, irrespective of neighbourhood socioeconomic status, are important sites for accumulation of physical activity in children.

Measuring and defining the 'neighbourhood' is fraught with challenges. Neighbourhoods are not constant across time, culture or location and difficulties arise when attempts are made to enable comparison between neighbourhoods. The dilemma of neighbourhood definition and measurement has been aptly termed 'the constant size neighbourhood trap' by Vallée, Le Roux, Chaix, Kestens, and Chauvin (2015). Neighbourhood has traditionally been defined and calculated using census units or block groups, both of which are authoritative constructs, useful for government bodies and urban planning departments, but with limited day-to-day relevance to residents (Dietz, 2002). These areas are often calculated based on availability of administrative data and may not represent 'true' neighbourhood environments where individuals are exposed to factors of interest (Perchoux, Chaix, Cummins, & Kestens, 2013). However, despite current debate, neighbourhoods are useful spatial areas to measure resource access and health inequalities in a region (Vallée et al., 2015) and their use in child built environment research is well established in NZ (Badland, Donovan, Mavoa, et al., 2015; Oliver et al., 2011) and overseas (Carroll-Scott et al., 2013; Villanueva et al., 2012). It is important that neighbourhoods are defined and measured based on theory, rather than technological advances (Thornton & Kavanagh, 2016).

The purpose of defining neighbourhoods is to allow calculation and aggregation of built environment features. There are varied methods for measuring, calculating and aggregating environmental information within children's neighbourhoods. A popular method in contemporary research is Global Positioning System (GPS) logging to create a sausage buffer around the places most frequently visited by children (Mavoa, 2015) or as a sausage buffer around the child's route between home and school (Ikeda, Mavoa, et al., 2018). However, the latter sausage method fails to account for neighbourhood destinations outside of the home to school route. Neighbourhood boundaries are often defined using a network buffer created around the home address. Mavoa (2015) tested associations between built environment factors and child physical activity using different network buffers around the home and found that the 500m or 800m road network buffer was most aligned with child physical activity and gave the greatest likelihood of significant findings. Research has also shown that only using an 800m buffer around the home would imprecisely represent children's actual movement within their neighbourhood and wider radii increases the likelihood of capturing the common places children visit (e.g., shops, parks and friends' houses) within children's neighbourhoods (Villanueva et al., 2012). However, it is acknowledged that the extent to which the spatial unit deviates from the 'true' neighbourhood may result in inferential errors (Vallée et al., 2015).

### **Physical Activity Built Environment**

A growing body of research suggests that the design and layout of neighbourhood built environments may play a key role in facilitating or inhibiting child physical activity through active travel, independent mobility and for opportunities for play (Frank et al., 2012; Loebach & Gilliland, 2016a; Oliver, Mavoa, et al., 2015; Schoeppe, Duncan, Badland, Oliver, & Curtis, 2013; Villanueva et al., 2012; Villanueva et al., 2013). In children, active travel usually refers to getting around by walking, cycling, scootering or other non-motorised modes such as skateboards, and is usually in reference to active travel to/from school or other neighbourhood destinations (Timperio et al., 2006). Children are said to be independently mobile when they travel around their neighbourhood without adult accompaniment (Bhosale, Duncan, Schofield, Page, & Cooper, 2015), however children don't need to be alone, they can travel independently with other children, siblings and/or pet dogs (Christian et al., 2016). Additional facilitators of independent mobility among children in NZ include mobile phone ownership (Chaudhury, Hinckson, Badland, & Oliver, 2017).

## **Neighbourhood Destinations and Accessibility**

Research has shown that neighbourhoods with built environments that encourage walking for transport are those with good access to a variety of destinations (Badland, Donovan, Witten, et al., 2015; Glazier et al., 2014; Kim & Lee, 2016). In adults, both the distance of the neighbourhood destination and the variety of neighbourhood destinations is an important determinant of active travel (McCormack, Giles-Corti, & Bulsara, 2008). The Neighbourhood Destination Accessibility Index – Child (NDAI-C), is a spatially derived, objective index which quantifies access to destinations commonly frequented by children, in support of their mobility within neighbourhoods (Badland, Donovan, Witten, et al., 2015). It accounts for 35 destinations, for example, shops, places of worship, and libraries, in nine domains based on the frequency of trips taken to those destinations measured during earlier research on children's independent mobility in Auckland, NZ (Oliver et al., 2011). Destinations are weighted based on the frequency of trips taken by children. Unlike land use mix, which is difficult to use for comparisons across different locations (Mavoa et al., In Press) and often poorly understood by policy makers (Giles-Corti et al., 2014), the NDAI-C is a useful tool that can easily be replicated in different locations worldwide.

## **Walkability**

Walkability is the extent to which the built environment facilitates or encumbers walking for purposes of daily living. For children walkability is often used as a proxy measure for the supportiveness of all kinds of active transport in children's neighbourhoods, as children often walk, cycle, skate and scooter on paths adults predominantly use for walking (Genter, Donovan, Petrenas, & Badland, 2008). The supportiveness for neighbourhoods to encourage walking in adults has been calculated as a composite measure of other neighbourhood characteristics that support walking such as land use mix, residential density and street connectivity (Leslie et al., 2007; Owen et al., 2007; Witten et al., 2012). However, child-specific measures have also been used to account for the different factors that influence children's walking and other modes of active transport (Giles-Corti & Donovan, 2003; Giles-Corti, Kelty, Zubrick, & Villanueva, 2009). For example, child specific walkability has been calculated as a summed score of both pedestrian network connectivity and traffic exposure (Giles-Corti et al., 2011). Pedestrian network connectivity is calculated as the ratio of the pedestrian network area to the maximum possible area within a defined neighbourhood area. This measure captures not just roads but also paths, sidewalks, and laneways. Pedestrian network connectivity is important for both perceptions of safety, and direct routes of travel and appears to affect show no difference in impact across



genders (Guliani, Mitra, Buliung, Larsen, & Faulkner, 2015). Traffic exposure is calculated to give an indication of traffic speed along neighbourhood roads. Giles-Corti et al. (2011) studied traffic speeds and defined roads with a speed limit  $\geq 60\text{km/h}$  as high-speed roads and roads with a speed limit  $<60\text{km/hr}$  as low speed roads. These classifications are used in this body of work. Traffic speeds influences parental licence for active transport to school, as high speed roads don't often have accompanying sidewalks and are associated with greater perceptions of danger and injury (Larsen, 2015). In some studies this association between increased traffic speed and reduced parental licence for active travel is found to affect boys' active travel more than girls (Guliani et al., 2015).

Walkability, and other objective GIS assessed measures of the physical activity built environment, such as greenspace, and aesthetic features like rubbish and graffiti, have been critiqued because of their positivist assumption that these objective measures are more reliable than subjective measures of perceptions of the physical activity built environment (Andrews, Hall, Evans, & Colls, 2012). While mismatches have been shown between actual features of the built environment and perceptions of them (Gebel, Bauman, Sugiyama, & Owen, 2011), some argue that interventions designed to address these mismatched perceptions may only be of little additional value (van Lenthe & Kamphuis, 2011). This is particularly important for children's active travel as parental perceptions of danger both from traffic, and strangers, is often cited as a barrier to children's active and independent mobility (Mitra, Faulkner, Buliung, & Stone, 2014), while incidences of harm caused to children are extremely rare (Pimentel, 2012). Rather than interventions aimed to change parental perceptions of danger, structured, adult-accompanied interventions to encourage walking and cycling for transport are present in Auckland with walking school buses (Collins & Kearns, 2010) and cycle trains (O'Fallon, 2008).

### **Distance to Parks**

Parks are a particularly important neighbourhood destination for children. In parks children engage in active play (Veitch, Salmon, & Ball, 2007) and have important social interactions (McCurdy, Winterbottom, Mehta, & Roberts, 2010; Peters, Elands, & Buijs, 2010) and restorative experiences (Korpela, Kytä, & Hartig, 2002). Access to parks (e.g., availability and proximity) enable children to enjoy the opportunities and potential benefits of activities parks have to offer. Children are limited in their independent geographical range because they are constrained by their ability to traverse space using non-motorised modes of transportation. Therefore, distance

to parks and active transport are important features of children's physical activity built environments.

Children who live in close proximity to parks, particularly 'big' parks, often have greater overall physical activity levels than children living further away from parks (Roemmich et al., 2006). However, factors such as the attractiveness, quality and safety of features of the parks often influences whether the parks are utilised (Edwards, Hooper, Knuiman, Foster, & Giles-Corti, 2015; McCormack, Rock, Toohey, & Hignell, 2010; Roemmich et al., 2006); and some parents report driving long distances to visit multi-use parks with 'good' facilities (Veitch, Bagley, Ball, & Salmon, 2006). How often this occurs, however, is unknown. Indeed, the same study that reported that parents were happy to travel some distances to access parks with good facilities, also reported that small parks located in close proximity to children's homes resulted in frequent visitation (Veitch et al., 2006). For children and their families, living close to a park can lead to increased and regular physical activity, including active transport to the park, as well as sport, running, climbing, jumping and active play in the park (McCormack et al., 2010).

### **Residential Density**

Residential density is usually used as a proxy for population density. It is an important component of neighbourhood walkability in adults (Witten et al., 2012). It is calculated by a weighted number of private, occupied dwellings within an area, usually expressed for a specific city or region or, in the case of this thesis, it can be calculated down to the level of the mesh block, with data obtained from the 2013 NZ census. Residential density is often included in assessments of the relationship between the built environment and children's physical activity as it is thought, that highly dense neighbourhoods increase the likelihood of friends living nearby and may increase opportunity for active travel between friends' houses, as well as other short trips in the neighbourhood (Sallis & Glanz, 2006). Conversely, highly dense neighbourhoods may also restrict opportunities for physical activity in children, due to decreased likelihood of outdoor space and increased parental perceptions of danger restricting children's movement outside of the home environment.

### **Nutrition Built Environment**

Research over the last decade has consistently shown that close proximity to unhealthy food outlets and increased exposure to junk food marketing is associated with increased prevalence

of overweight and obesity (Duffey, Gordon-Larsen, Jacobs, Williams, & Popkin, 2007; Fraser, Edwards, Cade, & Clarke, 2010; Jeffery, Baxter, McGuire, & Linde, 2006; Lebel et al., 2011; Lowery & Sloane, 2014; Smith et al., 2009; Zick et al., 2009). This research has primarily been conducted among adults. The link between unhealthy food marketing and childhood overweight and obesity is well established (Cairns, Angus, Hastings, & Caraher, 2013). However, research into food environment correlates and childhood overweight and obesity is emerging, with concrete findings yet to be demonstrated (Carroll-Scott et al., 2013; Skidmore et al., 2010). To date no studies have tested this relationship whilst accounting for the potential mediating influence of food purchasing behaviour and dietary behaviours.

### **Food Outlets**

Findings from a systematic review of qualitative studies of food environments indicated that the three main areas of concern to the community nutrition environment were the availability, accessibility and affordability of food (Pitt et al., 2017). These variables appear to be compounded by deprivation. Deprivation has been shown to be related to the obesogenicity of built environments, with highly deprived neighbourhoods having increased options of unhealthy outlets (Thornton et al., 2016), as well as greater numbers of them overall (Gordon-Larsen, Nelson, Page, & Popkin, 2006; Vandevijvere et al., 2016). Deprivation also likely influences public transport infrastructure and neighbourhood walkability, with international studies showing reduced accessibility of food outlets selling healthy food in highly deprived neighbourhoods due to poor public transport connections (Dammann & Smith, 2009; Zenk et al., 2011). In NZ however, these findings were contradicted with Pearce, Hiscock, Blakely, and Witten (2008) finding little evidence of poor locational access to food retail provision being associated with lower fruit and vegetable consumption in deprived communities. In Auckland, deprived neighbourhoods are often older, and follow a grid design (Field, 2009), so it is possible that increased walkability of deprived neighbourhoods accounted for the findings discovered by Pearce et al. (2008). Additionally, the outcome measure was fruit and vegetable consumption, not consumption of unhealthy food and drinks. While grid-style neighbourhoods with increased street connectivity do influence neighbourhood walkability (Leslie et al., 2005), recent findings by Curl, Clark, and Kearns (2018) highlight that individuals living in deprived neighbourhoods often have poor public transport options and suffer from reduced mobility and increased financial stress as a result.

