Grass Routes
An observational analysis of how children use green spaces.

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Thesis Public Health Submitted to Otago University for Masters in Public Health
Title page photo: Child collecting berries in green space by the road (Source: Kids’Cam photograph archive)
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Acknowledgements

A big “thank you” to my Supervisors, Dr Paul Blaschke and Dr Hera Cook, for their advice and support throughout my thesis. You both provided an enormous amount of encouragement and guidance as I navigated new territory and grappled with the different concepts that this research has presented in addition to your mentorship and even life advice that I appreciate extended beyond your role as supervisors. Between Paul’s technical knowledge of environmental concepts and Hera’s experience in the field of academia, your diverse perspectives have helped me to broaden my ideas about the concepts that the research presented and consider each new discovery from all angles.

I am also very appreciative of the technical support that James Stanley, the Statistician for the Kids’Cam team provided during the analysis stage of my research. Thank you for training me on how to use Stata and for your patience in assisting me to extract the data to and to understand what types of analysis were required. Your quick responses and calm methodical way of solving each new technical hurdle made what would have been a very difficult assignment a great learning experience.

I would also like to thank Associate Professor Louise Signal, the lead for the Kids’Cam team, and Dr Amber Pearson for being advisors to this research. Louise welcomed me into the Kids’Cam team and provided great oversight as to how my research would fit with the work of Kids’Cam and Amber’s advice provided valuable insight into details of the study that I had not considered. I believe it is also important to thank each of the members of the Kids’Cam team who not only taught me how to use the Kids’Cam software but have all provided ongoing information and shared learning throughout my thesis. To have a team of comrades while undertaking research via distance was an important aspect of maintaining motivation.

Special thanks go to Professor Philippa Howden-Chapman and the Resilient Urban Futures Programme. I am honoured to have been a scholarship recipient of the RUFP. I would also like to thank Regional Public Health for awarding me a Pacific Scholarship and for providing a supportive work environment that encouraged academic growth and development.

And finally, thank you to my husband Marc Freeman. It was you who picked up all the household responsibilities, you who kept the cupboards stocked, prepared my meals, made sure I had clean clothes and provided ceaseless encouragement at the hardest of times. Without your love and help I simply wouldn’t have been able to find the time and emotional strength to balance full-time work, moving countries and a Master’s thesis.

Thank you, to each of you for walking this journey with me.
Abstract

Aim
This research aimed to investigate whether there is inequality relating to the use of green space among different demographic groups and disadvantaged populations.

Method
Children’s use of green space was observed by coding images from a large database of photographs (the Kids’Cam database) taken by cameras worn by participants aged 11 to 13 years in the Wellington region over a four-day period in 2014/15. Images of participant’s interaction with green space were coded by the type of green space they were in, the kind of activity they were engaged in and who they were with. This data was compared with the data on participant’s gender, ethnicity, body mass index (BMI), school decile and socioeconomic deprivation (NZiDep).

Results and Conclusions
Just over half of the participants (58%) used green space at least once, with a mean frequency (m) of 4.2 visits to green spaces over a period of four days. On average, participants spent 36.2 minutes in green space per visit. Children from schools with a higher proportion of students who are of low deprivation, used green space most often (m=10.7 visits), and for longer periods of time (m = 125.4 minutes) while those from middle deprivation schools used green space the least (m=1.9 visits and 14.6 minutes), followed by those from high deprivation schools (m = 4.7 visits and 31.3 minutes), with p-values for the difference between school deciles on both the frequency and duration of visits below 0.001.

In addition, female participants used green space more frequently and for a longer duration (m = 5.8 visits, m= 50.3 minutes) than males did (m=2.4 visits, m=20.3 minutes) with p-values below 0.05.

Results also showed that most of the time spent in green space was using public green spaces as opposed to private green spaces. Participants visited fields and private green spaces most frequently but spent most of their time in playgrounds and beaches. On most occasions participants in green spaces were accompanied by another person (84.7%) and they were with an adult just over half of the time they were in green spaces (59.1%). In addition, weaker results indicated that there may be trends related to NZiDep, BMI, and ethnic group worth further investigation.
1. Introduction

When I was a child I used to go on adventures. My sister and I would go with other
eighbourhood kids into the empty lot on our street with and jump into The Black Hole (a
land slip that created an entrance into the bush). Together we would explore the massive
bush landscape of the hill we lived on and discover new worlds. We had no cell phones or
map, and if we became lost we would simply walk up the hill until we ended up in someone’s
backyard. Suffice to say our parents had no idea what we were up to.

To me this was a fairly typical childhood for what we term a ‘kiwi kid’; it was not until I began
travelling to other countries that I understood how rare childhood experiences like this are.
In fact as I moved and lived in different areas of my city it became more apparent that such
interactions with nature may not even be common for all New Zealand children. In Tokyo,
Japan, I found children’s playgrounds to be devoid of trees and grass and instead green
spaces were beautifully landscaped national parks that people had to pay to access. In the
Newtown of Edinburgh, United Kingdom, where I live, backyards are infrequent and instead
there are small urban green spaces on every city block surrounded by locked iron fences for
the exclusive access of select residents who pay hefty maintenance fees. While in Canada I
was informed that those who wish to roam the abundance of its wild natural spaces must
have appropriate survival knowledge and skills in case they encounter dangerous wildlife.
Each of these green space settings has their particular benefits but also barriers that will
likely lead to different types of green space use between demographic groups. Similarly, as
I saw different parts of Wellington, it appeared from my observations of that low socio-
economic areas with high numbers of Māori, Pacific and refugee residents have many green
spaces that are fenced flat grassed areas, whereas high socio-economic areas seemed to
have more plant diversity, trees and facilities provided in their green spaces. However, there
seemed to be no research to evaluate these possible disparities.

I have chosen to study this subject matter as I want to investigate whether there are
inequalities relating to green space engagement between ethnic groups, genders and social
economic groups.

Rationale

All children under Article 31 of The United Nations Convention on the Rights of a Child, have
the right to ‘rest, leisure play and recreational activities’ (The United Nations, 1989, p10). However, research indicates that participation in outdoor activities may be lower amongst
those of minority ethnicities, high socioeconomic deprivation and females (Astell-Burt, Feng, Mavoa, Badland, & Giles-Corti, 2014; Faulkner, Mitra, Buliung, Fusco, & Stone, 2015; Klinker, Schipperijn, Kerr, Ersbøll, & Troelsen, 2014). These results include some New Zealand studies that have found that new immigrants and those on lower incomes are less likely to use public green spaces (Lovelock, Lovelock, Jellum, & Thompson, 2011). Furthermore it is possible that any inequalities may become worse as urban population sizes continue to increase in New Zealand and globally (The World Bank Group, 2015).

Green space is a term that can encompass all types of natural environments or spaces where nature is a dominant feature (Blaschke, 2013). Unequal engagement with green space between groups with different ethnicities, gender and socio economic status could have an effect on health outcomes. The literature suggests that green space availability and use may encourage physical activity, rest and social contact (Bancroft et al., 2015; Holtan, Dieterlen, & Sullivan, 2014; Irvine, Warber, Devine-Wright, & Gaston, 2013; Roe, Aspinall, & Thompson, 2016). Each of these behaviours can affect the health of individuals by reducing stress levels, improving blood pressure, cardiovascular health, cognitive function and individual access to social resources that may assist with health and wellbeing (Dadvand et al., 2015; Gascon et al., 2015; Grazuleviciene et al., 2015; Nutsford, Pearson, & Kingham, 2013; Thompson, Aspinall, & Roe, 2014). These health-promoting behaviours may explain why a large body of research has found that the use and availability of green space may be associated with improved physical health outcomes, self-rated health, mental wellbeing, body mass index, and cognitive and behavioural development in children (Amoly et al., 2014; Bell, Wilson, & Liu, 2008; Maas, Verhij, Groenewegen, De-Vries, & Spreewenberg, 2006; R. J. Mitchell, Richardson, Shortt, & Pearce, 2015; Wolch et al., 2011).

Furthermore, some research has indicated that the use and availability of green space, might help to reduce health inequities, with results reporting enhanced health outcomes for disadvantaged groups such as youth, the elderly, ethnic minorities, and those on low incomes (Maas et al., 2006; Mitchell & Popham, 2008; Roe et al., 2016). These groups who often have higher levels of disease burden and limited means of accessing necessary resources to improve their health e.g. due to independence, transport, language and income limitations (Baur & Tynon, 2010; Holtan et al., 2014).

This study is part of a wider research programme called Kids’Cam. The Kids’Cam project aims to ‘objectively study the world in which children live’ (Signal et al., 2017, p1), through the use of wearable digital cameras that are configured to automatically take a photograph every seven seconds. The cameras were worn by 168 participants aged 11 to 13 years from
16 randomly selected schools across the Wellington region, for a period of four days between July 2014 and June 2015. This research examines photographs that show children interacting with all types of green space, from private domestic green spaces, to urban public green spaces as well as wild/natural green spaces.

The methods used by the Kids'Cam project are rare in the field of green space study as few studies have observed children’s actual use of green space. Instead most research in this field has compared the availability of green space or the density of vegetation in close proximity to the studied population with the occurrence of both positive and negative health outcome (Gascon et al., 2015; Lachowycz & Jones, 2011; Lee & Maheswaran, 2010; Wolf & Robbins, 2015).

Although a small number of studies have examined green space use, this has been through means of self-report methods that can be subject to recall and social desirability bias (Lachowycz & Jones, 2011).

Another unusual aspect of this research is that by using wearable cameras to record children’s activities as they go throughout their day, the methodology provides information on all the types of green space that children may engage with. These green spaces could include those that previous research may have excluded due to data limitations such as green space that is not usually accessible to the public, unmapped green locations and most importantly private green spaces that account for a large proportion of green space in New Zealand residential areas (Mathieu et al., 2007).

**Research Aim and Questions**

This research aimed to investigate whether there is inequality relating to the use of green space among different demographic groups.

The following questions were investigated using data from the Kids'Cam database, to achieve the aim of this thesis.

1) What is the frequency of use and the duration of time that children spend in green space?
2) How does the frequency of use and duration of time that children spend in green space differ by demographic characteristics such as their body mass index (BMI), ethnicity, school decile, gender and level of socioeconomic deprivation (NZDep)?
3) What kinds of green spaces do children visit?
4) What proportion of the time children spend in green space is spent using public green spaces as opposed to private green spaces and how does this differ between demographic characteristics?

5) What types of activities do children participate in while in green space?

6) What proportion of the time children spend in green space is spent being inactive?
   And how does the proportion of time spent inactive differ between demographic characteristics?

7) What proportion of the time children spend in green space is in social contact with another person? And how does this differ between demographic characteristics?

8) What proportion of the time children spend in green space is supervised by an adult?
   And how does this differ between demographic characteristics?

The thesis begins by providing a literature review of the evidence that examines how engagement with green space is relevant to health and wellbeing and the factors that influence this relationship. This is followed by a methodology chapter that gives a brief overview of the steps that the Kids’Cam team took to collect the data and how I have processed and analysed this data to examine children’s use of green space.

The results chapter presents the information that was extracted from the Kids’Cam data to answer the research questions by providing an analysis of all interactions that the participants had with green space. These breakdowns include the frequency and duration of visits to green space, and those interactions by gender, BMI, ethnic group, School Decile and NZiDep (New Zealand index of socio economic deprivation for individuals: (Salmond, Crampton, King, & Waldegrave, 2006)). Other factors that may influence green space use and health outcomes, such as the type of green spaces visited, the kind of activity engaged in while in green space, how much of the time spent in green space is supervised, if the children were in the presence of other people and if they were physically active, are also examined by demographic groups. This chapter is followed by a discussion chapter that summarises and interprets the results in relation to the research questions and the literature review.

Previous research indicates that there could be relationships between green space use and multiple health outcomes. If it is found that the patterns of green space use differs between demographic groups, including the frequency, duration, type of green spaces used and activities engaged in while in green space, this information may help to build a more detailed understanding of how the benefits of green space engagement can be utilised to reduce health inequities for children living in the Wellington region and across New Zealand.
2. Literature Review

The purpose of this research is to investigate whether there are inequalities relating to how green space is used by different demographic groups and disadvantaged populations such as Māori and Pacific children or those from low socio-economic households. This question will be investigated by examining the relationship between children’s social demographic characteristics such as gender, ethnicity and level of deprivation and their use of green space, including how often they use green space, the type of activity they participate in and the types of green space they visit. The literature presented and discussed in this review outlines why the relationship between green space and health is of importance to health research, in particular to what extent the use of green space and access to green space has been linked to health outcomes.

There are numerous factors that may be attributed to the health benefits that have been associated with green space. Figure 1 below is an adaption of Hartig et al.’s (2014) diagram on pathways between natural environments and health for the purpose of the Green Space Study. Figure 1 includes additional relationships that were not featured in Hartig et al.’s (2014) diagram, between contact with green space and health outcomes such as environmental benefits, body mass index (BMI), mental health, and cognitive development. The evidence on the relationship between green space and each of these outcomes is examined in detail in this review. In addition, this review explores the literature on variables that may interact with the relationship between exposure to green space and health outcomes, as also show in Figure 1 below. These factors include gender, ethnicity, the level of supervision, socio-economic status and the quality of green space.
Figure 1: Variables that relate green space to health (adapted from Hartig et al. (2014) for the Green Space Study)
Defining Green Space

This study was not able to draw an exact definition of green space from previous research because many of the studies comparing green space to health outcomes based their definitions on the function of the space such as; open green space, useable green space, agricultural, private use or the level of vegetation (Astell-Burt et al., 2014; Edwards, Hooper, Knuiman, Foster, & Giles-Corti, 2015; Maas et al., 2006; Ribeiro, Pires, Carvalho, & Pina, 2015; Richardson, Pearce, Mitchell, Day, & Kingham, 2010; Witten, Hiscock, Pearce, & Blakely, 2008). There are some studies that limited the focus of the green spaces they were studying to locations where they could observe specific behaviours such as physical activity (Powell, Slater, & Chaloupka, 2004).

A common element within definitions of green space is the presence of natural features such as bush, forests and river beds (Joseph & Maddock, 2016; Lovelock et al., 2011; Thompson et al., 2014). Natural resources are also present in built environments for example urban parks, sports fields, countryside and public gardens, that have been found to be commonly accessed in New Zealand (Ergler, Kearns, & Witten, 2016; Freeman, Van Heezik, Hand, & Stein, 2015; Veitch, Bagley, Ball, & Salmon, 2006). These types of green spaces are accessible to all, but also within the category of urban green spaces are domestic spaces such as private gardens and backyards; these are the green spaces that most people in New Zealand have access to on a day to day basis (Freeman et al., 2015). This wide range of examples is summarised in a report for the Department of Conservation on health and wellbeing benefits of conservation in New Zealand, which described green space as ranging across a continuum from private domestic green spaces, through to publically accessible wild/natural green space as depicted in Figure 2 below (Blaschke, 2013). However, not considered in the original version of this continuum were blue spaces such as coastal environments and river beds, which are also considered to be contributors to the health outcomes associated with natural environments (Nutsford, 2014). Therefore Figure 2 below has been adapted to also encompass these.

<table>
<thead>
<tr>
<th>Private garden</th>
<th>Urban park</th>
<th>Peri-uban green area</th>
<th>Scenic and marine reserve</th>
<th>Coastal and large wilderness area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private domestic green space</td>
<td>Public or private built green spaces</td>
<td>Public wild green space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Continuum of types of natural or green space (adapted from Blaschke, 2013 p7)
As little research has compared the value of different types of green space for health and wellbeing, the current study has explored any contact with natural environments, including all types of green and blue spaces within the continuum in Figure 2. Therefore, for this research green space has been defined as outdoor space where a dominant feature of the environment is vegetation (both natural and landscaped) e.g. public gardens, bush reserves, sports grounds, urban parkland, playgrounds, forests and private gardens/yards and coastal or riparian areas near the ocean or a river/stream.

Health Outcomes

The health benefits associated with access to and use of public green space have long been debated as a public health issue. The following sections outline previous research between the use of green space, its proximity and its density with the resulting biological health benefits, improvements to mental wellbeing, enhanced social contact, increased physical activity and reduced BMI.

Environmental Benefits

The vegetation in green spaces has the ability to improve air quality by reducing pollutants such as carbon dioxide, ozone, oxides of nitrogen, oxides of sulphur and particulate matter (Fowler, 2002 as cited in Hartig et al., 2014). It can also maintain and lower temperatures in a region and protect water quality through the prevention of storm water runoff (Oldfield, Warren, Felson, & Bradford, 2013; Shanahan, Fuller, Bush, Lin, & Gaston, 2015). These environmental benefits all have the potential to improve physical health outcomes through reducing rates of respiratory infections, heat related illness, acclimatization of vectors, and waterborne disease (Hartig et al., 2014; Oldfield et al., 2013; Shanahan et al., 2015).

General Physical Health

Green space may also have an effect on general health outcomes. Several cross sectional studies have found evidence of a positive relationship between exposure to green space and self-perceived general health (Maas et al., 2006; Triguero-Mas et al., 2015; Van Den Berg et al., 2015; Wolf & Robbins, 2015; Wolfe, Groenewegen, Rijken, & de Vries, 2014). Many of these studies focused on access to and use of public green spaces in urban environments. However, a few have looked at all available green space including private gardens; for example Triguero-Mas et al. (2015) presented research that compared data on self-perceived general health from the 9,048 adult respondents in the Catalonia Health survey, with the level of surrounding greenness within 300m of their home. Maas et al.’s (2006)
study used data from 250,782 participants in the Dutch National General Practice survey in conjunction with data on the percentage of green space within 1km and 3km of where they lived. Both of these studies reported a significant association between self-perceived general health and green space surrounding their residence. In particular, Maas et al. (2006) found that up to 15.5% of participants felt unhealthy if they lived in an area with only 10% surrounding green space, whereas 10.2% felt unhealthy if they lived in an area with 90% surrounding green space.

Conversely there have been several cross-sectional studies that applied similar methods and found either non-significant, or no relationship at all, between access to green space and health. For instance, Mitchell & Popham's (2007) study of self-reported health from the 2001 Census in England and the 2001 Generalised Land Use Database, concluded there was no significant relationship between access to public green space and health in high income areas. In addition, they found low-income areas had a negative relationship between access to public green space and health, with lower levels of self-reported health as public green space coverage increased.

Arguably, this inconsistency in results may be because self-perceived general health is not an objective measure of health in a population. For instance a systematic review of studies that were conducted in North America, Europe and Oceania, found small but statistically significant reductions in the risk of cardiovascular disease (of up to 5%) among those who had higher coverage of green space in their neighbourhoods (Gascon et al., 2015), although this study found the comparisons between the exposure to residential greenness and all causes of mortality to be inconsistent. Similar outcomes have been reflected in Richardson et al.’s (2010) research that compared the percentage of overall green space coverage within 1009 small urban areas in New Zealand with mortality rates for cardiovascular disease and lung cancer. They found that after adjusting for confounding factors (deprivation, smoking and air pollution) there was no significant relationship (Richardson et al, 2010).


However, not one of these studies included the availability of private green space which is often more likely to be used on a day-to-day basis due to convenience of location and might account for a large proportion of green space coverage in New Zealand. For example,
residential private green space accounted for more than 50% of the urban green space in Dunedin, New Zealand (Mathieu et al., 2007). Nor did any of the studies measure the actual use of green space, with all of the research mentioned above relying on green space availability rather than direct interaction with green space. This literature review was able to locate one randomised control trial (RCT) that examined green space used in Kaunas, Lithuania. That research identified improved health benefits from participating in physical activity in green space over non-green space by randomly assigning twenty, 50- to 74-year-old participants with coronary artery disease to walk for 30 minutes every day for a week, in either a park, or a busy urban street. Results showed that even though the demographic characteristics across both groups were very similar, the participants who were assigned to walk in a park had significantly greater reductions in heart rates and diastolic blood pressure as well as increases in exercise duration and heart rate recovery, when compared with the urban street group (Grazuleviciene et al., 2015). This suggests that participating in physical activity in green spaces is more likely to aid recovery for those with coronary artery disease, than walking in urban settings. The researchers advise that this difference may be due to the higher level of air pollution in the busy urban street, with the study measuring higher levels air pollution including nitrogen dioxide and PM_{2.5} (fine particulate matter) and noise pollution in the busy urban settings compared with the park settings. The researchers also propose it is possible that these results may be due to the emotionally restorative effects of green space, e.g. improved mental wellbeing through relaxation.

The research discussed demonstrates the wide variety of methods used to investigate the health benefits of green space. Such benefits include the impact of green space on environmental qualities that effect health, self-perceived general health among those in close proximity to green space, reductions in the presence of cardiovascular disease for those with greater green space coverage in their area and reductions in heart rates and diastolic blood pressure for those who are in direct contact with green space. The following sections will discuss literature that examines the full range of health benefits that are indirectly attributed to general health outcomes, including body mass index, physical activity, social contact, mental wellbeing and child development.

**Body Mass Index**

Childhood obesity is on the rise in New Zealand, with 21% of New Zealand children overweight and child obesity rates moving from 8% in 2007 to 11% in 2015. Obesity rates are even higher among Māori, with rates of 15%, and Pacific children at 30% (Ministry of Health, 2012). In addition, children living in areas of highest deprivation were three times
more likely to be obese in New Zealand than those from areas with the lowest levels of deprivation (deprivation measured using the New Zealand 2013 index of socioeconomic deprivation developed by Otago University). This link between deprivation and obesity raises strong health equity concerns as childhood obesity is linked to type 2 diabetes, asthma, hypertension, sleep apnea, social isolation, emotional distress and adult obesity, which can lead to an increased risk of cardiovascular disease, high blood pressure and stroke (Bell et al., 2008; Kim, Subramanian, Gortmaker, & Kawachi, 2006; Ministry of Health, 2016).

Research to date on the impact of the use of green space and BMI has found variable results. Lachowycz’s & Jones (2011) systematic review found only three out of 13 studies citing a positive relationship between healthy BMI and the availability and use of green space. The three studies that were positively associated with green space included associations with reduced weight amongst young people in highly populated areas who were exposed to an increase in vegetation where they lived; reduced weight gain over a two-year period for those who had increased exposure to green space; and a 40% reduction in the likelihood of obesity in the greenest areas across several European cities. Amongst the remaining tens studies, six found mixed or weak evidence and four found no relationship between green space and BMI. Lachowycz & Jones (2011) speculate that the diversity of results may be due to the wide range of factors that influence weight, the delay in time between exposure to green space and BMI changes, and differences between in age and socio-economic status of participants between studies as well as the type of green spaces used.

Another example is the study of Bell et al. (2008), which found that greater green density corresponded with lower BMIs in children aged 3 to 16 year in Marion County (Indianapolis, USA). The study examined geo-coded satellite images of green density, against the addresses of all children who had received care from subsidised health clinics between 1996 and 2002. They found that greater greenness was significantly associated with lower BMI scores and a lower likelihood that a child’s BMI would increase over a two-year period.