Studies have investigated how deprivation affects food consumption, particularly due to economic pressures where systematic reviews have shown that, globally, healthier diets cost more than unhealthy diets (Black, Moon, & Baird, 2014; Darmon & Drewnowski, 2015). The affordability of food is clearly a priority for people on low incomes (Piacentini, Hibbert, & Al-Dajani, 2001; Sa'uLilo, Tautolo, Egli, & Smith, 2018) impacting family food security and women and children disproportionately. The affordability of food varies across neighbourhoods in line with variations in deprivation impacting the obesogenicity of nutrition built environments (Ball, Timperio, & Crawford, 2009). However, in a study of food outlets in a large Australian city. Ball et al. (2009) found that while there was reduced access to healthy food options in neighbourhoods of high deprivation, the affordability of healthy food was cheaper on average in more deprived neighbourhoods. Further research into the quality of healthy food available in areas of high deprivation is needed in the NZ context. Specific to the nutrition built environment, the influence of outdoor advertising and the ubiquitous promotion of unhealthy food and drink on the normalisation of consumption of these produces also warrants further investigation.

To date research from NZ on the nutrition built environment and health has investigated associations between access to multinational food outlets, for example McDonalds and KFC, and adult body size (Pearce, Hiscock, Blakely, & Witten, 2009). This research was limited by nutrition and body size measurement data being self-reported. Self-reported nutrition and body size information collected from adults is notoriously inaccurate due to social desirability bias (Klesges et al., 2004), meaning that participants are likely to under-report unhealthy food intake and over-report healthy food intake. Social desirability bias is also likely to affect reporting of body size, with women generally under-reporting their weight and men over-reporting height (Gorber, Tremblay, Moher, & Gorber, 2007). The most recent findings showed that in urban areas of NZ, 68.5% of schools had an unhealthy food outlet located within 800m of the school front gate (Vandevijvere et al., 2016). Findings also showed statistically significant differences in neighbourhoods and both density and proximity to food outlets by deprivation. Schools located in the most deprived neighbourhoods in NZ had greater median density of unhealthy food outlets within their 800m buffer zone and shorter distances (approx. 100m less) to travel between the front gate of the school and the nearest unhealthy food outlet (Vandevijvere et al., 2016).

## **Advertising Unhealthy Food and Drink**

Children are particularly vulnerable to the marketing of unhealthy food and drink. In children's neighbourhoods, the presence of unhealthy outdoor advertising contributes to the 'normalisation' of consumption of these unhealthy products. Repeated exposure to advertising of unhealthy food and drink from all sources, for example on television, on products, on social media, in stores, and in the outdoor environment, combine and contribute to the normalisation of consumption of these unhealthy products (Pettigrew et al., 2013; Signal, Smith, Hosking et al., 2017). Powell (2018) argues that all advertising, including advertising for 'healthy' food and drink is detrimental to children's health as it perpetuates the Western, biomedical model of health and does not recognise the wider social, religious, political, environmental and cultural contexts of what constitutes 'health', 'healthy food and drink' and 'body size'. Unfortunately, while this perspective is acknowledged and expanded upon further in Chapter 3 (Methodology) and Chapter 7 (Discussion), it is beyond the scope of this research. Nonetheless, it is important to note that even advertising for 'healthy' meal bundles from fast food restaurants has been shown to influence consumption of unhealthy fast food (Boyland, Kavanagh-Safran, & Halford, 2015). While evidence clearly shows that marketing unhealthy food and beverages to children increases their consumption of and preferences for these products (Sadeghirad et al., 2016), corporate marketing budgets are increasing, advertising is specifically targeting children and in NZ this remains largely unregulated (An & Kang, 2014; B. Swinburn et al., 2017; Vandevijvere & Swinburn, 2015).

Despite the prevalence of unhealthy advertising in NZ, and NZ's relatively high rate of childhood obesity (Abarca-Gómez et al., 2017), few studies investigating dietary behaviours of children have been conducted, with the most recent NZ based evidence being over 15 years old (Ministry of Health, 2003a). Despite this limitation, evidence shows that children with excess body size have different dietary behaviours than children with a healthy body size (Anderson, Wynter, Butler, et al., 2016). Children who are overweight are less likely to eat breakfast compared to the national average (Utter, Scragg, Mhurchu, & Schaaf, 2007). Differences exist by ethnicity as well, with Māori and Pacific children being more likely to consume sugar sweetened beverages and purchase food on the way to/from school and/or from the school canteens, if available (Anderson, Wynter, Butler, et al., 2016; Utter, Scragg, Mhurchu, et al., 2007; Utter, Scragg, Schaaf, & Fitzgerald, 2006). Children's dietary behaviours in NZ, from the information that is available, suggests that children regularly consume unhealthy food and sweetened drinks, and eat fewer fruits and vegetables than the recommended 5 or more servings a day (Anderson, Wynter, Butler, et al., 2016; Hewitt & Stephens, 2007; Ministry of Health, 2003a).

While a detailed investigation of mental and emotional health is beyond the scope of this study, it is important to note that research from NZ shows adolescents who engage in unhealthy dietary behaviours are more likely to report emotional distress (Kulkarni, Swinburn, & Utter, 2015), and that overall quality of life can be increased when children with excess body size reduce their weight (Anderson, Wynter, Grant, Cave, et al., 2017). However, both the studies by Kulkarni et al. (2015) and Anderson, Wynter, Butler, et al. (2016) were conducted among participants with higher levels of deprivation than the national average and thus further research into dietary behaviours on a national level is needed. Likewise, it appears that a cyclical and interrelated relationship between worse mental health outcomes and unhealthy dietary habits exists. This is combined with a multitude of other factors such as physical activity, epigenetics and early postnatal nutrition (Jacka et al., 2013).

Links between the promotion of unhealthy food and drink on television, sedentary behaviour and dietary behaviour occur as well (Pearson & Biddle, 2011). In NZ, increased sedentary time is associated with increased likelihood of excess body size, especially when 2 hours or more per day is spent watching television (Utter, Scragg, & Schaaf, 2006). The rationale given by Utter, Scragg, and Schaaf (2006) for these results was that these children are more likely to consume unhealthy food and drink that is advertised to them on television, specifically sugar sweetened beverages, fruit drinks, and snack foods. However, results must be interpreted with caution. In 2006 most television viewing occurred on commercial television stations (free to air or via a paid subscription service) or via digital video discs (DVDs), all of which included advertising. In 2018 however, it is possible to pay for services to watch television without commercial advertisements, for example Netflix, Amazon Prime or YouTube Premium.

Kelly et al. (2016) studied the association between television viewing and unhealthy dietary behaviour in children and found significant associations between commercial television viewing, where unhealthy advertising was embedded into programmes, and increased consumption of unhealthy food and drink. This finding is important as television today can be viewed without advertising, and increasingly children are advertised to on social media and via online games (Elliott, 2015; Folkvord et al., 2017; Kelly et al., 2015) where advertising is also embedded into programmes. Evidence from systematic reviews shows children and adults who snack while watching television are more likely to have excess body size (Ghobadi et al., 2018), but what is unknown is what proportion of snacking can be reduced by watching television without advertising. The implications of such a study would likely influence policy and regulations

regarding the marketing of unhealthy food and drink to children. Deprivation is also important to consider, as not everyone has the means to purchase television without advertisements, or the technology required to operate it, and this may further drive the inequitable distribution of excess body size.

### **Children's Body Size and the Built Environment**

Child body size is influenced by a range of factors, including, but not limited to, the health behaviours of physical activity and diet. The focus of this thesis is on the potential pathways between the neighbourhood built environment and child body size, and the potential mediating factors of physical activity and diet. It is clear that engaging in recommended levels of physical activity and eating a healthy diet are associated with maintenance of a healthy body size as well as good overall health and wellbeing outcomes (Janssen et al., 2005). It is also well established that physical inactivity and frequent consumption of energy dense, nutrient poor foods and sugar sweetened beverages is associated with excess body size and a range of poor health outcomes (Anderson, et al., 2017B; Malik, et al., 2013; Vernarelli, et al., 2015).

Historically much of the research into built environments and children's health has focussed on the physical activity environment and links with physical activity (Buck, et al., 2015; Mitchell, et al., 2016), active travel (Ikeda, Stewart et al., 2018; Veitch, Carver, et al., 2007), or independent mobility (Villaneuva, et al., 2013). Emerging research is beginning to establish food outlets and junk-food advertising as important components of children's neighbourhood built environments for child health, particularly in the area surrounding schools (Vandevijvere, et al., 2018; Signal, Stanly, et al., 2017).

To date the majority of studies showing associations between the physical activity built environment and adult body size has been cross-sectional (Oliver, Witten, et al., 2015; Ball, et al., 2012). Findings from longitudinal research conducted with adults in the United Kingdom suggest obesity status remains unchanged in relation to neighbourhood physical activity built environments, (Hobbs, Griffiths, Green, Christensen, & McKenna, 2018). However, significant changes in body size were found when analyses were stratified by age group. This was based on the premise that an individual's mobility varies in different life stages, suggesting parks and other physical activity facilities may be more important to body size at different time points across the life course. Children were not included in the study by Hobbs et al., (2018) therefore further investigation is required to determine if the findings also hold true for children. Nonetheless, as

it is well established that children spend the majority of their time within their neighbourhoods (Villanueva et al., 2012) and children are one of the more frequent users of parks and physical activity facilities (McCormack, et al., 2010) the findings of Hobbs et al., (2018) adds theoretical insight into the potential for neighbourhood built environments to also influence children's body size. This association is further supported by interventions targeted to the level of the neighbourhood built environment showing causal relationships between environmental features and children's physical activity (Smith, Hosking et al., 2017).

Findings between nutrition built environments, dietary behaviours and body size are also found in the literature. Nutrition built environment factors, specifically, outdoor advertisements for unhealthy food and drink and outlets selling unhealthy food and drink, have been shown internationally to result in increased consumption of unhealthy products and increased likelihood of greater body size in adults (Lesser, Zimmerman, Cohen, 2013; Yancey, et al., 2009; Zick, et al., 2009). These findings are also shown to vary by area level deprivation, with adults living in the most deprived areas more likely to be exposed to unhealthy advertising (Adams, Ganiti, White, 2011; Kwate, & Lee, 2007; Settle, Cameron, & Thornton, 2014) and more likely to consume unhealthy food and drink (Zick, et al., 2009; Thornton et al., 2016; Gordon-Larsen, et al., 2006). For children in NZ, schools located in areas of high deprivation are more likely to have greater density and closer proximity to unhealthy food outlets (Vandevijvere, et al., 2018). Additionally, children living in the most deprived areas of NZ are five times as likely to be overweight or obese (Ministry of Health, 2015). However, an examination of the possible pathways between children's nutrition built environments and body size, accounting for dietary behaviours has yet to be undertaken.

Compared to studies conducted with adults, less is known about the wider environmental influences on children's body size. The influence of friends and social networks on adult body size was first established by Christakis, and Fowler, (2007), who used social network analysis to longitudinally assess the spread of obesity in a large social network. The influence of family and social factors on child body size, diet and physical activity has been investigated in international studies (Hendrie, Coveney, and Cox 2012; Franzini et al., 2009). Hendrie et al., (2012) used structural equation modelling to determine if social factors influenced child body size. Their findings highlight the importance of social norms within the family on physical activity and dietary behaviours. However, their data were based on perceptions of family and social factors as well as exercise knowledge rather than objectively measured physical activity. While important to consider, perceptions and knowledge are highly subjective measures that increase



the likelihood of bias and decreased sensitivity to variation within the dataset (Reilly, et al., 2008). Additionally, no data were collected by Hendrie, et al., (2012) on wider social and environmental influences, such as the impact of friends, community and neighbourhood level characteristics and thus results must be interpreted with caution.