Likewise, the parents of 3,178 children, in South California aged 9 to 10 years in 1993, were surveyed every spring for eight years to gather information on BMI, respiratory illness, physical activity, and the number of parks within 500m of the child’s home. Results showed that 9.5% of boys and 8.3% of girls who were overweight, reduced to a normal weight range if they moved to live within 500m of a park. A smaller but significant effect was also measured for obese, with 2.6% of boys and 2.1% of girls changing from being categorised
as obese, to being categorised as overweight, if they moved to live within 500m of a park (Wolch et al., 2011).

Similar but non-significant results were found by Potestio et al. (2009), who also examined 6,772 children’s BMIs (mean age of 4.95) in Calgary, Canada, in relation to four measures of green space access. These measures included the number of parks per 10,000 residents, park size in proportion to the size of the neighbourhood areas, the average distance to parks and the length of time taken to walk to a park from the postal code of participants. However, once the results controlled for education and the proportion of minorities, the effect of increased green space access on reduced risk of obesity and overweight children was no longer significant for any of the four measures of green space availability. The researchers note that it is possible that young children may be less likely to use parks in Calgary than other cities as temperatures are often below zero degrees centigrade for seven months of the year.

Lovasia et al. (2013) examined the BMI from pre-school health care records of 11,562 children living in New York City, USA and compared this with street tree-density data from the Department of Parks and Recreation within children’s respective zip-codes. They found that access to parks and walkability had no association with BMI but higher density of street trees (those in the 75th percentile) was associated with a 12% lower prevalence of obesity.

Conversely, reverse results were shown among adults by Cummins & Fagg (2012), who studied the BMI rates of 36,959 adults in their mid 40s, extracted from the Health Survey England years 2000 to 2007 and compared with the amount of publically accessible green space per square metre gathered from the United Kingdom Generalised Land Use Database. This research found that those from the greenest areas were 12% more likely to be overweight and 23% more likely to be obese. However, it may be that the results of this study differed from Bell et al.(2008), Potestio et al.(2009) and Wolch et al.'s (2011) findings because Cummins & Fagg (2012) excluded private gardens, backyards and green spaces that were less than 5m². Also, the study found that results did not change after controlling for physical activity levels, indicating that the assumption that researchers often make that physical activity is the effect modifier that influences the relationship between green space and BMI, may not always be true (Cummins & Fagg, 2012). This assumption that the relationship between BMI and green space can be attributed to physical activity has been further questioned by Lachowycz & Jones’s (2011) systematic review of 41 articles. The review found that only 40% of the articles identified a positive relationship between green
space and physical activity while the remaining 60% either reported no relationship or a weak or negative relationship between these two variables.

Obesity contributes to diseases, including type 2 diabetes, and cardiovascular disease (Ministry of Health, 2016). There are higher rates of obesity among deprived populations, including Māori and Pacific (Ministry of Health, 2012). Previous research that has tried to correlate the availability and use of green space with BMI has found variable results. Some studies found reductions in BMI amongst individuals who moved to areas with more green space or higher-density vegetation (Bell et al., 2008; Lachowycz & Jones, 2011; Wolch et al., 2011). However, more often studies produced insignificant and sometimes reverse results (Cummins & Fagg, 2012; Lachowycz & Jones, 2011; Lovasia et al., 2013). The varied results may arise due to exclusion of private green spaces from analysis; different population demographics; and the failure to measure actual use or interaction with green space.

Physical Activity

Given rising rates of childhood obesity in most countries, physical activity has been seen to be an important feature in child development and as a preventative health strategy (World Health Organisation, 2016). Engagement in physical activity may be linked to health inequities as results from eight national surveys in the United States and Canada between 1972 and 1983 found that young people from higher socioeconomic households engaged in physical activity more often (Stephens, Jacobs, & White, 1985).

Numerous studies have investigated the relationship between green space and physical activity (Christian et al., 2015; Coombes, Jones, & Hildon, 2010; De Vries, Bakker, Van Mechelen, & Hopman-Rock, 2007; Dyment & Bell, 2008; Edwards et al., 2015; Giles-Coti et al., 2005; Maas et al., 2006; Maas, Verheij, Spreeuwenberg, & Groenewegen, 2008; Powell et al., 2004; Ribeiro et al., 2015; Witten et al., 2008, 2015). Several articles have cited evidence of a positive relationship between access to green space and participation in physical activity (Bancroft et al., 2015; Baur & Tynon, 2010; De Vries et al., 2007; Dyment & Bell, 2008; Edwards et al., 2015; Hume, Salmon, & Ball, 2005). This suggests that green space that encourages and supports physical activity might assist in reducing obesity and sedentary lifestyles that can increase individuals' risk of type 2 diabetes and cardiovascular disease (Regional Public Health, 2010).

However, the evidence that links green space and physical activity remains variable. For instance a systematic review that examined research that compared the association between park access and physical activity found a range of findings, with five articles
reporting significant positive associations between access to parks and physical activity, nine with no association at all and six with mixed results (Bancroft et al., 2015).

This literature review found three studies that identified a positive relationship between the amount of physical activity children had and green space. Dyment & Bell, (2008) surveyed 5,105 students from 145 schools across Canada, on improvements to the school green spaces that children used. They found that more than 49% of participants perceived that improvements to green spaces promoted vigorous physical activity and 71% perceived an increase in moderate to light physical activity. The study also reported a wider range of children participating in physical activity in the improved green spaces when compared to the use of non-green outdoor spaces, with the latter perceived to limit activity within them to rule-bound play and sports.

Likewise, green spaces were found to be a key environmental feature relating to physical activity in Hume et al.‘s (2005) mixed methods study of children in Victoria, Australia. This study tracked student’s engagement in physical activity using an accelerometer and investigated environmental associations related to their physical activity, by asking students to photograph and draw maps of their neighbourhood environment. This study did not identify a direct association between physical activity and green space, but did indicate that participants who participated in high levels of physical activity also identified green space as an important feature of their neighbourhood.

More recently Janssen and Rosu (2015) measured the self-reported physical activity of children aged 11 to 13 years across all provinces in Canada to compare access to meadows (areas with more than 50% grass) and tree/shrub density (areas with more than 50% trees or shrubs) within 1km of their home. Their results showed that for every 5% increase in tree/shrub density, there was a 5% increase in self-reported levels of physical activity amongst participants, although no significant associations were found between physical activity and access to meadows. The researchers speculate that the results indicate that physical activity amongst 11 to 13 year olds is associated with more stimulating green spaces e.g. those that have greater diversity of plant life.

Similar results have been found in research with adult participants, including the study of Giles-Corti et al. (2005), which was based on interviews with 1,803 individuals aged from 18 to 59 years in Perth, Australia. The findings indicated a positive relationship between the proximity to public green space and engagement in physical activity. The study compared data on the proximity of people from randomly selected households in advantaged and disadvantaged districts to public green space, with observations of physical activity in public
green spaces. They found that those with access to large attractive public green spaces, were 50% more likely to participate in walking, six or more times a week (at total of 180 minutes or more), with an odds ratio of 1.50 (95% CI, 1.06–2.13) than those without such access. In a similar study that used self-report data from 532 adults in Portugal, the time spent in physical activity (during leisure time) was found to have reduced by 2.6% for every 100m of distance participants lived from from a park or non-residential destination (church, shop, library etc.) (Ribeiro et al., 2015).

Conversely, a number of studies have found there to be no association between access to open green space and physical activity (Bancroft et al., 2015; Bedimo-Rung, Mowen, & Cohen, 2005; Coombes et al., 2010; Lee & Maheswaran, 2010; Maas et al., 2008; Nutsford, 2014; Triguero-Mas et al., 2015; Witten et al., 2008). For instance, in a systematic review Lachowycz & Jones (2011), observed inconsistent findings across studies that investigated the relationship between access to green space and physical activity, with 20 studies reporting a positive relationship, and 28 reporting no significant relationship.

Four studies using a similar approach to that of Giles-Corti et al. (2005) and Ribeiro et al. (2015) (comparing self-reported participation in physical activity from national health survey data with proximity to geocoded green spaces acquired from national land databases), found there was no significant positive relationship between physical activity and green space (Maas et al., 2008; Nutsford, 2014; Triguero-Mas et al., 2015; Witten et al., 2008).

For instance, Maas et al.’s (2008) study found there was no relationship between the percentage of neighbourhood public green space in the Netherlands and participation in sports, leisure walking and meeting the recommended health recommendations of physical activity (30 mins of moderate activity at least five days per week). In addition the study found there was a negative relationship between green space and cycling for leisure, and walking for commuting purposes. Likewise Triguero-Mas et al.’s (2015) cross-sectional study in Catalonia using satellite images to identify dense vegetation within a 300m radius of individuals’ homes, found there to be no association between self-reported physical activity and the degree of greenness surrounding an individual’s home.

Witten et al. (2008) found similar results for New Zealand, reporting no association between physical activity and proximity to parks and beaches in a comparison of Land Information New Zealand data on 38,350 neighbourhoods across New Zealand with data from 12,529 participants in the New Zealand Health Survey. Nutsford’s (2014) research that used the same sources of data to study Wellington residents exclusively, found there was a negative association between proximity to both useable and non-useable green spaces and
engagement in physical activity (after controlling for area level deprivation). Neighbourhoods with the best proximal access to green space reported lower rates of individuals meeting the recommended physical activity guidelines (≥5 x 30 mins activity per week), while those who lived farther from green spaces tended to have higher rates of physical activity. However, the overall quantity of green space in a neighbourhood was positively associated with physical activity (Nutsford, 2014).

These conflicting results may be related to many of the studies relying on self-reported physical activity as opposed to objective measures. Numerous experimental studies have found the results from various forms of self-report methods of measuring physical activity questionnaires do not align with results recorded by accelerometers, GPS units and heart rate monitors (Elliott, Baxter, Davies, & Truby, 2014; Oliver et al., 2014; Prince et al., 2008; Silsbury, Goldsmith, & Rushton, 2015).

In addition, many of the studies focussed on green space access and coverage but did not look specifically at the use of green space in relation to participation in physical activity. This is important in New Zealand, where most people have access to green space close to their residence (Witten et al., 2008), and because the amount or proximity of green space may not be entirely related to green space use (Amoly et al., 2014). It is also possible that many low population density areas with larger proportions of green space have a greater distance between facilities, therefore increasing the likelihood of using vehicles and public transport as a means to travel between them, rather than using active transport such as walking or cycling (Maas et al., 2008; Nutsford, 2014). Furthermore, many of these studies controlled for socioeconomic status (SES) or household income as a potential confounder. However, SES and income may instead be effect modifiers, as the benefits of green space have been found by some studies to be stronger amongst those from low SES or low income areas (Maas et al., 2006; Mitchell & Popham, 2008). Therefore, it is possible that the studies that controlled for income and SES during analysis may have altered the measured relationship between green space and physical activity.

Social Contact

Green spaces can encourage and strengthen social capital in a neighbourhood (Holtan et al., 2014; Kweon, Sullivan, & Wiley, 1998; Roe et al., 2016; Sullivan, 2004; Wolfe et al., 2014). Social capital consists of the benefits gained from social connection with others, including shared knowledge, norms, extension of networks, enhanced collaboration, connection with other cultures, and shared sense of community (Holtan et al., 2014; Neal, Bennett, Jones, Cochrane, & Mohan, 2015; Porter & McIlvaine-Newsad, 2014). Higher
levels of social capital have also been found to be related to higher incomes and increased opportunities for employment, social support, societal participation, and reduced prejudice, loneliness and isolation (Matsunaga, 2015; Neal et al., 2015; Piracha, Tani, & Vaira-Lucero, 2013; Wang & Lu, 2016). This can promote multiple health benefits, as social capital has been found to be associated with improved individual and community wellbeing and self-rated health in chronically ill people (Baur & Tynon, 2010; Wolfe et al., 2014; Yamaguchi, 2015). This was demonstrated in a study that compared British Household Survey responses to three social capital measures (social participation, social network and loneliness), with results from the General Health Survey (Yu, Sessions, Fu, & Wall, 2015). Results (n=10,000) indicated that ‘social participation’ was a predictor of self-reported mental health (4.09 p < 0.01), while ‘loneliness’ had a negative relationship with mental health (-0.05 p < 0.01) and physical health (-0.06 p<0.01). The measure for ‘social network’ was also positively related to mental health and physical health. However, the findings were not significant (Yu et al., 2015).

Several studies have found examples of a positive relationship between social capital/contact and the degree of access to residential green space. A study measuring the percentage density of tree canopy near homes in Baltimore city found a significant positive relationship between the percentage of tree canopy coverage and social capital (Pearson’s r = .241, p < .01) (Holtan et al., 2014). This increase in social capital is likely to be due a to rise in use of shared community spaces, as the study found that while overall tree canopy coverage correlated with increased social capital, access to private backyards did not (Holtan et al., 2014). It is possible that the participants in Holtan et al.’s (2014) study experienced higher levels of social capital associations with tree canopy, as the sample had a high number of participants who were unemployed, of minority ethnicities, and on lower incomes. For example interviews with 80 adults in Manchester also found minority groups in deprived areas were more likely to engage in social activities in green spaces (Roe et al., 2016).

Furthermore a study in the Netherlands that questioned 1,112 participants with chronic disease about their connection to community also found an extremely weak but significant relationship (-0.00, p < 0.01) between the percentage of green space coverage per kilometre and social contact (Wolfe et al., 2014). In addition, several studies comparing the level of social connection amongst individuals who were randomly assigned to different public housing configurations in Chicago and Baltimore found that that those who had been assigned to neighbourhoods with shared green spaces had higher levels of social connection (Kweon et al, 1998; Sullivan, 2004).
There are several speculations as to why green space may contribute to social capital or contact, including the creation of a central, safe community space for individuals to meet, the shared interests of those using the green space e.g. whether it is for exercise, children’s recreation or dog walking, or perhaps that the effects of being in a natural environment can encourage social contact (Holtan et al., 2014). In particular, the potential for green spaces to provide an environment for connection between different social groups has been reported in qualitative studies. For example Neal et al.’s (2015) mixed method study of one-on-one interviews and focus groups with park users found that parks provided a place for people of different ethnic groups, ages and sub-cultures to come together, ultimately resulting in more mixed social contact as different groups shared the same space and resources. Furthermore, case studies of community garden projects in Illinois (USA) and Canterbury (New Zealand) found that the community garden became a place where those with and without disabilities as well as community members of different ethnic, age, economic, educational and occupational backgrounds connected. Interviews with those who participated in community garden projects, reported several positive outcomes, including reduced isolation, sharing of resources, sense of community and social support within the neighbourhood (Minchington, 2014; Porter & McIlvaine-Newsad, 2014).

Green spaces may provide shared community spaces that can promote social contact and the development of social capital. This has been suggested by several studies that have found connections between social capital and the density of green and natural features in the area in which people lived, in particular for ethnic minorities and those on low incomes (Holtan et al., 2014; Kweon et al., 1998; Porter & McIlvaine-Newsad, 2014; Roe et al., 2016; Sullivan, 2004; Wolfe et al., 2014). By aiding in the development of social capital, green spaces can help to reduce isolation and improve community cohesion, societal participation, social support, and shared resources (Matsunaga, 2015; Neal et al., 2015; Piracha et al., 2013; Wang & Lu, 2016; Yu et al., 2015).

**Mental Health**

Mental health is a prominent health concern in New Zealand, with one in five people in New Zealand affected by mental health disorders. In addition Māori are 1.7 times more likely to experience difficulties with mental wellbeing than other ethnic groups (Mental Health Commission, 2012). Mental illness not only has a large sum of health and social costs, it also contributes to a number of physical health conditions including strokes and heart disease (Hippisley-Cox, Fielding, & Pringle, 1998).
A literature review of research from 1990 to 2010 found that most of the evidence that linked green space and mental health was weak and often limited by poor design that did not adequately control for confounding, bias or reverse causality (Lee & Maheswaran, 2010). However, more recent evidence supports the hypothesis that people seek out green space for respite and restoration (Irvine et al., 2013). For example, Gascon et al.'s (2015) systematic review found 18 studies out of 28 observed lower rates of mental health disorders and illness amongst those who lived in areas with higher levels of surrounding greenness; one study was a longitudinal survey that identified a measured reduction in mental illness symptoms after participants moved to areas with higher levels of surrounding green space. Similar results were found by Thompson et al. (2014) in a cross sectional study in Scotland in which self-reported stress and mental well-being were compared with the quantity of all green space near participants’ homes (including private gardens) measured via Graphic Informational System (GIS) mapping. Their findings indicated that individuals who lived in areas with higher levels of green space or visited green space more often, experienced lower self-reported stress, with ‘restorative qualities’ being cited as the most common reason for visiting a green space. However, there was no significant association between higher levels of residential green space and overall mental wellbeing. The study used random sampling methods to recruit participants and applied standardized tests to measure participants’ stress levels and mental wellbeing. However, the study was still vulnerable to bias, as surveys were completed by the participants, rather than using an objective measure of green space use.

These researchers conducted further investigations to support these findings by measuring the relationship between green space and stress using salivary cortisol measures as a biological measure of participants’ stress levels (high cortisol levels being indicative of higher stress). To measure stress, four salivary cortisol samples were taken, four times a day, from 106 non-working participants aged from 33 to 55 years, from deprived areas, over a period of two days. Results showed a greater decline in cortisol levels amongst participants in settings with high green space as opposed to those in lower green space settings (Thompson et al, 2014). While the findings provide key information on a specific high-need population, it is difficult to apply these results to a more general population as the study sample was restricted by age and occupation and relied on convenience sampling at unemployment offices and door-to-door requests.

More recently Van Den Berg et al. (2015) examined survey data of self-rated mental health and time spent in green space from 3,748 participants across major cities in Spain, the Netherlands, and Lithuania and conducted 35 interviews with randomly selected participants
from 30 different neighbourhoods. They found that across all participants there was a weak but significantly positive association between the time spent in green space and participants’ mental health score (with a rate ratio ranging from 0.03 – 0.04 out of 100 across all locations).

Nutsford et al.’s (2013) cross-sectional study in Auckland, New Zealand, found similar results. This study aggregated 7,552 anxiety mood/disorder treatment counts from the Ministry of Health, Tracker, and correlated their distribution with the distribution of all green spaces within census area units (excluding private gardens). They found a 4% reduction in anxiety/mood disorder treatment counts and a 3% reduction in mood treatment for every 100m decrease in distance between residence and useable green space (Incident Rate Ratio 1.35, p = 0.033). The same researchers’ conducted a study of green and blue space visibility in Wellington in 2016, that also found an association between the visibility of blue (aquatic) space and reduced psychological stress, but not green space (Nutsford, Pearson, Kingham, & Reitsma, 2016). In this study, they considered 22 visible exposure variables for a variety of natural environments, in order to measure visibility of green and blue space from the homes of 442 participants who completed the Kesslers Psychological Distress scale as part of the in the 2011/12 New Zealand Health Survey. They reported lower psychological distress scores amongst those with higher levels of visible blue space, compared to those with lower visibility. No relationship was found for green space visibility, but this may be because the study excluded private green spaces such as backyards and gardens. In addition, measurements of green space visibility were not collected for each participant’s place of residence and were instead based on population-weighted calculations from their neighbourhood, which may have reduced the accuracy of green space visibility measurements.

There are numerous examples of research on the relationship between green space and adult mental wellbeing; much less research has been undertaken on the impact of green space on the mental wellbeing of children. In a study of parental perceptions of free play across 16 countries, 54% of parents said their child was happiest when engaging in activities outside, with seven out of ten parents also stating that their children would prefer to play outside if they were given the choice (Singer, Singer, Agostino, & Delong, 2009). This indicates that parents perceive their children to experience positive emotions when outside and in green space.

Mental health and wellbeing is a growing health concern in New Zealand (Mental Health Commission, 2012). Recent evidence indicates that people seek out green space for rest
and restoration with several studies reporting reduced mental health symptoms and self-reported stress and lower cortisol levels for those who live in areas with a high level of green space available (Gascon et al., 2015; Irvine et al., 2013; Nutsford et al., 2013; Thompson et al., 2014; Van Den Berg et al., 2015). However, there is a need for further research, using wider population samples, on the connection between green space and mental health, including studies that examine children’s mental wellbeing.

**Child development**

The impact of green space on emotional wellbeing may be of particular benefit to children’s development of emotional resilience, environmental awareness and social skills. Strong links between children’s learning and contact with nature have been reported in Scandinavian countries that have included nature-based educational settings to enhance learning and development. This ranges from encouraging children to walk in the park to the establishment of ‘Forest Schools’ in Sweden, which have found improvements in learning, concentration and a reduction in the incidence and severity of symptoms of Attention Deficit Hyperactive Disorder (ADHD) (Muñoz, 2009).

The BREATHE project in Catalonia, which surveyed the parents of 2,111 students aged from 7 to 10 years from 36 schools in Barcelona, found a positive association between exposure to green space and children’s reported behaviour. In this study, green space was identified by using mapping technology to measure the density of vegetation in the spaces in which children played and lived. Children’s personality strengths improved and personality difficulties such as emotional symptoms and peer relationship problems reduced the more time they spent playing in highly vegetated (green) settings. There were also lower scores for personality difficulties as well as symptoms of hyperactivity and impulsivity amongst those with higher levels of vegetation in their immediate residential areas and in the areas surrounding their school. This study had some key methodological strengths. For instance it collected information on child ‘strengths and difficulties’ from parents using standardised questionnaires and from teachers using a questionnaire based on the DSM-IV assessment of ADHD. It also applied robust methods in recruitment by selecting students from 39 schools across Barcelona and surrounding areas that were found to match general population trends in socio-economic vulnerability. However, a key weakness was the reliance on a parent’s knowledge of their child’s contact with green space, as this meant that the accuracy of measuring the child’s use of green space was subject to the parent’s recall and whether they had complete knowledge of how often their child had contact with green space (Amoly et al., 2014).
To support their findings, these researchers used the same participants to examine exposure to green space and cognitive development of children using a different methodology. This was conducted by administering a computer test to measure working memory, superior memory and inattentiveness every three months for one year. Results from the tests were compared with the children's exposure to green space by measuring the surrounding greenness within a 250m radius from their home, along their shortest possible school route and within a 50m radius of their school. They found that after 12 months, for every inter-quartile range exposure increment along home-school routes and at school, there was a 5% increase in enhanced working memory, a 6% improvement in superior memory and a 1% reduction in inattentiveness. No relationship was found for green exposure near the home (Dadvand et al., 2015).

The density of green space where people live and the use of green space has been associated with reduced behaviour disorders, emotional difficulties and peer relationship problems (Amoly et al., 2014; Dadvand et al., 2015). However, the research that examines child development and behaviour in green space is limited to self-reported use of green space and the residential density of trees and green spaces. Further research that observes children's use of green space may provide a greater understanding of how green space can impact on child development.

**Effect Modifiers**

The following section discusses variables that may influence the impact that green space can have on health outcomes as depicted earlier in Figure 1. In addition, the evidence will describe how the amount of green space available differs between subgroups within each variable and how often different subgroups engage with green space.