Another study to investigate the physical and social neighbourhood on child body size was Franzini et al., (2009). This study accounted only for the potential pathway between the neighbourhood built environment, physical activity and body size (Franzini et al., 2009). In their research, Franzini et al., (2009) did not account for the potential pathway between the neighbourhood built environment and body size as potentially mediated by diet, despite strong evidence of the influence of social environments on dietary behaviours (Hendrie et al., 2012) and dietary behaviours on child body size (Malik, et al., 2013; Vernarelli, et al., 2015). The study by Franzini, et al., (2009) was theoretically founded on The Social Determinants of Health (Schulz, & Northridge, 2004) and The Environmental Health Promotion Model (Schulz, et al., 2005). However, the terminology used in the paper and the discussion on parenting behaviours could be interpreted as placing blame for excess child body size on both the individual child and the parent. This highlights the need for child-centred studies on nutrition built environments and child body size.

Research including both physical activity and nutrition built environment factors on the body size of children is limited. Searches to date have identified few studies investigating this built-environment-body size relationship in children (Carroll-Scott et al., 2013; Ghenadenik, Kakinami, Van Hulst, Henderson, and Barnett (2018) and one conducted among adolescents (Larson, Wall, Story, & Neumark-Sztainer, 2013). Ghenadenik, et al., (2018) tested associations between built environment factors and the body size of children in Canada. This study included robust assessment of the neighbourhood built environment, including the variables: residential density, pedestrian aids, traffic calming features, physical activity facilities, and the presence of visible signs of disorder such as, rubbish and graffiti. However, the potential mediating influences of individual physical activity and nutrition were not taken into account in the analysis. Furthermore, only the research by Larson et al. (2013) measured the built environment factors within a comprehensive neighbourhood buffer zone created around both primary residential address *and* school address centre points. Neither of the aforementioned studies on child body size included outdoor food marketing in the analysis of the nutritional built environment or

children's food purchasing behaviour, despite both being identified as important components influencing children's consumption of unhealthy food and drink.

Clear associations have been demonstrated between the built environment and the body size of adults in the United Kingdom (Hobbs, et al., 2018), Australia (Ball, et al., 2012) and NZ (Oliver, Witten, et al., 2015), however associations between the neighbourhood built environments and the body size of NZ children is presently unknown. Greater understanding of the environmental associates of child body size will inform public health, child health and urban planning at local, national and international levels.

### **Summary**

A greater understanding of the neighbourhood built environment factors associated with the body size of children is warranted. Schools are central components of children's neighbourhoods, and neighbourhoods are useful spatial areas to measure resource access and health inequalities in a region. Various built environment factors have been shown to both facilitate and inhibit child physical activity behaviours. Likewise, several built environment factors, specifically density and proximity of food outlets and exposure to unhealthy outdoor food marketing, have been shown to be associated with the nutritional behaviours of adults, however less is known about their impact on children and further investigation is needed. This research is first to assess both the physical activity and nutrition built environment factors in relation to child body size, while also accounting for the potential mediating influence of individual movement and diet.

### Methodology

*"It is our choices, Harry, that show what we truly are." J.K.Rowling (1999) Harry Potter and the Chamber of Secrets*

#### Preface

This chapter presents the theoretical underpinnings of the work contained within this thesis. It builds upon the previous chapter by illustrating how the theoretical frameworks and technology chosen are best suited to answering the overarching research question and disseminating the results. Greater detail on the methods used to conduct the research is provided in the following chapters.

#### Theory

Humans have an innate desire to put everything into boxes (Rutherford, 2018, July 10). The scope of this is broad, as evidenced by scientific taxonomy research identifying different species of deep sea squid (Bolstad et al., 2018; Braid, Kubodera, & Bolstad, 2017) to the sense of belonging adolescent girls receive from joining cliques (Thomas, 2009). However, the body size of children is complex, so complex that classification and organisation via genetic sequencing or observable commonalities is not possible. It is thus important that any body size research is well grounded in theory. Indeed, *"the best theory is likely to be grounded in real lessons from practice. Similarly, best practices should be grounded in theory"* (Glanz, 2015, p. 6).

#### The Socioecological Model of Health Behaviours

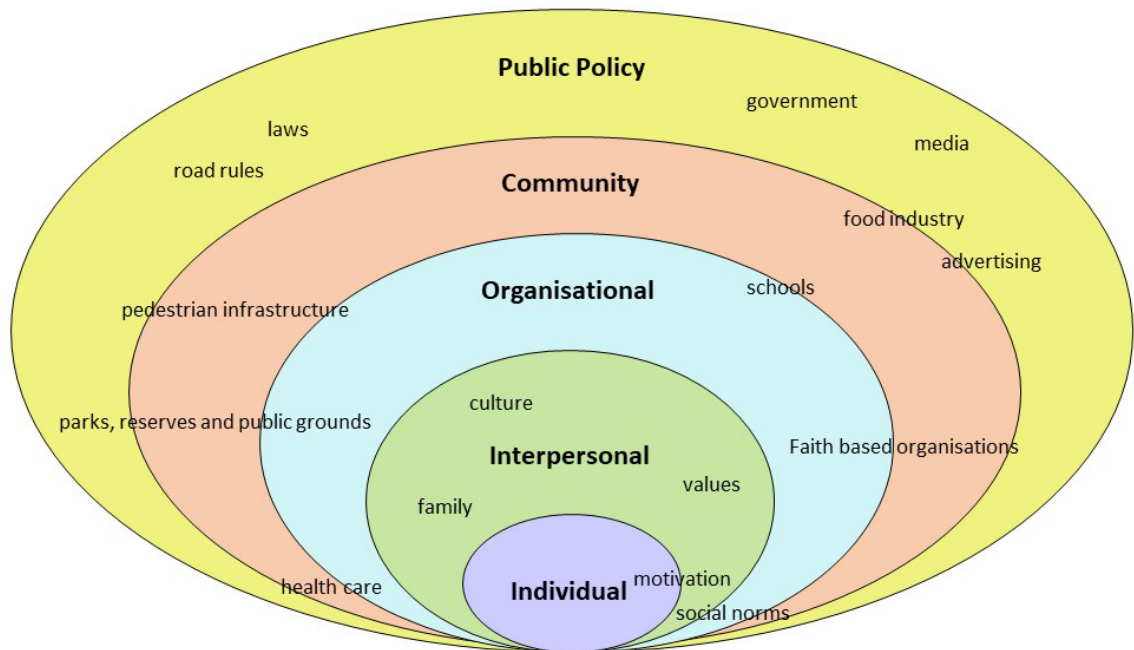
Neighbourhoods are important geographic areas that have been shown to influence health behaviours of children. Environmental influences on health outcomes and health behaviours, including physical activity and nutrition, are best understood through a socio-ecological perspective. Ecological perspectives provide useful insights to understand and frame public health issues. Socioecological perspectives recognise the individual, family, community and societal influences on health and that these influences occur across the life course. The determinants of overweight and obesity are complex and multi-dimensional, ranging from individual level epigenetic determinants (Quarta, Schneider, & Tschop, 2016) to the influence of social networks (Christakis & Fowler, 2007), culture (Braginsky, Kataoka-Yahiro, & Inouye, 2016)

and government policies operating at national levels (Lobstein et al., 2015; Swinburn & Wood, 2013). The socio-ecological model for understanding health behaviours developed by Sallis, Owen, and Fisher (2015) has been used as the theoretical basis in previous work investigating the neighbourhood built environments and child health (Carroll-Scott et al., 2013; Loebach & Gilliland, 2016b; Oliver, Mavoa, et al., 2015) and provides a useful and appropriate foundation to inform this research.

The socioecological model of health behaviours proposes that all levels of the model from the individual through to public policy are of importance and can influence health behaviours and outcomes (Sallis et al., 2015). They are displayed as network, hierarchical levels: individual, interpersonal, community, organisational, and public policy (see Figure 3.1 below). That action between the different levels is reciprocal cannot be overstated, for example, public policies reflect dominant ideas within a society, are culturally specific and often representative of social norms (Fitzpatrick & Burrows, 2017). The benefit of the socioecological model is it can be applied to many different health behaviours in many different contexts and space is allowed for multiple theories to be used alongside the model. It has been used to guide a range of health behaviour research from smoking and sedentary behaviour (Hadgraft, Dunstan, & Owen, 2018) to accessing health services (Ma, Chan, & Loke, 2017), and in as varied contexts as New Zealand (Oliver, McPhee, et al., 2016), Ghana (Awuah et al., 2018), Denmark (Pawlowski, Schipperijn, Tjørnhøj-Thomsen, & Troelsen, 2016) and China (Robinson, 2008).

The socioecological model is a popular tool to understand behaviour and guide health promotion interventions, however it has not been without criticism. This has occurred specifically for its inability to account for common method bias. Common method bias often occurs through researchers' inability to account for social desirability bias and mood state when conducting surveys and other quantitative research, and has implications for predicting behaviour or promoting behaviour change based on the socio-ecological model (Wingate, Sng, & Loprinzi, 2018). This is a particular concern with self-reported data (Klesges et al., 2004) and will be discussed further as the results of this research are interpreted in Chapter 7 (Discussion). Despite these criticisms, the benefit of the socioecological model is it allows for a greater understanding of child body size beyond the simplistic biomedical explanation: energy in and energy out. It also pays particular attention to deprivation and the social determinants of health (Kasten, 2018), as well as wider influences on health and wellbeing such as those included in the Māori conceptualisation of health and wellbeing, *hauora*.

Figure 3.1. A simplified socioecological model of health behaviour as it applies to children's body size



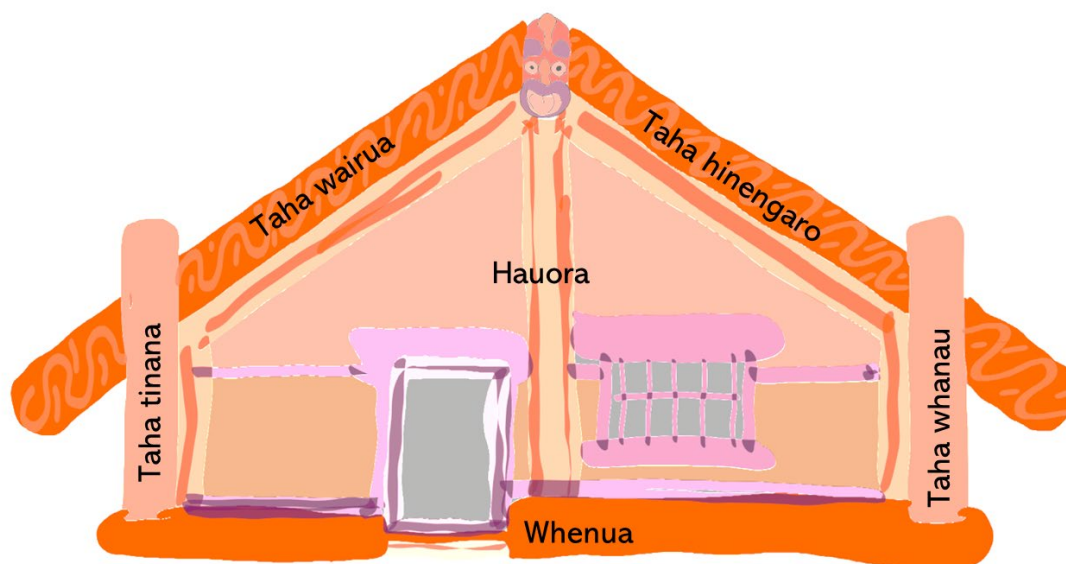
Adapted from: Sallis, J. F., Owen, N., & Fisher, E. (2015). Ecological models of health behavior. *Health behavior: Theory, research, and practice*, 5, 43-64. and Hadgraft, N. T., Dunstan, D. W., & Owen, N. (2018). Models for Understanding Sedentary Behaviour. In *Sedentary Behaviour Epidemiology* (pp. 381-403). Springer, Cham. (Image by Victoria Egli)

### **Hauora (Health and Wellbeing)**

This research respects and upholds a holistic approach to *hauora* (health and wellbeing) (Te Morenga et al., 2018). This research is unable to account for all factors that contribute to the body size of children, including but not limited to, the epigenetic determinants of obesity, parental influences, and individual motivations; however, it acknowledges and uses a wider, more indigenous view of health and wellbeing, termed '*hauora*' in *te reo* (Māori language). This research does not solely focus on *tinana* (physical dimension) as a main indicator of health but seeks to investigate the contributing influence of neighbourhood environment. Beyond *tinana* (physical dimension) the Māori health perspective also includes *wairua* (spiritual), *hinengaro* (mental and emotional), *whānau* (close and wider family), *whenua* (the land, identity and belonging), *te reo* (language), *te taiao* (the environment) and *whanaungatanga* (extended family and relationships) (Durie, 1998; Durie, 1985; Mark & Lyons, 2010). An illustration of Te Whare Tapa Whā (the Māori health model), developed by Durie (1985), is presented in Figure 3.2 below (Ministry of Health, 2017b). The image shows a picture of a *marae ata* (Māori spiritual meeting

house) and how in order to have *hauora* the foundation needs to be the land, identity and belonging, the walls physical health and family and social health and the roof, spiritual health and mental and emotional health. While not specifically measured in this study, these concepts are revisited in Chapter 7 (Discussion) and are used to further understand the implications of this research.