**Supervision**

The availability of supervision may be a predictor of children’s use of green space because parents’ perceptions of neighbourhood safety has been found to be more commonly associated with children’s use of outdoor green spaces than the amount of green space near where they live (Valentine & Mckendrickt, 1997; Witten, Kearns, Carroll, Asiasiga, & Tava’e, 2013). Parental safety concerns regarding traffic, crime, strangers and intimidating teenagers are often cited as reasons for parents restricting their children’s independent mobility outdoors (Faulkner et al., 2015; Muñoz, 2009; Veitch et al., 2006; K Witten et al., 2013).
Interviews with 70 parents randomly selected across nine areas in the UK found that middle-income families felt societal pressures to ensure their child was supervised more often, while low-income families had more social pressure to encourage their child to play outdoors unsupervised (Valentine & Mckendrickt, 1997). In addition, there are also social pressures amongst different ethnic and socioeconomic groups for parents and caregivers to restrict their child from roaming in outdoor public spaces unattended (Singer et al., 2009; Valentine & Mckendrickt, 1997; Veitch et al., 2006). For example, in Pacific cultures in particular, Samoan and Tongan parents disapprove of the level of independence adopted by palagi (western) parents and believe that children may be more likely to misbehave without supervision and that girls in particular should be supervised on most occasions (Schoeffel & Meleisea, 1996). Likewise, research has found that the gender of a child may also affect a parent’s perception on the need for supervision, with research identifying higher rates of supervision over girls (Carver, Timperio, Hesketh, & Crawford, 2010; Stone, Faulkner, Mitra, & Buliung, 2014). If we consider that the opportunity for independent mobility may impact on engagement with green space, then the difference in the way caregivers apply rules for supervision between different income and ethnic groups or based on their child’s gender may have an impact on green space use across different demographic groups.

What is perceived as higher levels supervision over children’s outdoor play in more recent years, has become a topic of debate among experts, who argue that independent interaction with green space and outdoor play is important for child development and physical activity (Brussoni et al., 2015; Carver et al., 2010; Singer et al., 2009; Stone et al., 2014; Valentine & Mckendrickt, 1997). Other research has found results that indicate children who are left unsupervised in green spaces have a higher likelihood of injury or drowning, with some studies finding associations between lower injury rates among children under the age of ten, who are under direct supervision (Baron-Epel & Ivancovsky, 2013; Brussoni et al., 2015). For example, Moore, Summers, Jackson, & Tesfayohannes (1994) reviewed hospital injury data from 52,061 children under age 16 years in Liverpool and 11,291 children under age 16 years in Chester in the United Kingdom. Moore et al. (1994) applied an injury severity score (ISS) to each of the cases, with a score of zero for no injury, and a three for minor cuts and bruises. They found that those who were not supervised had on average an ISS of 3.2 (range 0-14), while those who were accompanied by an adult at the time of the injury had an ISS of 2.5 (range 0-29). These results show that there was on average, a slight decrease in the severity of injury if the child was supervised at the time of the injury; however, as the range of ISS scores was broader amongst the supervised children these results are not robust enough to draw any strong conclusions.
Moore et al.'s (1994) study is of importance when considering whether children are safe outdoors, in particular to travel to green spaces independently. In support of Moore et al.'s findings, another study conducted by Wills et al. (1997) found that in a sample of 142 child pedestrian injury cases, 64% of the children were not supervised at the time they were injured. Furthermore, 66% of those not supervised when injured were with peers and 42% of those supervised when injured, were being supervised by an older peer. This indicates that a peer supervisor may not be as effective in injury prevention as an adult, with the researchers suggesting that it is possible that the high rate of peer presence when injuries took place may be related to an increased likelihood of distraction and risk-taking behaviour when children are in the company of their peers (Wills et al., 1997). Similar findings were supported by Morrongiello, Schmidt, & Schell (2010) who in a study that examined older siblings’ reactions to a simulation of a child exhibiting risk-taking behaviours found that older siblings were less likely to identify potential hazards than was a parent.

While neither study directly observed real life scenarios, based on their results it is possible that risk of injury when in green space or travelling to green space may be higher when a child is accompanied by their peers or older siblings than when accompanied by an adult. This raises concern for caregivers who may perceive their child to be safer outdoors when they are accompanied by other children. For example, Brown and Paskins (2007) reported that one-third of children in the United Kingdom are allowed to play outdoors unsupervised only if they are with a friend. In addition, Petrass, Blitvich, & Finch (2011) observations of caregiver supervision of children under 14 years old on Australian beaches found that children playing with other children were less likely to be given high-quality supervision.

Concerns over safety, injury and crime have led to a generational change in the type of outdoor play that today's children engage in, with numerous studies finding children have less independent mobility and unsupervised play than their parents did (Muñoz, 2009; Valentine & Mckendrickt, 1997; Wen, Kite, Merom, & Rissel, 2009; Witten, Kearns, Carroll, & Tava, 2013). This strong emphasis on child safety in today’s society could have the potential to restrict children’s engagement with green spaces, particularly as parents’ time to accompany children to recreational activities, including green spaces, becomes more limited due to stronger economic constraints, longer commutes, shift work, and more dual working parent households (Witten et al., 2013). This in addition to households having fewer neighbourhood connections, families moving more frequently, and the trend towards living in busier urban environments. These factors may all compound to reduce the safety of neighbourhood environments and discourage children from independent play in green space.
However, while many researchers have hypothesised that the decrease in children’s unsupervised activity levels has led to a reduction in the time children are spending in green spaces (Muñoz, 2009), this may be misleading as research has indicated children are instead spending more time in private gardens and backyards or engaging in organised forms of outdoor activities through sports and clubs (Valentine & Mckendrickt, 1997). Instead, it is also important to consider whether the shift towards higher levels of child supervision has a negative impact or constrains children’s experience of green spaces and the outdoors.

As adults, we may have fond memories of exploring natural environments or engaging in highly creative play when left unconstrained by the supervision of adults. This is based on the idea that free play provides a sense of freedom and confidence within children to explore outdoor surroundings and relinquish sub-conscious behaviour that may inhibit creative play (Valentine & Mckendrickt, 1997). While much of the research cited favours a common belief that independent and unsupervised play is inherently positive for child development, well-being and life experience (Singer et al., 2009; Valentine & Mckendrickt, 1997), there is little evidence to support these beliefs. However, there is some evidence that has identified a link between children’s engagement in unsupervised or risky outdoor play with physical activity (Brussoni et al., 2015; Stone et al., 2014).

For example, a systematic review of 21 peer-reviewed articles conducted by Brussoni et al. (2015) found that most papers reported that unsupervised or independent mobility was positively related to high levels of physical activity and vice versa. Similar results were also found by Carver et al.’s (2010) cross-sectional study of 170 children aged 10 to 11 years and 270 adolescents aged 15 to 17 years from 19 schools across Melbourne, Australia. The study surveyed parents on perceived risk and restrictions they placed on their children’s activities, and compared results from this survey to accelerometer data from children’s non-school hours. The findings of this study identified that higher limitations on children’s independent play were negatively associated with active transport and moderate to vigorous physical activity for young boys and all ages of girls. These results did not include those from a small percentage of children who avoided all unsupervised activities, and who instead had unusually high levels of physical activity that were thought to be associated with engagement in organised sport. Stone et al. (2014) conducted a similar study using accelerometer data over seven days with 10 to12-year-olds in Toronto, Canada, and parental reports on how often their children were allowed to go out without adult supervision. Much like Carver et al.’s (2010) study, Stone et al. (2014), found that the more independence children were given, the higher were their physical activity levels.
Previous research has found that parents of minority ethnicities and from high income groups, and the parents of girls, supervise their children when outdoors more often than other parents (Mack, Dellinger, & West, 2012; Schoeffel & Meleisea, 1996; Singer et al., 2009; Veitch et al., 2006). This may contribute to health inequities as research has found higher levels of supervision to be associated with lower levels of physical activity (Brussoni et al., 2015; Carver et al., 2010; Stone et al., 2014).

Despite this, there is no evidence to indicate whether there is an association between supervision rates and the rate or quality of engagement with green space. In addition, hospital data findings indicate that there may be a link between supervision and reduced likelihood of injury among children (Baron-Epel & Ivancovsky, 2013; Brussoni et al., 2015; Moore et al., 1994; Wills et al., 1997). Research also indicated that the risk of injury may be higher for those accompanied by siblings or peers compared to when they are accompanied by adults or in some cases when children are on their own (Morrongiello et al., 2010; Wills et al., 1997). This may warrant further investigation as parents have been found to be more likely to allow children outdoors unsupervised when they are with other children (Brown & Paskins, 2007; Petrass et al., 2011).

**Gender**

A large proportion of self-report studies have found that boys spend more time in green spaces and outdoors than girls do. One example is that of a survey-based study on how 1,205 13-year-old children from small private schools in Nebraska, USA spend their time. The survey found that 68% of boys listed outdoor activities compared to 50% of girls (Cherney & London, 2006). While this study has limited applicability to the wider population, as 86% of the sample were Caucasian of upper and middle socioeconomic status, similar results have been found amongst wider samples including Wen et al.’s (2009) five-day diary-based study of 1,975 children aged 11 to 12 years from 24 schools across Sydney, Australia and Mauldin & Meeks's (1990) diary study of children aged 3 to 17 years in Columbia, USA. Both studies found that boys recorded more time playing outside than girls, with Wen et al. (2009) reporting 8% more outdoor play amongst boys ($p <0.001$) compared to girls and Mauldin & Meeks (1990) reporting an average of 30 minutes more outdoor activity amongst boys, compared to girls.

Many studies have taken the exploration of children’s time outdoors further by adopting mixed methods approaches and employing the use of accelerometers. Faulkner et al. (2015) coupled the use of accelerometers with parent interviews on the amount of time their
child spent outdoors in Toronto, Canada. This study found that boys were more likely to play outdoors more frequently and for a greater duration than were girls.

A similar study that used accelerometers and GPS units in Copenhagen, Denmark, amongst 170 children aged 11 to 16 years, found that boys spent more time outdoors, at 226.7 minutes, compared to girls, at 194.5 minutes, on average ($p < 0.05$). Girls’ outdoor leisure time was also lower at 45 minutes compared to boys at 71.9 minutes (Klinker et al., 2014).

However, different results have been found among younger samples of children: for example, Baranowski, Thompson, Durant, Baranowski, & Puhl’s (1993) study of younger children aged 3 to 4 years old observed 191 children from Galveston, Texas for 12 hours on up to four days of the year. Results showed that although boys spent significantly more time in physical activity than girls did, there was very little difference between the average number of minutes that boys spent in playgrounds (2.37) and other general outdoor settings (2.37), than girls (at 2.31 and 2.34 respectively).

Furthermore, there is a growing body of evidence that in recent years female engagement with the outdoors has been increasing (Harth, 2007). One good example of this is from the Outdoor Foundation’s Outdoor Participation Report for 2013, which surveyed 7,528 individuals of all ages across the USA. The survey found a 2% increase in outdoor participation amongst girls since 2012, with girls aged 11 to 15 more likely to participate in outdoor activities than any other physical activity, while boys’ outdoor participation decreased by 3% (The Outdoor Foundation, 2013). There is no such data on participation in outdoor activities in New Zealand; however, a survey of 8,500 students from 91 schools across New Zealand found that although participation in vigorous physical activity was lower among females, there was a 13% increase in females’ participation in vigorous physical activity between 2001 and 2012 (Clark et al., 2013).

It is possible that low female engagement with green spaces may be related to low engagement in sports and moderate to vigorous physical activity (MVPA) among girls. A large number of studies across countries have found that boys are more physically active than girls across all ages and are more likely to participate in sports, while girls have been found to spend more of their free time socialising (Bailey, Wellard, & Dismore, 2004; Cherney & London, 2006; Mauldin & Meeks, 1990). In addition, several studies have found that females engage with green spaces through different types of activities to boys and similarly, they participate in MVPA through play and social activities rather than sports. For instance, in an observational study conducted by Powell et al. (2016) in five schools of high deprivation in the West Midlands, United Kingdom, physical activity of 82 children aged 7 to
10 years was observed during school break times followed by interviews with 80 children on their perceptions of the playground environment. They found that social contact in small-to-medium-sized groups were stronger predictors of MVPA in girls than was sports participation, with a large proportion of girls seen walking and talking or engaging in imaginative play in the playground (E. Powell et al., 2016). Similar results were also discovered by Pearce, Page, Griffin, & Cooper’s (2014) study of children aged 10 to 11 years in the UK, who found that interaction with friends and siblings was positively associated with MPVA for girls, but not for boys.

Pearce et al. (2014) explored this further by studying 427 children aged 10 to 11 years in Bristol, United Kingdom, using accelerometers to measure physical activity and GPS devices to measure the time spent in outdoor spaces over a three-day period. This data was matched with diary recordings to record the activities the children engaged in after school each day. The researchers found that girls and boys spent a similar amount of time outdoors each day, at 21 minutes and 20.3 minutes respectively. However, girls spent more time with friends than boys did (girls = 32.1%, boys = 28.6%) and boys spent more time engaged in MVPA (girls = 21.1 minutes, boys = 25 minutes) (Pearce et al., 2014).

These studies highlight a need to explore all types of interaction with green space for girls and boys in order to gather an accurate measure of green space use between genders. In addition, the potential difference between the level of green space engagement and type of activities males and females participate in while in green space may influence health outcomes impacted by MVPA, such as childhood obesity.

**Inequalities**

Research indicates that there is a potential to address health inequalities through improving access to open green space in low income areas (Astell-Burt et al., 2014; Holtan et al., 2014; Maas et al., 2008, 2006; Mitchell et al., 2015; Mitchell & Popham, 2008; Powell et al., 2004). In particular many of the studies mentioned earlier in this review found more pronounced effects amongst marginalised groups including the elderly, young people and those with low incomes, who have less ability to access spaces outside their neighbourhood, and are therefore reliant on resources within walking distances e.g. (Baur & Tynon, 2010; Holtan et al., 2014).

For example, Mitchell & Popham’s (2008) study of mortality records of under 65 year olds in England from 2001 to 2005, found that income-related health inequalities were less amongst those with greater access to useable green space (excluding private gardens). Results
included an Incident Rate Ratio (IRR) of 1.93 (95% CI 1.86–2.01) between low and high income groups amongst populations with low green space access, and an IRR of 1.43 (95% CI 1.34–1.53) between high and low income groups amongst those with high green space access. For Circulatory Disease, this effect was more pronounced with an IRR of 2.19 (95% CI 2.04–2.34) between high and low income groups amongst the low green space group and 1.54 (95% CI 1.38–1.73) in the high green space group. However, Mitchell & Popham’s (2007) earlier study using 2001 census data found no significant association between public green space access and health in high income areas and a negative association between green space access and health in low income areas. This contrast in results may be due to the 2007 study’s reliance on self-reported health rather than health records.

Enhanced benefits have also been identified amongst vulnerable groups in another study of perceived general health, and access to useable green spaces, using data from the Dutch National General Practice survey (Maas et al., 2006). Youth, the elderly and those with high socioeconomic deprivation were noted to have gained the greatest benefit from having a public green space in close proximity to their living environment. This study was reliant on self-perceived general health rather than on an objective measure of health but the large sample size of 250,782, distributed across the Netherlands, adds strength to the study. In addition, unlike other studies that have not been able to control for migration, the study sample was limited to those who had been registered with the same GP for more than 12 months (Maas et al., 2006).

Likewise, green space has been found to reduce disparities amongst groups with mental illness. For example, Mitchell et al. (2015), who conducted research that compared the European Quality of Life survey data from 21,294 participants across 34 European nations, found that the gap between socioeconomic inequalities and mental wellbeing was 40% narrower amongst those who had the best levels of access to green space, in comparison to those who had the worst ($\chi^2 = 16.8, p = 0.041$). In addition, when looking at a range of services in neighbourhoods e.g. postal services, public transport, movie theatres, banks etc., recreational green space was found to be the only community service to have a significant interaction with financial inequality and mental wellbeing.

However, green space inequalities have not been found in all countries or regions. For instance, a study of publically accessible parks in Nebraska did not find an association between income and green space access (Stewart, 2015); and while the availability of green
space has been found to be lower amongst lower socioeconomic (SES) areas across major cities in Australia, including Sydney, Perth and Adelaide, the inequality was reversed in Melbourne, with lower SES neighbourhoods experiencing increased access to green space (Astell-Burt et al., 2014). The variation in results may be because Astell-Burt et al.’s (2014) study relied on locations identified as parkland by the Australian Bureau of Statistics to measure green space and did not include private green spaces or differentiate between public green spaces and private green spaces, e.g. golf courses that are not publically accessible.

Some New Zealand studies examining environmental deprivation have identified a link between income deprivation and aspects of inequality relating to environmental goods, but these results have been weak. For example Pearce, Richardson, Mitchell, & Shortt’s (2011) found low levels of environmental protective factors (including access to green space) in high deprivation areas, and high levels in low deprivation areas. However, this relationship was not linear. Similarly, Richardson et al.’s, (2010) study of public green space coverage in small urban population areas, found that although there was less green space coverage in areas that were rated as being of low socio economic status (SES), there was slightly more usable green space (green spaces accessible to the public), in areas with low SES. This study measured the percentage green space coverage per census area unit, using data sets on green space from the Department of Conservation and Land Information New Zealand. Findings indicated an 11% decrease in general green space coverage and a 2% increase in usable green space coverage, as the deprivation score of an area increased per one standard deviation (deprivation measured using NZDep2001). This indicates that although there was less overall green space in high deprivation areas, high deprivation areas had a slightly higher percentage of green space that could be accessed and used.

The weak relationship between green space and deprivation in New Zealand may be due to an overall abundance of green space access in New Zealand, with a higher frequency of both private gardens and public spaces when compared to other developed countries with higher density and larger populations (Richardson et al., 2010). For example, Witten et al. (2008) found that 75% of the 38,350 neighbourhoods examined across New Zealand were within 2.4 minutes driving distance of a green space. However, these studies that have investigated the associations between green space and health have not measured the use of green space by populations with different rates of socio-economic deprivation. This may be of importance because evidence from self-reported use of green space has found relationships between socio-economic factors such as employed parents and home
ownership to be associated with higher use of green space amongst children (Valentine & Mckendrickt, 1997; Wen et al., 2009). This is of relevance to the Wellington region, where those from high-income households (average household income over $70,000) were more likely to be frequent users of regional parks, while low-frequency users were most represented by those from low-income households (with an average household income of $30,000) (Waititi & Cox, 2009).

In addition, most research has not examined the variation in the quality of green spaces provided for different demographic groups. For example, Wolch et al. (2011) found that $140 per capita was spent on parks in high socio-economic areas compared to only $80 per capita on parks in low socio-economic areas in South California in the United States. Likewise, in New Zealand Hand, Freeman, Seddon, Stein, & van Heezik (2016) found that biodiversity scores between neighbourhoods in Auckland, Dunedin and Wellington were significantly related to socioeconomic indicators within the area, with mature, highly biodiverse gardens being more common in areas of high socio-economic status. A few reasons can be considered for why there may be a difference in the quality of green space between high and low income areas. The difference could be related to lack of investment in low-income areas or, if high quality public green spaces are thought to be a community resource and to enhance the characteristics of a neighbourhood, the presence of high-quality public green spaces may increase the value of property close by, resulting in lower-income families moving to more affordable locations (Comber, Brunsdon, & Green, 2008). These factors should be investigated in order to identify opportunities that may address health inequity by ensuring resources like quality public green spaces are distributed equitably.

**Ethnicity**

Among the inequalities that might be associated with the use and access of green space are those related to ethnicity. A number of previous studies have indicated that ethnic minorities have less access to or make less use of green spaces than others do. The majority of studies that have explored this used information from government land use databases to map the size and proximity of green spaces and compared this to census data on the ethnic demographics of populations within the smallest adjacent area units available. Dai’s (2011) study was among the research that was conducted using this method, with results that found significantly less access to green space amongst minorities in comparison to white Americans in Atlanta. Likewise, Comber et al.’s (2008) study of race and religious groups in Leicester, England found that Indians had significantly less access to green spaces than
majority groups such as Bangladeshis and British-born people; and likewise, Hindus and Sikhs had significantly less access to green spaces than Christians did.

The study by Roe et al. (2016) used a similar method but exclusively selected the 20% of the most deprived communities in Manchester, England, the sample was also limited to areas that had a population of at least 9% minority cultures and 20-45% green space coverage. Like Dai (2011) and Comber (2008), they compared the demographics within census area units with the level of green spaces available (from the United Kingdom Generalised Land Use Database). Roe et al. (2016) also conducted face-to-face household interviews with a small sample of 85 residents from this population on their self-reported use of green space and perceptions of green space quality. This research found that while majority ethnic groups (white and Indian people) visited green space the least, they had the highest levels of access to green space, compared to most minority groups, including Afro-Caribbean, Pakistani and Bangladeshi.

Roe et al.’s (2016) research also identified that only those of minority ethnicities had a positive association between good health and green space use. These minority groups also perceived the quality of their local green space to be poorer (less safe and less attractive) compared to majority ethnic groups and were most likely to visit green space with others than alone, highlighting the link that green space provides for social contact for minority groups.

Other methods used to measure the association between ethnicity and green space have included the use of satellite imagery to measure the density of tree canopies across geographic areas and to compare these measurements with the demographics of populations within census area units. These studies also found negative relationships between the percentage of minority ethnicities and the percentage of tree canopy cover within close proximity to where those minorities lived.

Zhou & Kim, (2013) showed that in Illinois, USA, ethnic minorities were more likely to live in neighbourhoods with a lower tree density than were majority ethnicities. However, this research did not find a significant relationship between ethnic groups and park access. Likewise, Heyen, Perkins, & Roy's (2006) research in Milwaukee, USA that found that residential tree density had a negative relationship with the percentage of minority cultures present compared to white majority residents, whose population distribution had a positive relationship with residential tree density. Residential tree density was also negatively associated with the percentage of renters and housing vacancies and positively associated with higher median household income. These results indicate that the relationship between
low tree density in areas with minority cultures might be related to economic deprivation or other income-related factors that may be more common among minority cultures.

One key consideration when examining these findings in the contexts of resource distribution and health is that they were all focussed on publically accessible green space even though in some countries, including New Zealand, private green spaces are used more often than public green space (Freeman et al., 2015). Therefore these studies have not provided a consistent measure of the relationship between green space and ethnicity regarding all of the green spaces that people might be using. Examining private green space access and use is important when we consider that a high proportion of urban green space resources in New Zealand are classified as domestic green space (Mathieu et al., 2007).

New Zealand also has a fast-growing immigrant population that is largely made up of those who have moved from Pacific and Asian regions of the world (Statistics New Zealand, 2006). New Zealand literature indicates, as does the evidence from the UK and the USA, that minority ethnic groups have a lower participation in the use of outdoor and green space environments (Lovelock et al., 2011). Ethnic equality in outdoor participation is of particular importance in New Zealand, where research has reported that ethnic minorities have substantially lower levels of participation in numerous outdoor activities including tramping, fishing, kayaking, and mountain biking, compared to majority ethnic groups. According to the study by Lovelock et al. (2011), qualitative interviews with 25 recent immigrants from Asia, South America, Africa, UK, Europe, and the Pacific who now reside in Wellington and Auckland, suggested that this may be because national and regional parks were largely designed for majority groups (most often NZ Europeans). To address this, Lovelock et al. (2011) highlight a need to incorporate social elements into green spaces, as minority cultures associate green spaces as places to sit, prepare food and to enjoy the aesthetics of the environment. These aspects were seen to be of high importance to Pacific immigrants, who usually involve the whole family when visiting green spaces, including older family members who cannot enjoy the physically active components that are often the dominant activity for public green spaces such as national parks and scenic reserves.