Figure 3.2. Te Whare Tapa Whā



Adapted from: Durie, M. H. (1985). A Maori perspective of health. *Social Science & Medicine*, 20(5), 483-486. (Image by Victoria Egli)

### Child-Centred Research

Child-centred research is that which values children's rights, including their rights of expression (Unicef, 1989). It values meaningful and active participation by children and thus chooses appropriate methods to ensure children are at the centre of the research process and the voice of the child is authentically heard (Barker & Weller, 2003; Jones, 2008). As body size is an emotionally charged, sensitive and stigmatising issue, a child-centred approach to this research is appropriate as it ensures that children's rights, welfare and *hauora* are at the centre of the research process.

The additional benefit of child-centred research *with* children is the increased depth of understanding that can be obtained compared to adult-centric research *on* children. This research did not ask children about the outcome of interest, *body size*. Instead we used child-

centred methods to gain a greater understanding of children's perceptions of the independent variable, their neighbourhood (see Chapter 6). Understanding children's viewpoints in this research adds context and value to the results of the studies presented in Chapters 4 and 5.

Participatory approaches to studies in human geography have a history of using innovative methods designed to both appeal to children and allow meaningful participation by them; examples include: go along interviews, drawing and role play (Carroll, Witten, Kearns, & Donovan, 2015; Hayball & Pawlowski, 2018; Oliver et al., 2011; Wilks & Rudner, 2013). The main limitation of these methods is that they are resource-intensive, allowing capture of information from small sample sizes only. Despite this limitation, participatory geographic approaches are useful because they allow children to have a say in the things that are important to them (Hayball & Pawlowski, 2018) and using participatory geographic research methods with a child-centred approach ensures that children's needs, their perceptions and their desires are at the centre of the research process.

### **The Theory of Affordances**

Sitting firmly within a child-centred research approach is the theory of affordances, first described by Gibson in 1979, and built upon by Heft (1988) and Kyttä (2003). This theory will be used in Chapter 6 as an appropriate lens for informing the analysis of children's use and perceptions of neighbourhood destinations. In affordance theory, objects, spaces and things are perceived as opportunities for action (Gibson, 2014), socialisation or feelings (Kyttä, 2003). For example, objects offer themselves up to be picked up and thrown. Surfaces are to be run on, climbed on, injured on and/or jumped over (Kyttä, 2003). Spaces allow opportunity for quiet reflection, spending time with others, danger and/or imagination. Affordances are situated in-between the person and the environment (Kyttä, 2004) and are shaped by culture, context, social norms, age, size, development and imagination (Kyttä, 2008). For example, a tree can afford climbing only once a child is tall enough to reach the lowest branch, and a chair can afford sitting, but not when the chair is on display in a gallery (Kyttä, 2003). The same object, space or thing can be a positive or negative affordance for different people (Chaudhury et al., 2017). This distinction is important for neighbourhood destination research. What is unique about the theory of affordances is it allows researchers to capture the relationship between the intended function and the actual use of spaces as they differ for different children (Kreutz, 2014). Affordance theory, while a relatively new theoretical concept, has been applied successfully in previous research with children in NZ (Chaudhury et al., 2017).

## Knowledge Translation

Where you live, what you have, how active you are, what you eat, what size and shape your body is and what this means for your health is lived by ‘real’ people in ‘actual’ neighbourhoods. There is a need in population health research to not just talk about numbers, variables and outcomes, but to translate what those numbers mean to the people who contributed to them and are affected by them. Simply put, knowledge translation is the process of putting theory based research into action (Straus, Tetroe, & Graham, 2009). Moving knowledge from ‘the ivory towers’ of research institutions and academia (Etzkowitz, Webster, Gebhardt, & Terra, 2000, p. 322) into communities where it can educate and be used as a tool for advocacy and empowerment requires a degree of translation (Buckley & Du Toit, 2010; Straus et al., 2009). Nowhere is this more necessary than when considering the socially stigmatising and yet fundamentally important health issue of child body size (Brewis, SturtzSreetharan, & Wutich, 2018; Petherick & Beausoleil, 2016).

Clearly conveying complex messages is a challenge for the fields of public health; health promotion and urban planning and models, diagrams, videos and infographics are useful tools to accomplish this (Egli, Oliver, & Tautolo, 2016). Visual graphics provide an ideal way to accomplish this by ensuring knowledge translation moves beyond simple synthesis and distribution, and that the knowledge is actually used and applied (Egli et al., 2016; Straus et al., 2009).

This thesis will go beyond disseminating new knowledge through traditional academic means, such as peer-reviewed journal publications and scientific conferences only, by also creating a graphic presented in Chapter 7 (Discussion) and in a video for the lay person summary (see [https://www.youtube.com/watch?v=FXXIVeEQ\\_IE](https://www.youtube.com/watch?v=FXXIVeEQ_IE)). To align with the concept of knowledge translation, the importance of child-centred research, and the need to show greater links between theory, research and practice, some of this data is to be presented in the form of a graphical model and accompanying short video. The video is in a format that is acceptable for use with children, parents, teachers, schools and community groups and will be shared widely on social media. It is the intent that the knowledge developed in this thesis will be put into action.

## Technology

Children in NZ today are *digital natives*, meaning they have not known life without the influence of technology and the Internet (Helsper & Eynon, 2010). The use of technology in research with



them and about them is important as it meets children where they are at in the world. Technology is a familiar medium to children (Livingstone, Haddon, Görzig, & Ólafsson, 2011) and its use in health and geographic research internationally is well established (Kyttä et al., 2018).

### **Technology: Public Participation Geographic Information Software (PPGIS) Approaches to**

#### **Participatory Mapping**

This research utilised the PPGIS programme Maptionnaire ([www.maptionnaire.com](http://www.maptionnaire.com)) to undertake participatory mapping and both closed and open-ended survey questions from a large number of children. The child-centred, PPGIS approach used facilitates greater understanding of the research questions asked in this thesis and importantly allows children, who are the subjects of this study, to have a say. PPGIS is able to use digital, Internet technologies to capture perceptions of places alongside participatory mapping (Kahila & Kyttä, 2006). PPGIS approaches are those that capture *soft* data primarily concerned with human experiences, together with *hard* objective GIS data (Kyttä, Broberg, & Kahila, 2012). PPGIS is a useful method of conducting child-centred research with, rather than on, children (Kyttä et al., 2018). Child-centred research using PPGIS has been successfully implemented in many and varied locations, with noteworthy examples from Finland (Kyttä et al., 2012) and Japan (Kyttä et al., 2018). The benefit of PPGIS is it also allows urban structures and the physical characteristics of neighbourhoods to be analysed alongside residents' perceptions of place (Kyttä et al., 2012). In this research PPGIS is used in Chapters 6 and 7. The *hard* GIS data accompanied by closed-ended survey questions is the focus of Chapter 6 and the open-ended survey data, allowing a large number of children to voice perceptions of their neighbourhoods, is combined with *hard* GIS data in Chapter 7.

Child-centred research recognises that children and childhood are not homogenous (Beazley et al. 2009) and that childhood is more than a physiological and psychological period of development (Prout and James 2003). In this research, children are active, social beings who shape the structures and processes around them (Morrow 2008). Thus, it is important that in addition to the quantitative research on neighbourhood built environments and child body size, the child's voice is also heard.

### **Technology: Using Google to Investigate Built Environments**

A suite of geographic tools and cartographic functionality is freely available through Google ([www.google.com](http://www.google.com)). Google Street View is the most widely accessible form of omnidirectional

image capture (Kelly, Wilson, Baker, Miller, & Schootman, 2013), has good coverage globally and is recently updated in locations unaffected by conflict and/or natural disasters (Google, n.d). Google Street View has been used to understand more about neighbourhoods (Griew et al., 2013; Marco, Gracia, Martin-Fernandez, & Lopez-Quilez, 2017; Odgers, Caspi, Bates, Sampson, & Moffitt, 2012; Rundle, Bader, Richards, Neckerman, & Teitler, 2011; Vanwolleghe, Van Dyck, Ducheyne, De Bourdeaudhuij, & Cardon, 2014). Specifically, in NZ it has been used to measure pedestrian and cycling infrastructure (Badland, Opit, Witten, Kearns, & Mavoa, 2010) and smokefree signage around schools (Wilson, Thomson, & Edwards, 2015). Internationally it has been used to predict outcomes of political elections (Gebru et al., 2017), measure neighbourhood disorder (Mooney et al., 2017) and in the biosciences to assess species habitat in urban areas (Berland & Lange, 2017; Burr, Schaeg, & Hall, 2018; Olea & Mateo-Tomás, 2013), amongst others.

Despite being freely available, the use of Google in public health and health geography research is presently underutilised. One notable exception was a study by Chang et al. (2009), who used satellite imagery from Google Earth to predict and monitor a dengue outbreak in Nicaragua. Dengue is a mosquito-borne illness and through the use of satellite imagery, researchers were able to not just map the spread of the disease, but also predict outbreaks of mosquito larva (Chang et al., 2009) and therefore prioritise control strategies and target interventions to these high-risk areas. The use of Google Earth and Google Street View in noncommunicable disease research is less well studied. Google Street View saves past image captures and shows promise for analysing neighbourhood level built environment features both longitudinally and in response to natural experiments. Likewise Google Earth, through the Earth Engine feature (<https://earthengine.google.com/timelapse/>), shows time-lapse videos from 1984-2016 clearly illustrating differences that have occurring in land use type. Accessible public spaces like shops, playgrounds and streetscapes are examples of children's third-spaces (Carroll, et al., 2015). Oldenberg (1989) first coined the term 'third-spaces' distinguishing them from the often confined and more regulated spaces of home and school (Oldenberg, 1989; Hooper, Ivory & Fougere, 2015; Carroll, et al., 2015). Given children's use of third-spaces as activity spaces, research opportunities exist to combine satellite imagery from Google Earth with people's perceptions of place and develop a method of assessing opportunity for physical activity in neighbourhoods using Google Earth.

Using satellite imagery Google Earth and its fee-based application for programming Google Static Maps API (<https://developers.google.com/maps/documentation/>) makes it possible for

researchers to conduct large scale studies of built environments and link them to national health data. In the USA (Maharana & Nsoesie, 2018) analysed built environment features with adult obesity prevalence rates. However, the specific features of the built environment were less specific than traditional GIS measures. Maharana and Nsoesie (2018) found statistically significant associations between built environment features and obesity prevalence specifically residential density and green cover, however the results may simply reflect neighbourhood deprivation. Nonetheless its utility for assessing a large area's obesity rates may help city planners decide where to implement health behaviour interventions and prioritise scarce resources.

### **Technology: Social Media**

Globally, New Zealanders are among the highest users of the internet with 91% of the population regularly using it; 85% of those report using it for social media (Crothers, Smith, Urale, & Bell, 2015). While usage of social media across age groups is not equally distributed, children and their parents and teachers are on social media, using it to communicate with each other (Asterhan & Rosenberg, 2015). Social media platforms such as Facebook, Instagram and YouTube are ideal places for researchers to share results of research back to participants and the wider public and this is changing the landscape of health communication and health promotion today (Chou, Hunt, Beckjord, Moser, & Hesse, 2009; Madathil, Rivera-Rodriguez, Greenstein, & Gramopadhye, 2015). In NZ smartphone ownership and Internet use are widespread, particularly among adolescents and those <65years of age (Research New Zealand, 2015; Whittaker et al., 2017). Pacific mothers in New Zealand report that the majority of health messages they receive are from smartphones (Sa'uLilo et al., 2018). Likewise, social media has been used as an important tool to empower Māori politically (Waitoa, Scheyvens, & Warren, 2015). A higher value is placed on objects and concepts people are able to shape (Heimans & Timms, 2018) and social media allows users to tag, share, comment and modify content.