Minority cultures also faced practical barriers to enjoying regional and national parks, including transportation difficulties, because minority groups are less likely to own a car to travel the long distance to a national park, and time, because those from minority groups are more likely to be working long hours. Lovelock et al.’s (2011) study identified these challenges as barriers to immigrant integration in New Zealand, where nature and the landscape are often reasons immigrants chose to relocate to New Zealand. However, many
of the participants in Lovelocks et al.’s (2011) study also said that the New Zealand climate, which is often perceived as cold and wet, was another reason that they preferred not to visit natural environments.

The relationship between ethnicity and green space may have implications for reducing health inequalities for Māori and Pacific people. Māori and Pacific people make up 14% and 7% of the population respectively (Statistics New Zealand, 2013a). However, Māori and Pacific are over-represented in several measures of poor health that have been linked to less access and use of green space in the evidence presented in this report, e.g. obesity, physical inactivity, and high blood pressure in adults (Bancroft et al., 2015; Bell et al., 2008; Wolch et al., 2011). For example 15% of Māori children and 30% of Pacific children were identified as being obese in 2012 (Ministry of Health, 2012). In addition, Māori, Pacific and Asian adults were each “…30% more likely to be physically inactive than non- Māori, non-Pacific and non- Asian adults respectively…” with an alarming increase in physical inactivity from 9% in 2007 to 17% in 2015 among Māori adults (Ministry of Health, 2015, p18). Furthermore Māori and Pacific adults are more likely to be taking medication for high blood pressure than non Māori and non Pacific (after adjusting for age and sex) (Ministry of Health, 2015).

Access to green space is of importance within New Zealand, where Māori have shown strong concerns over the sale of public land over the last 20 years, that has potentially impacted on Māori and their engagement with green spaces for recreation, particularly for locations that had previously been used in an egalitarian manner (Curry, 2001).

Both Māori and Pacific people have an interconnected relationship with nature and its resources through traditional bonds that link Māori and Pacific people to ecosystems. This link is embedded within traditional practices, language, mythology and beliefs that have been handed down through generations. For example, the word ‘whenua’ not only means placenta, but also means ‘land’, depicting how the connection between people and land is essential to life (Harmsworth & Awatere, 2013). For Māori, whakapapa or genealogical history can be traced through Māori creation mythology where Ranginui (Sky Father) and Papa Tu a Nuku (Earth Mother) had five children that all Māori are descended from; these five children were responsible for the wind, plants, the sea, the rivers and animals (Harmsworth & Awatere, 2013). The link between the natural environment and Māori identity has been captured in the health and well-being model of Nga Pou Mana, which includes four elements: Whānaunga-tanga (family), Taonga tuku iho (cultural heritage), Te Ao tūroa (the natural environment) and Turangawaewae (land base – place of belonging).
This model highlights how engagement with the natural environment is considered to be a vital part of health and wellbeing for Māori (Royal Commission, 1998).

Land and the natural world still holds strong importance for modern Māori, as 52% of Māori income and investment depends upon primary industries, including pastoral farming, horticulture, forestry and fisheries (Harmsworth & Awatere, 2013). This highlights how both reliance on the natural world and kaitiaki (guardianship of the environment) remains as applicable in today’s world as it did prior to colonisation. Therefore, facilitating young Māori to engage with and understand natural environments is not only essential to maintain Māori identity, concepts of wellbeing and health but also is of key importance for young Māori to identify future opportunities to succeed in the context of today’s economy.

In summary, several studies have found that ethnic minorities live in areas with less availability of green space and density of vegetation (Comber et al., 2008; Dai, 2011; Heyen et al., 2006; Roe et al., 2016; Zhou & Kim, 2013). Research also indicates that ethnic minorities visit green space less often and are more vulnerable to conditions that can benefit from green space exposure (Roe et al., 2016). In New Zealand studies similar results were also found for minority groups, in particular among Māori and Pacific people, who are over-represented in obesity, diabetes, cardiovascular disease and high blood pressure rates (Ministry of Health, 2012). However, few studies in New Zealand or globally have investigated use and access to domestic green space among ethnic minorities.

The strong values that Māori and Pacific culture place on connecting with land and nature highlight the need to explore ways to improve access to green space and to encourage the use of green space among Māori and Pacific people (Harmsworth & Awatere, 2013).

**Type and Quality of Green Space**

While most children in New Zealand have good access to green space, it is important to consider what types of green space are best for improving health outcomes or are most likely to be used. For example, Veitch et al.’s (2006) interviews with the parents of children in inner city Melbourne found that nearly three quarters of their sample was more likely to engage in unstructured activity or free play at home, followed by one third who reported the street and one third who reported free play in public green spaces such as parks, playgrounds, bushes and rivers. Furthermore, research suggests that children are more likely to enjoy natural green spaces that feature mud, grass and trees as opposed to modern designed playgrounds that often remove these natural features (Muñoz, 2009).
The type of facilities in playgrounds may also impact on whether children are likely to use them and engage in physical activity within them. For instance, the study by Klinker et al. (2014), which gathered accelerometer data from 367 Danish children, found that amongst 11 to 16 year-olds moderate to vigorous physical activity was relatively low in playgrounds compared to other types of urban green spaces. This may be because playgrounds do not often cater to older children (Veitch et al., 2006). The provision of playground facilities in residential areas that cater to older children is a key concern, because while children aged 10 to 13 may be too old to play in facilities that typically cater to younger children, they still have a limited level of independence and are not yet old enough to drive to more remote green spaces.

The quality of green spaces provided is not only important for encouraging the use of green space, but also for the health of populations. In interviews with adults in deprived areas in Manchester, UK, found that participants the poorest health ratings were more likely to describe the green spaces within their area as being of poor quality, while those with good health who were more likely to perceive their local green spaces to be of high quality (Roe et al., 2016). This could be explained by the relationship between the quality of green space provisions within a neighbourhood and physical activity. A number of studies have identified key features that can promote physical activity within green spaces, including aesthetic improvement, amenities, the number of trees, signage, types of plant life, distance, safety and access (including routes, entrances and disabilities access) (Bell et al., 2008; Edwards et al., 2015; Giles-Coti et al., 2005; Lachowycz & Jones, 2011; Oldfield et al., 2013; Regional Public Health, 2010).

A study of 1,304 adolescents aged 11 to 15 years living in Geraldton, Australia, found that parks were three times more likely to be used for every additional quality/aesthetic feature present (Edwards et al., 2015). This study found seven park features significantly associated with adolescent physical activities, in particular public toilets, barbeques, skate parks, lighting around courts, and the presence of at least 25 trees (Edwards et al., 2015). For a number of these features, it is speculated that the provision of social facilities (most often associated with sedentary behaviour) such as picnic tables, toilets, shade from trees, and barbeques, not only supports active park users to stay for a longer period of time, but also encourage greater use of the amenities by the whole community. However, it should be noted that this study was conducted in a rural location and therefore was limited to a small sample of parks (Edwards et al., 2015).
Further studies have found that the aesthetics of usable green spaces could impact on participation in walking by at least 50% (Bell et al., 2008; Giles-Coti et al., 2005; Humpel, Mashall, Leslie, Bauman, & Owen, 2004). For example, Giles-Corti et al.’s (2005) interviews with 1,803 people aged between 18 and 59 years in Perth, Australia, about their use of public green spaces, found that public green spaces that were described as ‘attractive,’ were 50% more likely to be used for high levels of walking (at least six walking sessions per week, totalling ≥180 min) with an odds ratio of 1.50 (95% CI: 1.06–2.13) than other types of open spaces. Participants described the presence of trees, water, bird life and size, as the strongest motivators of public green space use. In addition, 70% of participants tended to use public green spaces that had higher ratings for environmental quality, amenities and safety, more often than others; this response included 70% of walkers and 75% of cyclers. However, those who engaged in organised sports more often used open spaces that scored low in environmental quality, amenities and safety (Giles-Coti et al., 2005). This is likely to be because outdoor sports areas are usually plain, large grassed flat areas, developed for one specific function.

Thompson et al. (2014) conducted a before and after study of quality improvements made to a woodland in Glasgow, Scotland. The interventions included the removal of rubbish, fixing damage, improved signage and site promotion. The study surveyed 110 people living within 500m of the site in 2006 before the intervention, and again in 2009 after the improvements had been made. This was compared with a control site in Milton, where 106 people within 500m of a similar green space with no intervention, were also administered the same survey in both 2006 and 2009. The researchers found that satisfaction with the quality of the physical environment increased three times for the intervention site ($p < 0.001$), the number of visits to the intervention site increased five times ($p < 0.001$), and there was a notable increase in physical activity for the intervention site as opposed to a decline in physical activity at the control site. However, despite these results, the perception of the quality of the intervention site’s usable green space declined. This decline could be attributed to the intervention inadvertently causing a heightened awareness of quality aspects of green space.

The ways in which green spaces are used are determined by the type of green space as well as the quality of the green space and facilities within it (Klinker et al., 2014; Muñoz, 2009; Veitch et al., 2006). For example, the frequency and duration of visits to a green space may be affected by the presence of certain conveniences, such as toilet facilities, shade for rest and tables for eating at, as well as the space’s aesthetic qualities including variation in vegetation or play equipment (Bell et al., 2008; Edwards et al., 2015; Giles-Coti et al., 2005;
Lachowycz & Jones, 2011; Oldfield et al., 2013; Regional Public Health, 2010). These quality aspects can also alter the activities that a green space is used for e.g. whether a green space is used for rest and restoration, physical activity, creative play, or socialisation (Bell et al., 2008; Giles-Coti et al., 2005; Humpel et al., 2004

Chapter Summary

There is a wide range of evidence that examines the relationship between health and access to and availability and use of green spaces. In particular, the association between green space and resiliency factors such as inequalities, physical activities, child development, mental wellness, and social contact has been examined. Research investigating the association between green space and general health, health inequities (including gender, ethnicity and deprivation), mental wellbeing, obesity and physical activity improvements, have found variable results. As presented above, some studies found improvements in health amongst those with increased exposure or access to green space, while others found no association or in some cases a negative association with the availability or accessibility of green space.

This variation in results may be due to many studies measuring the overall availability or proximity of green space in relation to areas where individuals live and work, rather than how much individuals used green space. This is a gap in the research, as the mere provision of green space does not reveal how often or for how long individuals visit a green space.

There are a number of other variables, in particular for children that might affect the use of a green space, including their gender, the level of independence children are given, the quality of the green space provided, the amount of free time individuals have available, weather, their personal interests and ethnic and cultural values. This is of particular importance to children, who are often perceived as requiring supervision and may not be able to go to a green space whenever they choose.

Those studies that did measure the use of green space often relied on self-report data collected via surveys, diaries and interviews from either the individuals participating or the parents of child participants. Only one study (Powell et al. 2004) used observation as a technique to measure the use of green space. Similar methods were used for measuring physical activity, self-perceived general health and mental wellbeing in several of the studies examined. Self-report can be a less accurate method than other for measuring health and wellbeing and also participation in activities, because all self-report methods – including
surveys, interviews and diaries – are vulnerable to recall bias and social desirability bias with the potential to both over- and under-report events (Lachowycz & Jones, 2011). This reinforces the need for further studies investigating the actual frequency and time spent in green space.