Specifically, in regard to research dissemination, there is increased awareness that '*the fruits of research*' take too long to reach people who could benefit from them (Glanz, Rimer, & Viswanath, 2008, p. 5), and this has led to an increased emphasis on results dissemination. In practice, however, this is rarely achieved to the level required for wide spread reach and understanding by people in communities on the ground (Bonney, Phillips, Ballard, & Enck, 2016; Israel, Schulz, Parker, & Becker, 1998). Instead, in NZ the predominant research dissemination pathway aligns with academic institutions that favour the traditional research output of peer-

reviewed papers in academic journals and conference presentations, with little thought as to how this knowledge will trickle down to the communities affected by them (Te Morenga et al., 2018). Social media provides a unique opportunity for researchers to engage with communities, to recruit participants to research projects (Topolovec-Vranic & Natarajan, 2016), collect data (Alshaikh, Ramzan, Rawaf, & Majeed, 2014; Tsou, 2015) and share results (Chapman, 2017).

Images are particularly important for successful reach and 'sharing' of health messages on social media (Chapman, 2017; Vaterlaus, Patten, Roche, & Young, 2015), as is helping users to feel like members of a community. Therefore, linking any research output with stakeholders, interest groups and other followers is important (Freeman, Potente, Rock, & McIver, 2015). This body of work will attempt to ensure that all knowledge generated is translated back to research participants and others who could benefit from them and also ensuring that theory will inform research, which in turn will inform practice (Glanz et al., 2008).

### Discussion

*“Last night, while I lay thinking here,  
Some Whatifs crawled inside my ear  
And pranced and partied all night long  
And sang their same old Whatif song” Shel Silverstein (1981) A Light in the Attic*

### Introduction

This thesis sought to understand the role of neighbourhood built environments on children’s (aged 8 – 13 years) body size in Auckland, NZ. A mixed-methods, child-centred approach was used based on the socio-ecological model of health and acknowledging the wider influences on health detailed in Te Whare Tapa Whā (the Māori health model) (for details please refer to Chapter 3). The research contained within this body of work comprised three distinct but inter-related studies (Chapters 4, 5 and 6). Chapter 4 presents the use of Google Street View to map outdoor advertising around schools. Chapter 5 details quantitative modelling of physical activity and nutrition built environment associations on children’s WtHR. Finally, Chapter 6 allowed children to voice the neighbourhood destinations that were important to them and presents the Kids-PoND framework for analysing children’s perceptions of neighbourhood destinations.

For ease of reference, I have restated the thesis objectives below. They are:

- (4) To develop and investigate the utility of a new way to measure outdoor nutrition advertising for inclusion in future modelling of the nutrition built environment.
- (5) To determine possible associations between neighbourhood built environment factors and children’s body size, adjusting for physical activity and eating behaviours.
- (6) To contextualise the results of quantitative modelling through an investigation into children’s perceptions of neighbourhood destinations, allowing them to voice the important influences in their environment.

Childhood obesity interventions targeted to the level of the individual have been shown to have little to no sustained effect on participants (Lloyd et al., 2018; Mead et al., 2017). As prevalence rates of child overweight and obesity in NZ remain high (Ministry of Health, 2003b, 2017a), a greater understanding of the role of wider environmental influences on children’s body size and related behaviours was needed. In NZ, associations have been demonstrated between the built

environment and the body size of adults (Oliver, Witten, et al., 2015). However, whether associations existed between neighbourhood built environments and the body size of children in NZ was unknown at the inception of this thesis. Ghenadenik et al. (2018) looked at associations between built environments and the body size of children in Canada, however the potential mediating influences of individual physical activity and nutrition were not accounted for. In the USA, Carroll-Scott et al. (2013) looked at the relationship between the neighbourhood built environment and child body size and accounted for individual physical activity and diet. Their findings demonstrated that access to fast food, grocery stores and parks was associated with body size and health behaviours of children. However, in their study, the neighbourhood boundary used was not individualised (i.e., census tracks were used) and the socio-cultural demographics of participants were vastly different to population demographics of Auckland, NZ. Additionally, neither Ghenadenik et al. (2018) or Carroll-Scott et al. (2013) included outdoor advertising or food purchasing behaviour as variables in their analyses.

Body size is a sensitive and emotionally charged topic for people of all ages, and this is especially true for children (Puhl, 2007). There are ethical implications and negative consequences that arise from public health practitioners and researchers attempting to tackle ‘the obesity epidemic’, specifically increased stigma and discrimination (Boero, 2007; Pausé, 2017). Unlike other public health approaches to behaviour change such as smoking, increasing stigma and discrimination is not a helpful tool to reduce body size or improve overall health outcomes (Pausé, 2017; Puhl & Heuer, 2010). Rather, research shows *“the stigmatization of obese individuals poses serious risks to their psychological and physical health, generates health disparities, and interferes with implementation of effective obesity prevention efforts”* (Puhl & Heuer, 2010, p. 1019). Therefore, a child-centred approach grounded in the socio-ecological model, including an emphasis on the wider environmental influences, was used to conduct this study. The benefit of this approach includes the provision of unique insights not otherwise gained from adult-centred, biomedical, positivist approaches. The insights revealed through this research, specifically the influence of friends and opportunities for socialisation, will be of particular relevance to public health and urban planning interventions.

### **Methodological Strengths and Contributions to Knowledge**

The methodological strengths of this body of work are the child-centred approach to exploring associations between the neighbourhood built environment and child body size, where quantitative numerical data and open-ended responses are incorporated from a multitude of sources including children, researchers and spatial data modelled using GIS. This is the first body

of work to investigate the relationship between neighbourhood built environments and child body size drawing conclusions from both quantitative modelling and children's perceptions while also focusing on appropriate child-centred knowledge translation throughout the research process. The methodological rigor and original contributions to knowledge to arise from Chapters 4, 5 and 6 are summarised below.

#### **Chapter 4: Viewing obesogenic advertising in children's neighbourhoods using Google Street View**

There were many methodological strengths in Chapter 4 as follows:

- (1) The research assistant training was a detailed, repetitive and rigorous process as detailed in the methods section of Chapter 4.
- (2) Up-to-date classification of healthy and unhealthy food and drink advertisements were used based on WHO (2007) guidelines and in consultation with a NZ registered dietician.
- (3) The use of kernel density maps further contextualised the findings.

This Chapter made a novel contribution to research knowledge in a number of ways.

- (1) It was the first study to quantify unhealthy food and drink advertising around schools in NZ. This work has since been expanded and findings reproduced nationwide in a study of on the ground field audits by Vandevijvere, Malloy, et al., (2018). However, to date Chapter 4 remains a comprehensive assessment of outdoor advertising in Auckland neighbourhoods due to the use of 800m road network buffers around all school entry points, whereas Vandevijvere, Malloy, et al. (2018) used 500m buffers around the front of school gate only.
- (2) Findings from Chapter 4 showed significantly more advertising for unhealthy food and drink than for other food and drink, echoing results from international studies (Linn & Novosat, 2008; Linn, 2004; Signal, Stanley, et al., 2017).
- (3) Globally, Chapter 4 is the first study to compare school walkability and neighbourhood level deprivation with outdoor advertising. The results of the kernel density maps indicated that deprivation was a greater contributor of density of unhealthy food and beverage advertising than walkability.
- (4) Chapter 4 is the first to document issues associated with using Google Street View to map obesogenic advertising in children's neighbourhoods. The issues identified, namely image quality and ease of manoeuvring at street level add valuable contributions to the knowledge base, particularly in light of likely technological advances to Google and omnidirectional imagery capture systems.

## **Chapter 5: Neighbourhoods matter: Physical activity and nutrition built environments and the body size of children in Auckland, New Zealand.**

Chapter 5 uses quantitative modelling to test associations between the neighbourhood built environment and child body size while also accounting for individual nutrition and physical activity behaviours. The methodological approach to this study is novel on a number of fronts.

- (1) It is the first to use SEM in the analysis of these relationships.
- (2) Internationally it is the first to explore the neighbourhood built environment and associations with child body size using individualised neighbourhood buffer boundaries.
- (3) It is also the first to include food purchasing behaviour as a component of dietary behaviour in the nutrition built environment - dietary behaviour - body size relationship.
- (4) Specific to the NZ context, it is the first to account for the potential mediating influence of individual health behaviours and deprivation on the relationship between neighbourhood built environments and child body size.

The findings of this Chapter contribute to the knowledge base by being the first to find a significant inverse relationship between a positive physical activity promoting built environment and a poor nutrition built environment.

## **Chapter 6: Understanding children's neighbourhoods: Presenting the Kids-PoND framework**

Chapter 6 provides in-depth understanding to the overarching aim of this body of work. Methodological strengths of Chapter 6 include:

- (1) The child-centred approach, grounded in the socio-ecological model, that acknowledges the wider influences on health and wellbeing, is appropriate for conducting research with children in a way that is non-stigmatising and minimizes the potential for harm.
- (2) Chapter 6 acknowledges *hauora* through not mentioning 'body size' or the like to children, allowing children to define their neighbourhood boundary and decide what constitutes a neighbourhood for themselves.
- (3) The use of PPGIS allows over 1000 children to voice their use and perceptions of neighbourhood places in their own words, yielding novel findings in the NZ context.

Additionally, this Chapter presents many unique findings to the body of knowledge on children's neighbourhood use and perceptions of place.

- (1) The Kids-PoND framework developed is the first child-centred, place-based framework to be developed based on the theory of affordances.



- (2) The Chapter adds important depth to the overarching research aim and is theoretically supported by the principles of child-centred research.
- (3) Unique insights, such as the importance of spending time in neighbourhood destinations with friends and consuming unhealthy food and drink at the shops further contextualises the findings of Chapter 5 and would likely not have emerged without a child-centred approach.
- (4) Children's neighbourhood destinations were treated with utmost privacy by the researcher and NfAK team. Only one map was created to illustrate the spatial clustering of neighbourhood destinations. Specific GIS tools were used to ensure privacy and anonymity of participants and schools.

## **Discoveries and Opportunities for Further Research**

### **Deprivation**

This body of work highlights the socio-economic disparities that exist in children's neighbourhoods, specifically in relation to obesogenic neighbourhood factors such as unhealthy food outlets and advertising. Deprivation was a key factor related to both the body size of children and the distribution of obesogenic neighbourhood factors. This is the first time a significant finding of an inverse relationship between a positive physical activity promoting built environment and a poor nutrition built environment has been found in the global neighbourhood built environment literature. Excess body size is a complex issue, and not related solely to activity or nutrition behaviours. Accordingly, this research took a comprehensive approach and simultaneously analysed relationships with both the physical activity built environment and the nutrition built environment. Regardless of children's neighbourhood deprivation, the health behaviours they liked to engage in in neighbourhood destinations, were active play and consuming unhealthy food and drink.

This research showed a statistically significant association between a positive physical activity built environment and a negative nutrition built environment. Deprivation may explain this inverse relationship. In Chapter 5, highly deprived areas were more likely to have poor nutrition built environments and good physical activity built environments, and the relationship was reversed in areas of low deprivation. Paradoxically, environments that facilitate walking and cycling to key destinations may increase exposure to unhealthy food marketing and outlets. It appears that promoting a better physical activity built environment in the absence of a simultaneous control over poor nutrition environments may result in intensification of health inequalities. This is the first study to show a significant, inverse relationship between the physical

activity built environment and nutrition built environment. Further investigation on this inverse relationship and health outcomes, controlling for deprivation, is needed. Child-centred research opportunities that combine PPGIS with in-depth qualitative methods to explore children's lived experience of residing in areas with positive physical activity built environments and poor nutrition environments would yield interesting results and fill current gaps in the literature.

Social inequalities in overweight and obesity prevalence are present globally and in NZ (Devaux & Sassi, 2011; Ministry of Health, 2017a). The results of the quantitative modelling show greater WtHR in children was significantly associated with Pacific ethnicity and high levels of deprivation. This was an expected finding in line with national statistics (Ministry of Health, 2017a). In NZ, people of Pacific ethnicity are overrepresented in both overweight and obesity statistics and more likely to reside in areas of high deprivation (Minister of Health and Minister of Pacific Island Affairs, 2010). In Chapter 4, observable differences in outdoor advertising of unhealthy food and drink were higher in areas of deprivation. This finding was furthered in a nationwide study of outdoor advertising using on-the-ground field audits (Vandevijvere, Malloy, et al., 2018). Interventions targeting physical activity, diet and body size should be prioritised in neighbourhoods of high deprivation as children living in highly deprived areas are exposed to poorer nutrition environments and may have reduced access to resources (such as organised sport, gyms and nature play spaces) beyond their immediate neighbourhoods (Carroll-Scott et al., 2013). Future research opportunities exist to quantify if this difference in access to out-of-neighbourhood resources in NZ. To curb the inequitable distribution in prevalence rates of overweight and obesity, between the 'haves' and the 'have nots', public health interventions, town planning and urban design practices in Auckland, NZ may require greater prioritisation of areas of greater relative deprivation.

### **The Socio-Ecological Model and Child-Centred Research**

The intersectionality and complex mix of influences on child body size is present across all levels of the socio-ecological model (Sallis et al., 2015). Data for this thesis were collected from several different levels within the socio-ecological model, see Figure 3.1. Individual physical activity, diet and food purchasing behaviour were collected at the intrapersonal level. Active living domains and the perceived environment were explored through children's likes and dislikes of neighbourhood destinations. Behaviour settings were assessed through Google Street View and objectively collected spatial data analysed in GIS. Results and implications of the results were discussed in light of the local and national policy environment in Auckland and NZ. This body of work was firmly grounded in theory and aims to guide practice and empower communities by

making sure knowledge is appropriately translated and distributed back to children, parents, schools and communities during the research process, in addition to being presented in peer-reviewed journals and academic conferences.

This thesis employed child-centred research methods that were situated under the umbrella of the socio-ecological model, acknowledging the wider influences on *hauora* outlined in Te Whare Tapa Whā, developed by Durie (1985). Allowing children to have meaningful participation in research about them, yields a depth of understanding to the research problem that is not possible to capture using adult-centred methods alone (Barker & Weller, 2003). This body of work showcases the usefulness of PPGIS as a child-centred research method, specifically in its ability to allow a large number of children to voice aspects of their neighbourhood that are important to them, in their own words.

The child-centred PPGIS methods allowed for the Kids-PoND framework to be developed based on the perceptions of a large sample of children. In Chapter 6, the Kids-PoND framework illustrates the unique and wide-ranging insights children can give researchers about their neighbourhoods. These include perceived intrapersonal benefits from destinations, such as time spent in quiet reflection in nature-based settings. As well, components of the perceived environment were raised by participants, such as threats to personal safety from dogs and/or traffic. The access and characteristics of wider neighbourhood level behaviour settings also arose, such as the presence of amenities and facilities in parks to promote or hinder active play. Of specific interest to the nutrition built environment to dietary behaviour relationship was the finding that children like opportunities to purchase food/drink with friends on the way to and from school. The Kids-PoND framework builds on affordance theory first developed by Kytä (2003) and is the only framework to date to have been developed based on the theory of affordances. Kids-PoND is a novel, useful place-based framework for analysing children's active living domains and behaviour settings and is one of only a few place-based frameworks developed in NZ, alongside the ANGELO (ANalysis Grid for Environments Linked to Obesity) framework (Swinburn, Egger, & Raza, 1999), NDAI-C (Badland, Donovan, Witten, et al., 2015) and a systems model of independent mobility (Badland et al., 2016). Unlike the aforementioned frameworks Kids-PoND is unique because it focuses on children's perceptions of place and is holistic in capturing both their perceptions and experiences in neighbourhood destinations, in addition to where they go and/or how healthy or unhealthy a specific destination may be for them. The Kids-PoND framework has the potential to be used both in conjunction with the aforementioned frameworks and independently. It is sufficiently comprehensive to be used in

academic research and simple enough to be incorporated into health and geography curricula for children aged 8 – 13 years.

### **Being Social and Spending Time with Friends**

The importance of being with friends and opportunities for socialisation in neighbourhood destinations were notable findings from Chapter 6. Children mentioned friends as something they liked about their neighbourhood destinations. Conversely, a lack of opportunity to play with friends and/or socialise was often mentioned as something children disliked about destinations. This perceived importance of friends was a surprising, albeit fortunate finding as it highlights the different links between the levels of the socio-ecological model and the relationship between the neighbourhood built environment and child body size. Research has shown that friends and peer networks exert influence over children's physical activity (Hohepa, Scragg, Schofield, Kolt, & Schaaf, 2007; Jago et al., 2009) and food intake (Cullen, Baranowski, Rittenberry, & Olvera, 2000) at the intrapersonal level. The finding that children like to participate in active play in the park, consume unhealthy food and drink at the shop, and do both activities with friends, adds in-depth understanding to the associations between the physical activity and dietary behaviour relationships that were found in Chapter 5.

How behaviour settings, specifically destinations within children's neighbourhoods, facilitate spending time with friends is an important finding of this body of work that requires further research. A specific focus could be understanding the reach of influence of friends and any potential opportunities that exist for prevention efforts and intervention programmes. In adults it is widely accepted that obesity is spread through social networks (Christakis & Fowler, 2007). For children, the appeal of spending time with friends in neighbourhood destinations, specifically in parks to participate in physical activity and at the shops to eat unhealthy food and drink, further contextualises the relationship between the neighbourhood built environment and health behaviours of physical activity and diet. However, research to assess the influence of friends and social networks as a potential mediator between the built environment and health behaviour relationship is needed, as this may help to explain the null findings of the quantitative modelling in Chapter 5.

### **Te Whare Tapa Whā (The Māori Health Model)**

In Te Whare Tapa Whā, relationships with whānau (family and close friends) are an important pillar, or support structure of mental and emotional health (Durie, 1985) (see Chapter 3). The importance of family relationships is echoed in other non-western models of health. Of

importance to the NZ context is the Fonofale framework (Pulotu-Endemann & Tu'itahi, 2009), Te Vaka Atafaga health assessment model (Kupa, 2009), the Kalaka concept (Thaman, 2008) and Fa'afaletui model (Tuafuti, 2011) among others. Given the finding that friends and opportunities for socialisation are important to children, future research opportunities exist to examine mental and emotional health as a mediator of the neighbourhood built environment to child body size relationship. Low levels of physical activity and unhealthy diets contribute to poorer mental health outcomes in children and young people (Biddle & Asare, 2011). Children with excess body size are more likely to experience mental and emotional difficulties (Wardle & Cooke, 2005). Therefore, future research to account for both friends and mental and emotional health in any future modelling of the relationship between the neighbourhood built environment and health behaviours of physical activity and diet would yield new findings and constitute an important area of future research.

In this thesis, no significant associations between the physical activity or nutrition built environments and physical activity or diet were found, despite strong theoretical support for the hypothesis that these factors would be related. Building upon the work conducted in Chapter 5, future modelling that includes variables reflective of all levels of the socio-ecological model and/or all the pillars of Te Whare Tapa Whā is required. This thesis highlights how complex child body size is, and that friends, family and social networks may be important mediating variables.

Given that much research on the influence of friends and social networks on child health behaviours to date has been qualitative (Jago et al., 2009; McCormack et al., 2010; Rogers, 2012; Zeinstra, Koelen, Kok, & de Graaf, 2007), future research opportunities exist to develop indexes and tools that adequately quantify these complex relationships for use in complex quantitative modelling. Specific to the NZ context, it is important that any tool or index developed is not only a sensitive, specific and valid measurement instrument, but that it is also culturally appropriate and child-centred. Likewise, food purchasing behaviour and outdoor advertising are theoretically important components in the nutrition built environment to dietary behaviour pathway that warrant further development, research and inclusion in modelling.

### **Advertising and Food Purchasing Behaviour**

This body of work is the first to include outdoor advertising and food purchasing behaviour as components in the nutrition built environment - diet - body size relationship. The quantitative modelling in Chapter 6 showed that the majority of children (>95%) purchased food on the way

to and from school at least once a week. Building upon this finding and previous research on nutrition built environments (Ayala et al., 2017; Coffee, Kennedy, & Niyonsenga, 2016; Cooksey-Stowers et al., 2017; Thornton et al., 2016) and the influence of advertising unhealthy food to children and children's diet (Boyland & Whalen, 2015; Lesser et al., 2013), this research was the first to include a measure of outdoor advertising for unhealthy food and drink as a component of children's nutrition built environments. An original contribution to the global body of built environment research is made in Chapter 4, where Google Street View was used to quantify outdoor advertising around schools and highlights a number of potential uses for Google Street View as tool in future built environment research. Even though the data collected were not able to be used as a variable in the quantitative modelling in Chapter 5. It is also the first time Google Street View has been used to assess food and drink advertising globally. Immediately following the publication of Chapter 4, there was demand from the community to use Google Street View as a tool for quantifying other neighbourhood built environment factors, and thus the data collection protocol has been adapted for the community (see Appendix B).

### **Limitations and Implications for Future Research**

The series of studies conducted had a number of strengths, but also a number of limitations. Some of these specifically refer to each study individually and these have already been mentioned in the discussion sections of Chapters 4, 5 and 6. The implications for future research from these specific limitations have also been previously discussed in each Chapter as they occur. Because of these limitations, results must be interpreted with caution.

The specific limitations previously discussed in Chapter 4 are:

- (1) A lack of ground-truthing of Google Street View images means the results must be interpreted with caution. Although dates for the image data aligned with the NfAK data collection period, it is possible that variance in exposure differed due to changes in temporary boards or changing signage. Future research could investigate construct validity using on-the-ground researcher field audits concurrent with participant data collection. Automated photography and GPS worn by participants would be useful to validate images encountered, as well as improve specificity by identifying routes travelled.
- (2) Many of the images were not able to be categorised due to poor image quality. It is possible that the inability to categorise images was not evenly spread across categories, and thus some bias in categories of advertising coded may have existed. As technological

advances occur with omnidirectional imagery, Google Trek and Google VR, these limitations will likely be reduced.

- (3) It was not possible to determine the size or dimensions of the advertisements. This means that detailed features of outdoor advertisements (i.e., the magnitude of exposure) could not be determined. For example, because we could not determine the size of food and drink advertisements specifically, it was not possible to determine portion sizes being advertised and promoted or indeed if overconsumption of unhealthy food is promoted more than other food (e.g., ice creams with 3 scoops, 'supersized' soft drinks).
- (4) This study focused on outdoor advertisements located on publicly accessible footpaths, and grass and other verges, and thus it is not wholly representative of outdoor advertising around schools. Missed advertising included those that were or could have been located on the façade of buildings e.g. "special all chips now \$1.99", pinned as a poster to the outside of the building, or displayed inside a shop window. As a result of this limitation it is likely the overall results quantifying food and beverage advertising around schools are conservative, because the owners and leasees of retail outlets, particularly food and beverage outlets, advertise the goods and services they provide on the outside of their premises to entice customers inside (Bryden et al., 2012; Iveson, 2012).

The specific limitations previously discussed in Chapter 5 are:

- (1) The use of total/overall physical activity rather than out-of-school physical activity. This may have reduced specificity of the built environment-physical activity relationship.
- (2) Related to the above, the physical activity data collected were not divided into during school time and out of school time. Therefore, it is possible that compensatory physical activity, specifically minutes spent in MVPA, occurred during school time, either initiated by children, or as a formal part of school physical activity programmes and facilities.
- (3) The inclusion criteria for accelerometer data used in this study was that of Mattocks et al. (2007). Had this research used the International Physical Activity and the Environment Network (IPEN) (2013) data inclusion criteria, the physical activity data meeting the stricter inclusion criteria may have given more reliable estimates of time spent in MVPA, step count and sedentary time. However, the Mattocks et al. (2007) study demonstrated acceptable reliability. Using these criteria is seen to be an appropriate compromise to reduce participant loss and mitigate any potential bias from

excluding participants who had less recorded physical activity (Smith and Taylor, et al., 2017; Toftager et al., 2013).

- (4) The dietary behaviour data were self-reported. Children were asked about portion sizes during piloting of the survey and it was clear children were unable to report portion sizes. Therefore, indicator questions regarding frequency of consumption of unhealthy foods and frequency of purchasing food on the way to and from school were used in place. The results of the pilot research showed children were able to recall this information. Nonetheless, the implications are that the data collected can only be used to indicate broad estimates of unhealthy dietary behaviours. The use of weighed food records, 24 hour food recall, detailed diet histories or wearable image capture devices would have captured dietary behaviours in greater detail (Burrows et al., 2010), however that would have increased participant burden significantly and reduced feasibility of the study.

The specific limitations previously discussed in Chapter 6 are:

- (1) While PPGIS was a useful tool for capturing a large number of children's perceptions, the focus on prioritising children's voices meant that uncertain, confusing or context specific responses were difficult to analyse. For example, after being asked how much children liked a particular destination (using a sliding Likert scale), children were asked what they liked or disliked about that destination. It was anticipated there would be a synergy between the sliding scale and the comments whereby a response of liking a destination a lot would align with the comments, however this was not always the case. For example, one child may specify they like a destination a lot but then state they don't like that all the older kids hang around there. Consequently, unless the open-ended text clearly specified a like or dislike for a characteristic, the data were not able to be coded due to ambiguity. Despite this, the implications of this are minimal due to the large number of children who participated and provided detailed responses. A more detailed narrative of children's perceptions and preferences for neighbourhood destinations would likely have been enhanced with researcher prompting during the open-ended responses, separating out what children (a) liked and (b) disliked about the destination, and adding space for researcher notations in the survey.
- (2) The child-centred approach meant it was likely that key destinations of importance to children were captured, but it is possible a comprehensive measure of *all* neighbourhood destinations for children was not attained. The median number of neighbourhood destinations per child was 2 and the mean was 2.54. This low number



could reflect participant burden, as the PPGIS survey also included other questions and activities not presented in this Chapter. Alternatively, this low number could indicate that children really do only visit a small number of places outside of home and school. This approach demonstrates one of the challenges of using a child-centred approach and allowing children space to interpret neighbourhood destinations themselves.

- (3) Information needed to quantify food and drink consumed in neighbourhood destinations was not collected. As with the point above, this meant quantitative behavioural data could not be triangulated with the spatial and perception data to gain a comprehensive understanding of what children consumed in neighbourhood destinations. However, it is an interesting opportunity for future research.

### **Multidimensional Influences on Child Body Size**

While this research acknowledges the multidimensional influences on child body size, it does not account for them all. Moreover, while the research was grounded in the socio-ecological model, it did not assess all elements or all levels of influence (to do so would have been beyond the scope of a doctoral thesis). Clustering at the level of the classroom was accounted for in the quantitative modelling in Chapter 5, however a detailed analysis of the school environment, including nutrition policies or opportunities to engage in regular physical activity during school time on school property was not accounted for. While this study makes important contributions to the knowledge base for neighbourhood built environment - child body size relationships, the specific areas of family, friends and socialisation as well as mental and emotional health, may combine to fill knowledge gaps left by this thesis and constitute important areas of future research. Research conducted with Pacific families living in NZ highlights the importance of the home environment on adolescent body size (Teevale & Kaholokula, 2016) with specific findings that, even in families experiencing high levels of socio-economic deprivation, parents were able to alter their micro-environments and prevent excess body size in their children. The appreciative inquiry approach taken by Teevale and Kaholokula (2016) is a culturally appropriate, strength-based investigation into adolescent body size that should be modelled and adapted for future research into the influence of the family-home environment on the body size of children in NZ.

### **Food Purchasing Behaviour**

A strength of this research was the novel inclusion of food purchasing behaviour as a variable in the quantitative modelling. Nevertheless, the research was limited in scope. Specifically, there was no accounting for school food purchasing behaviour policies, or if the food was purchased

while accompanied by an adult. It is also unknown if the food purchased was healthy or unhealthy as per WHO Nutrition Guidelines (2007), or if it was consumed immediately, at a later point in time or given away. The link between food outlets, food purchasing behaviour and consumption was not able to be confirmed in the quantitative modelling in Chapter 6. The inclusion of open-ended responses, where children, unprompted, voiced their fondness for purchasing and consuming unhealthy food and drink in their neighbourhoods, was a strength of this body of work. This finding highlights the need for future research into children's food purchasing behaviours. Specific opportunities include using GPS monitoring and automated camera (e.g., SenseCam, Kids'Cam) devices or GPS monitoring and detailed food diaries, including data on food purchasing behaviour, to build upon the findings contained within this body of work. In NZ, physical activity built environment research using GPS devices and children's physical activity and independent mobility is well established (Mavoa & Oliver, 2011b; Mavoa, Oliver, Witten, & Badland, 2011; Oliver et al., 2014; Stewart, Duncan, & Schipperijn, 2017). Additionally, the use of automated cameras to capture images of children's neighbourhood environments is emerging (Signal, Smith, et al., 2017; Signal, Stanley, et al., 2017). Opportunities exist to build on this research base to further understand the role of nutrition built environments on food purchasing behaviour and diet within the context of area level deprivation and wider influences from within all levels of the socio-ecological model (e.g. peer-pressure (Lieberman, Gauvin, Bukowski, & White, 2001), parental licence (Nyberg, Sundblom, Norman, & Elinder, 2011) and school policies (Seliske et al., 2013)).

It is important that future research builds upon the food purchasing behaviour results presented in Chapters 5 and 6 of this thesis. Greater understanding of the food purchasing behaviour of children, particularly with an emphasis on the role of friends, may yield new insights into the mechanism through which the built environment exerts influence on children's dietary behaviours and body size. There is an opportunity to build upon built environment research into physical activity and child independent mobility with nutrition built environment research and children's food purchasing behaviour. Independent mobility is the ability for a child to play, move and roam about unsupervised by an adult, usually within their neighbourhood and/or close to home (O'brien, Jones, Sloan, & Rustin, 2000). In the past, much independent mobility research has focused on physical activity accumulation (Mavoa & Oliver, 2011a; Schoeppe et al., 2013; Schoeppe, Duncan, Badland, Oliver, & Browne, 2014), active transport (Bhosale, Duncan, & Schofield, 2017; Schoeppe et al., 2013), opportunities for spatial awareness (Björklid, 2004; O'brien et al., 2000) and cognitive development (Villanueva et al., 2016). To date no research has investigated the possible connection between child independent mobility and food

purchasing behaviour. To engage in this future research, one must not reinvent the wheel. Sadler et al. (2016) published a landmark study using GPS devices showing an association between unhealthy food outlets and purchasing behaviour of adolescents in Canada. Adapting the study methods of Sadler et al. (2016) for use among children in the NZ context is warranted. As children progress through childhood into adolescence, greater permission for independent mobility is granted by parents (Carver, Timperio, Hesketh, & Crawford, 2010); therefore a longitudinal investigation into food purchasing behaviours of children, with a follow up during adolescence, would fill gaps in the current nutrition built environment knowledge base, assessing the possible link between parental licence, independent mobility and food purchasing behaviour.

### **Family, Culture and Social Norms**

While ethnicity was included as a covariate in the quantitative modelling in Chapter 5, the impact of culture, religion, social norms, celebrations and eating food with others on dietary behaviours was not factored into this body of work and is a limitation of the thesis. The social context of eating has great influence over the dietary behaviours of children (Green et al., 2003), families (Kaufman & Karpati, 2007; Lindsay, Sussner, Greaney, & Peterson, 2009) and communities (Sa'uLilo et al., 2018; Sanjeevi, Freeland-Graves, & Hersh, 2018). Opportunities for socialisation both with friends, siblings, parents and extended family members was an important finding of the study into children's perceptions of neighbourhood destinations in Chapter 6. At present much of the research in the field has used qualitative methodologies, specifically interviews and focus groups. The benefit of these qualitative approaches has been the depth of insight gained on the influence of social norms and culture on dietary behaviour. Insights specific to Pacific people living in NZ include the importance of food palatability, price, eating together as a family and social pressures to provide an abundance of food at celebrations (Haden, 2009; Sa'uLilo et al., 2018; Teevale & Kaholokula, 2016). Building on this work, opportunities exist to develop and test culturally specific indexes of the socio-cultural influences on dietary behaviours of children in NZ. A co-designed, kaupapa Māori approach would be appropriate for developing an index specific for use with Māori children and their whanau (Pihama, Cram, & Walker, 2002). Research with communities in NZ is needed to determine if a universal index could be used at the population level. The development and validation of indexes to assess social norms, religious influences and cultural influences on dietary behaviours would allow for further statistical analysis of the nutrition built environment - dietary behaviour relationship while also accounting for the potential mediating influence of social, religious and cultural factors.

This body of work was limited by omitting potential moderators in the physical activity built environment - physical activity relationship, specifically family physical activity patterns, participation in organised sport and social norms regarding active transport. A recent meta-analysis reports the influence of parental physical activity modelling and support for children's physical activity as significant predictors of child physical activity levels (Yao & Rhodes, 2015). This is expanded on in a study by Li, Adab, and Cheng (2015) investigating influences on child physical activity patterns when childcare was primarily provided by grandparents with limited mobility. Findings from the study of Li et al. (2015) showed these children had significantly less overall physical activity levels than peers whose caregivers were younger with greater mobility. Participating in organised sport is associated with greater overall physical activity levels in children (Hebert, Møller, Andersen, & Wedderkopp, 2015). Specific to the NZ context, associations between children's active transport to school and overall physical activity levels is less clear, due to complicating factors such as deprivation, family car ownership and access to public transportation (Oliver, Parker, et al., 2016). However, results from international studies suggest that children who regularly engage in active transport have greater overall physical activity levels (Carver et al., 2010; Veitch et al., 2017). It is possible that this body of work found no relationship between the physical activity built environment and physical activity behaviour because the relationship was moderated by participation in organised sport, active transport to school and other neighbourhood destinations and family physical activity patterns.

## **Implications of this Body of Work**

### **Multi-level Interventions and Policies for Prevention**

The depth of the information presented in this body of work constitutes a novel contribution to the study of obesogenic environments and their association with the body size of children. Notwithstanding that all levels of the socio-ecological model were not accounted for in this series of studies, the results support the implementation of multi-level interventions and prevention programmes to promote physical activity and reduce unhealthy dietary behaviours of children in NZ.

Interventions to reduce rates of child excess body size targeted to the level of the individual and conducted in isolation from their physical and social environment are not supported by this body of work, systematic reviews (Mead et al., 2017) or large randomised control trials (Lloyd et al., 2018). Even research poised at the cutting edge of medical science, such as probiotic supplementation and faecal transplants, cannot ignore the wider social implications, stigma and

blame that accompanies both living with excess body size and engaging in research focused on excess body size (The Liggins Institute, 2018).

Alternatively, international studies have shown that multi-level approaches including interventions at each level of the socio-ecological model when conducted together, show promise for greater reach, sustainability and long-term behaviour change than interventions targeted only to the individual level (Kaufman, Cornish, Zimmerman, & Johnson, 2014; Sallis et al., 2015; Swinburn et al., 2011). Specific public health examples include reducing prevalence rates of smoking (Sallis et al., 2006) and incidences of Human-Immunodeficiency-Virus infection (Kaufman et al., 2014). Specific to the NZ context, as alignment exists between both the socio-ecological model and Te Whare Tapa Whā, and given the disproportionately high rates of excess body size and associated co-morbidities among Māori (Marriott & Sim, 2015; Ministry of Health, 2003b, 2017a), long-term, coordinated, multisectoral and structural policies and actions that focus on the wider influences on *hauora* is needed (Theodore, McLean, & Te Morenga, 2015). A specific example of a childhood obesity intervention that is not targeted to the level of the individual is Whānau Pakari. This intervention is a culturally appropriate response to high rates of excess body size among children in the Taranaki region of NZ. Whānau Pakari is conducted in the community and is whānau-centred. The programme uses a multi-disciplinary team that includes a psychologist, active living coordinator, paediatrician and dietician. Participants are whānau/family units rather than individual children (Anderson, Wynter, Grant, Cave, et al., 2017). In addition to being more cost-effective than standard individualised medical care (Anderson et al., 2018), Whānau Pakari has been successful in reducing the body mass index of participants and improving cardiovascular fitness and quality of life (Anderson, Wynter, Grant, Cave, et al., 2017). However, long-term maintenance of health gains, specifically prevention of weight gain recidivism, post discharge from the Whānau Pakari programme are yet to be established (Anderson, Wynter, Grant, Cave, et al., 2017).

There are multiple challenges to implementing multi-level health promotion interventions. Obtaining funding is particularly difficult given the different expectations and priorities of stakeholders, health departments and communities, combined with differing expected timeframes between academic institutions, funding bodies and communities (Te Morenga et al., 2018). There is a significant time and financial cost to engaging the community and implementing multi-level interventions (Te Morenga et al., 2018). This is further complicated by a persistent belief in the medical science and health research community that the gold standard of evidence is the randomised control trial (Kippax, 2012). Therefore, interventions addressing

factors at multiple levels are often not attempted because a randomised control trial is not feasible or even appropriate (Kaufman et al., 2014). Also, as multi-level interventions may result in sustained health behaviour at a population level, quick, tangible benefits may be more appealing to funding bodies and institutions comfortable with the neoliberal doctrine of individual responsibility (Kaufman et al., 2014; Pausé, 2017). Strong political leadership is required to establish policies, particularly in the absence of a large body of 'gold-standard' research evidence (Dobbs et al., 2014; Swinburn et al., 2015). Initial government expenditure will be required to distribute a systemic range of initiatives, that will likely result in long-term healthcare savings and productivity (Theodore et al., 2015). Real-world implementation of multi-level, multi-sectoral interventions for child excess body size necessitates coordination and engagement, combining grass-roots, community-led, bottom-up interventions with top-down business and government interventions (Theodore et al., 2015). The time and commitment needed to achieve the necessary relationship building and collaboration cannot be understated (Eyles et al., 2016; Te Morenga et al., 2018; Theodore et al., 2015).

Throughout this body of work the inequitable distribution of advertising for and outlets selling unhealthy food and drink has been shown and discussed. In Chapters 4, 5 and 6 arguments are put forward to increase restrictions and enforce stricter regulation on marketing and selling unhealthy food and drink to children. An example of a policy environment intervention are fiscal policies that increase taxes on unhealthy food and drink, as has recently been implemented in Mexico (Colchero, Rivera-Dommarco, Popkin, & Ng, 2017). Economic modelling in NZ shows that a 20% tax on carbonated sugary drinks would reduce daily energy intakes by 20 kilojoules per day, and that due to their greater responsiveness to changes in food prices, the impact would likely be larger amongst children and young people and Māori and Pacific peoples (Ni Mhurchu, Eyles, Genc, & Blakely, 2014). While reducing the morbidity and mortality attributed to carbonated sugary drinks would benefit public health, fiscal policies that increase taxes on products also disproportionately affect the most deprived individuals within society (Kruger, Ham, Berrigan, & Ballard-Barbash, 2008). However, results are not universal across countries, with one study showing that the effect of a sugar tax across socio-economic groups was equal (Backholer et al., 2016). Given the current levels of inequality in NZ (Marriott & Sim, 2015), research is needed to show if fiscal incentives to purchase and consume healthy food and drink, by removing the goods and services tax that is currently on vegetables, fruits and whole milk, at the same time as introducing a fiscal policy such as a sugar tax, would impact deprived families and improve health-promoting dietary behaviours.

This thesis has argued for greater restriction and regulation around the location of unhealthy food outlets, as well as the types of food provided around schools, based on normalisation of consumption. However, as Krueger (2018) argues, in order to promote equity within society, if something is removed from the environment, something else needs to be provided in its place. An example of a behaviour-setting intervention conducted in the school environment to normalise healthy food consumption, and consequentially target child excess body size, are school food policies and school lunch programmes. While this body of work did not measure school food policies, schools that dictate what types of food can and cannot be brought onto the premises can have powerful impacts on children's health behaviours (Thomas, 11 January 2017). Many children with excess body size are also malnourished (Tanumihardjo et al., 2007; World Health Organization, 2008). Internationally, school lunch programmes have been successful in addressing malnutrition and undernutrition in countries and communities of high deprivation (Morgan & Sonnino, 2013; Wang & Stewart, 2013). School lunch programmes are particularly successful when universally implemented across regions and with all students in a school (Wang & Stewart, 2013). Over the last 15 years an industry-sponsored school breakfast programme has been implemented in some low-decile schools in NZ (Sanitarium, ND). Unfortunately, as implementation was not universal across or within schools, uptake of the programme has been poor (Ni Mhurchu, Gorton, et al., 2013). Potential reasons for the poor uptake include the associated stigma of attending an optional before-school food programme, as well as logistical and practical difficulties with attendance outside of normal school hours (personal communication, Moala T, May 12, 2017). Research is needed to assess the potential consequences for families and children if greater restrictions on unhealthy food outlets are to be implemented around schools and if school policies and school food programmes would be appropriate, concurrent interventions. Qualitative studies using interviews and focus groups with children, parents, teachers, and food outlet owner-operators would provide unique insights into current behaviour and identify any potential consequences of a policy to restrict food environments around school. Doing so would allow interventions to be adapted to prevent harm and promote the optimum behaviour change and positive health and wellbeing outcomes.

### **Theory, Research and Knowledge Translation**

This body of work, grounded in the socio-ecological model, has attempted to fill many gaps in the literature relating to neighbourhood built environments and associations with child body size. It has also identified many areas where research is still needed. However, *"there is an increased recognition that the fruits of research take too long to reach people who could benefit from them"* (Sallis et al., 2015, p. 5). Therefore, despite the need for future research,

implementing interventions, specifically those that operate at multiple levels within the socio-ecological model, should not be delayed (Lobstein et al., 2015; Swinburn et al., 2015). Additionally, there is a need to communicate research findings back to communities in order to empower them to advocate for their own change and to inform bottom-up, context-specific interventions (Boydell, Gladstone, Volpe, Allemang, & Stasiulis, 2012; Mertler, 2016; Wallerstein & Duran, 2010).

Throughout this body of work, visual images and graphics have been developed to be disseminated via social media and used in conversation with schools, teachers, community workers and the wider neighbourhood built environment research community. Research dissemination using diagrams and graphics designed to share information with members of the community is increasing in the field of neighbourhood built environments and health behaviours (Active Living Research, 2018; Bird et al., 2018; Egli et al., 2016). Bird et al. (2018) conducted a systematic review where results were presented as a series of diagrams, one for each topic identified as a finding of the review. Likewise, the use of social media to both share research results and track the spread of health messages through social networks is emerging (Hirose & Wang, 2012; Park, Reber, & Chon, 2016). It is expected that this trend will gain momentum as early career researchers, specifically those born as digital natives, progress up through the ranks of academia, bringing with them technological skills and an innate understanding of the potential impact of a successful social media campaign (Mathews et al., 2017). Future research opportunities exist to track the extent and spread of the models, videos and graphics developed during the course of this thesis. Specific studies could investigate the level of understanding gained, and if there was a direct or indirect effect on health behaviours. The spread of the messages could also be investigated simply using social media analytics, for example Altmetrics, reach, clicks, likes, comments and views.

Social media and the Internet are widely used by children. The lay person summary video (<https://www.youtube.com/watch?v=VP5tev4VdMs&t=5s>) will be shared widely on social media and sent directly to schools and children that participated in the NfAK research. Accompanying this video is a paper version of the summary for children to colour in and fold themselves (see Figure A.2). Many people place more value on things they are able to mould and shape themselves as they can personalise them and adapt them for their specific needs (Heimans & Timms, 2018). Thus, the lay person summary diagram was intentionally left black and white, and contain a child-appropriate, interactive elements. Upon confirmation, the graphical abstract for Chapter 6 will also be sent directly back to the NfAK schools and



participants. The Kids-PoND framework is able to be adapted for individual needs of schools and community members and licensed under a creative-commons-attribute-share-alike-licence for this purpose. The data collection protocol for using Google Street View has been adapted so it is fit for use by communities and schools advocating for their own health promoting-neighbourhoods. Upon confirmation of this thesis, this Google Street View protocol will also be gifted to NfAK schools, with accompanying presentations where requested.

Knowledge translation is an important component of research with children, schools and communities because it acknowledges the rights of participants to know the results of research that was conducted on/with them. Specifically, for children, translating knowledge from academia into a format that is able to be interpreted, understood and most importantly, used, is empowering for research participants. The added benefit of successful knowledge translation specifically for neighbourhood and built environment research is that it educates communities and empowers them to be active change agents, often termed 'champions' in their neighbourhoods. An example is empowering citizens to advocate for the removal of vending machines selling unhealthy food and drink from Auckland Council recreation facilities (Stuff, 27 July 2016), inspiring students to test health claims on sugary drink packaging (Vasagar, 27 March 2007) and running a healthy kai (food) workshop in the community with excess produce from local community gardens (Tamaki WRAP, 2015). Future research opportunities exist to measure the impact of, identify issues with and improve with feedback from participants the models, comics and lay person summaries developed during the course of this body of work. Opportunities exist to situate this within the participant research evaluation process.

The effort spent translating the results of this research to children, schools and communities was warranted firstly in order to complete the child-centred research cycle (Graham et al., 2006). Secondly to provide opportunities for future research to improve knowledge translation efforts and finally, to empower and inspire future 'champions' for neighbourhoods for healthy kids.

### Conclusion

*“It is one of life's bitterest truths that bedtime so often arrives just when things are really getting interesting.” Lemony Snicket (2009) The Grim, Grotto*

Neighbourhood built environments are associated with health-promoting behaviours, specifically physical activity and nutrition, in children. Associations between neighbourhood built environment factors and children's body size was tested using quantitative modelling, adjusting for physical activity and unhealthy eating behaviour covariates. Innovative tools such as Google Street View were used to measure outdoor nutrition advertising around schools. These results were contextualised through an investigation into children's perceptions of neighbourhood destinations, allowing them to voice the important influences in their environment and developed into the Kids-PoND framework. Knowledge translation efforts were employed throughout this body of work.

Neighbourhood built environments and child body size are multi-faceted and intertwined across different levels of the socio-ecological model. The unique findings of a statistically significant inverse relationship between a positive physical activity built environment and a poor nutrition built environment provide a novel and valuable contribution to the field of neighbourhood built environment research. Google Street View shows promise as a tool for measuring obesogenic environments. The Kids-PoND framework developed is a comprehensive tool to assess children's perceptions and use of neighbourhood destinations.

Overall this body of work brought multiple data sources together using a variety of tools, technologies and methods and drew upon the theoretical underpinnings of the socio-ecological model, Te Whare Tapa Whā, and employing a child-centred research approach. In doing so, this thesis produced nine original contributions to knowledge as listed below:

1. Chapter 5 presents the first use of SEM to analyse pathways between the physical activity and nutrition built environment, physical activity and dietary health behaviours with body size in one complex model.
2. Chapter 5 was the first internationally to explore pathways between the built environment and child body size using individualized neighbourhood buffer boundaries.

3. Chapter 6 was the first internationally to include a measure of food purchasing behaviour in the analysis of built environment to body size relationship.
4. Specific to the NZ context Chapter 5 was the first to report on the inverse relationship between a positive physical activity built environment and a poor nutrition built environment.
5. Chapter 6 presents the Kids-PoND framework, which is the first place-based framework for analysing children's perceptions based on the theory of affordances internationally.
6. Chapter 4 was the first to quantify outdoor advertising around schools in NZ.
7. This thesis remains the only study to have quantified outdoor advertising around schools in NZ using an 800m road network boundary around all school entry points.
8. Chapter 4 was the first internationally to compare school walkability and neighbourhood deprivation with outdoor advertising.
9. Chapter 4 was the first internationally to document issues associated with using Google Street View to measure obesogenic environments.

This body of work provides evidence that inequalities exist, particularly for poorer nutrition environments in areas of high deprivation. These important findings indicate that promoting better physical activity built environments in the absence of concurrent restriction of poor nutrition environments may intensify health inequalities. Further investigation into theoretically sound, multi-level interventions including government policies, urban planning and public health approaches targeted to the level of the environment, conducted in a manner which respects the rights of the child, is warranted. Future research opportunities exist to investigate the role of friends and family behaviour patterns as influences on children's health behaviours and if these forward our understanding of the neighbourhood built environment to body size relationship. Ultimately, neighbourhoods that get kids moving and support healthy eating are important for healthy kids.

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