Few studies cited considered different types of green spaces in terms of how they are used and what types of activities they are used for. A small number of studies provided breakdowns in results between public and private green space or useable and non-useable green space but most did not differentiate between types of public green spaces e.g. fields, playgrounds, or natural spaces. In particular, when examining the associations between green space and health, not one of the studies considered the different types of green spaces. This information could be crucial in understanding the role green space has to play in health outcomes for those who frequent them.

The research presented identified a range of variables that may impact on the likelihood of people interacting with green space, in particular in regard to gender, with males more likely to engage with green space than females. However, this may be a changing trend, especially as studies begin to measure all types of green space engagement rather than just sports-based activities. In addition, low-income groups and ethnic minorities have generally been found to have less access and engagement with green space despite being most likely to experience measurable health improvements from the social and physical benefits of green space exposure.

The literature presented in this chapter generally supports a link between health inequities relating to ethnicity, and income and access to green space, often comparing high and low socio-economic areas or individuals in relation to the amount of green space within close proximity to where people live. This is of particular importance in New Zealand, where a large proportion of the population has very good access to green space through both private gardens and public green spaces, yet very little is known about whether there is an equal distribution of socio-economic groups who visit and use green space.

In summary, the relationship between green space and numerous health outcomes has been widely researched. The range of research has explored access to, availability, visibility, and use of green space. While some research has found there to be no relationship between green space and health, there is enough supporting evidence to suggest that the availability, density and use of green spaces can improve health inequities amongst demographic groups, in terms of physical health, mental wellbeing, child development and
social contact. Therefore access to and use of green space is relevant to public health discussion and debate.

The current investigation may play a key role in contributing to the evidence relating to green space by observing children’s actual use of green space in their daily routine. This investigation will observe how often children visit green space, the types of green space participants are most likely to visit, how long they spend there, whether they are physically active when in green spaces, if they are engaged in social activities and what factors may influence the likelihood of their interacting with green space, e.g. demographic differences, the type of activity they engage in and whether they engage with green space unsupervised. These questions might contribute to a better understanding of the types of green environments that are more likely to be used and the social and demographic differences that may impact on contact with green space for children in Wellington, New Zealand.
3. Methodology

The research aimed to observe children’s use of green space by identifying and coding image data. For the Green Space Study various codes have been applied to each of these photographs in order to perform a quantitative analysis to compare the demographic characteristics of participants with the frequency with and duration for which they used green space, the nature of their activities, the settings they went to and who they were with. This chapter will outline the research methods before detailing the procedures used for sampling, data security, coding and analysis.

Overview of Methodology

This research was carried out in two separate stages. The first stage of study design, sample selection and data collection was completed by the Kids’Cam team (Signal et al., 2017). The second stage of this research was my analysis of the Kids’Cam data for the use of green space. The design, data coding and analysis of this second stage is referred to as the Green Space Study and was completed by myself as the sole researcher for the Green Space Study. For the purpose of clarity I have described the methods for coding and analysis for the Green Space Study in first person narrative to differentiate these tasks from those that were conducted by the Kids’Cam team.

Kids’Cam was established to ‘objectively study the world in which children live’ (Signal et al., 2017, p.1), with current research projects examining children’s exposure to nutritional advertising and product branding, second hand smoke, alcohol advertising, sun protection, screen time and use of green space. Photographs were the primary information source for all Kids’Cam research including the Green Space Study. The Kids’Cam project collected 1.4 million images from 168 participants aged 11 to 13 years from 16 schools across the Wellington region from July, 2014 until June, 2015. This data was gathered through the use of cameras that were calibrated to automatically take 136 degree photographs approximately every seven seconds (Signal et al., 2017). These cameras were worn by participants on a lanyard around their neck for four days. Thursday through to Sunday were the days of the week chosen in order to capture two school days and two weekend days, with different dates of the year allocated to each school so as to capture children’s activity throughout the school year. To encourage the participants to wear the cameras as often as possible, they were reminded by text message to wear the camera every morning and to charge them over night. However, participants were instructed to remove or turn off the camera when in locations
where cameras were not permitted and privacy was needed e.g. “in toilets and shower facilities, if they felt uncomfortable or if requested” (Signal et al., 2017 p 3). Participants were also told to remove their camera when engaged in vigorous activity such as sport or when swimming, in order to prevent injuries and damage to the equipment (Signal et al., 2017).

Probability proportional size sampling was used to invite 24 schools from a list of 93 supplied by the Ministry of Education from across Porirua, Upper Hutt, Lower Hutt and Wellington Cities within the Wellington Region. To improve the likelihood of obtaining an even distribution of participants from each school decile¹ and target ethnic groups, the 93 schools were stratified into three groups: low-decile (those rated deciles 1-3), medium-decile (deciles 4-7), and high-decile (deciles 8-10), by three ethnic groups (NZ European, Māori and Pacific). Schools that did not meet recruitment targets for each ethnic group were eliminated from the sample. Further details on the recruitment methods and inclusion criteria are described in Signal et al.’s (2017) article on the Kids’Cam methodology.

¹ School Decile information is gathered by the Ministry of Education New Zealand, once every five years by examining Census Meshblock data on where students in each school live. Data on average household income, occupation, household crowding, educational qualifications, and income support in each meshblock are used to quantify a decile ranking for each school based upon the level of deprivation measured in the areas the school’s students are living in (Ministry of Education, 2016)
**Study Region**

This study sample gathered participants from several cities in the Wellington region, including Upper Hutt, Lower Hutt, Wellington City and Porirua. Wellington City on its own is New Zealand’s third-largest city; Figure 3 below demonstrates that all of the cities that participants lived in had a high degree of access to a variety of green and blue spaces, including coastal environments, rivers, natural bush, and public parks, gardens, and fields. While it is possible that participant’s visited locations outside their cities during data collection, most cities have good access to both green space and blue space (Patterson & McDonald, 2004; Witten et al., 2008).

![Figure 3: Map of Wellington region green spaces (Greater Wellington Regional Council, 2011)](image)
In Table 1 below I have presented a comparison between the percentage of each demographic group and measures of socioeconomic deprivation in the geographic area that the study sample was taken from, and compared this to the New Zealand population. Table 1 shows that there is a relatively similar proportion of each group represented in the geographic sample area compared to the whole New Zealand population (Statistics New Zealand, 2013b). This is with the exception of 5% fewer females in the study area (although the percentage of males was 49% for both populations), 1.9% fewer Māori, and 1.9% more Pacific people. The study area had a slightly higher working-aged population with 4.1% more 15 to 64-year-olds and likewise 4% more people who were employed full time. In addition, 1.7% more people in the study area had access to a motor vehicle than in the whole population, which may impact on access to green spaces, or use of active transport in green spaces.

Table 1: Demographic percentages for Study area and New Zealand Population derived from Census 2013 statistics.

<table>
<thead>
<tr>
<th></th>
<th>Study area</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>48.5%</td>
<td>48.7%</td>
</tr>
<tr>
<td>Female</td>
<td>46.2%</td>
<td>51.3%</td>
</tr>
<tr>
<td>under 15</td>
<td>19.6%</td>
<td>20.4%</td>
</tr>
<tr>
<td>15-64</td>
<td>69.4%</td>
<td>65.3%</td>
</tr>
<tr>
<td>over 65</td>
<td>11.0%</td>
<td>14.3%</td>
</tr>
<tr>
<td>age 10-14</td>
<td>6.3%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Māori</td>
<td>12.0%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Pacific</td>
<td>8.9%</td>
<td>7.0%</td>
</tr>
<tr>
<td>NZ Euro</td>
<td>70.4%</td>
<td>70.0%</td>
</tr>
<tr>
<td>No of occupied dwellings</td>
<td>36.8%</td>
<td>37.0%</td>
</tr>
<tr>
<td>Employed full time</td>
<td>40.5%</td>
<td>36.3%</td>
</tr>
<tr>
<td>Employed part time</td>
<td>10.6%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Unemployed</td>
<td>4.0%</td>
<td>3.6%</td>
</tr>
<tr>
<td>No access to motor vehicle per household</td>
<td>4.4%</td>
<td>2.7%</td>
</tr>
<tr>
<td><strong>Total population count</strong></td>
<td><strong>381090</strong></td>
<td><strong>4242048</strong></td>
</tr>
</tbody>
</table>

In Figure 4, I have presented the distribution of individual income amongst the study population and the New Zealand population. In this graph we can see the study area has a higher percentage of high-income individuals overall than the NZ population. This is less likely to be reflected in the study sample as the Kids’Cam sample methods attempted to sample evenly across ethnic groups and school deciles with reasonable precision. As school decile ratings are based on the proportion of students from low deprivation areas, this
increases the likelihood that the sample had an equal number of participants across household income groups.

![Income percentages for the study area and New Zealand populations](image)

**Figure 4: Income percentages for the study area and New Zealand populations**

**Green Space Study Sample**

For the Green Space Study, I limited the sample of photographs examined to those from 3pm – 7pm on Thursday and Friday and from 8am - 7pm on Saturday and Sunday. These times were chosen as there was a higher likelihood of capturing activity in green space during daylight hours. In addition, the times chosen excluded school hours, as green space availability was anticipated to be relatively similar between schools and green space use is more likely to be prescribed by the school curriculum during this time. By examining green space use only outside school hours, the likelihood of gathering information on the green spaces that children and their families may choose to go to increased.

Due to time constraints the sample was also limited to only the students who participated during summer months in the analysis, School Term 4 of the 2014 school year (October – December 2014) and School Term 1 of 2015 (February – April 2015). This decision was made based on my preliminary analysis of 20 participants, which found the frequency of visits to a green space during winter months (Terms 2 and 3) was approximately half that of the number of visits made in summer months (Terms 1 and 4). The decision to focus on summer activity is supported by Ergler et al.’s (2016) study of seasonal play among 8 to 10-year-olds in New Zealand, which found children spent more time playing outdoors in summer than in winter.

The Green Space Study sample totalled 81 participants and a total of 285,097 photographs after removing two students who did not complete the study or submitted zero photos.
Participant Information

Information on Kids’Cam participants’ ethnicity, NZiDep and BMI was collected through the following means.

Table 2: Measures for demographic variables (Barr, Signal, Jenkin, & Smith, 2013)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity</td>
<td>The ethnicity question from the 2006 New Zealand Census was included in a questionnaire completed by the participant’s parents.</td>
</tr>
<tr>
<td>NZiDep</td>
<td>Administering a series of eight questions about the participant’s exposure to deprivation in a questionnaire completed by their parents. Those that score one have no deprivation characteristics and those that score five have a high level of deprivation (Salmond et al., 2006).</td>
</tr>
<tr>
<td>BMI</td>
<td>Used Precaster CA770 electronic laser (CBG Health Research Limited, 2014) to measure height. Used HD-316 Wedderburn Scales on a wooden board (made by TANITA Corporation, Tokyo, Japan) to measure weight to the nearest 0.1kg. Height and weight were measured according to the New Zealand Health Monitor survey standards (Ministry of Health, 2008). All measurements were taken twice; if there was a difference greater than 1% between measurements, then a third measurement was taken, and an average between all three was recorded as the final measurement. BMI results were grouped into four categories based on the recommended BMI levels adjusted for age and gender from the Ministry of Health. The four categories were labelled as underweight, not overweight, overweight and obese.</td>
</tr>
<tr>
<td>School Decile Groups</td>
<td>The grouping of students based on the decile ranking of the school they attended. From Low (deciles 1-3), Medium (deciles 4-7) and High (deciles 8-10). Decile 1 schools are those with the highest proportion of students who live in high deprivation areas, and decile ten schools are those with the lowest proportion of students who live in high deprivation areas.</td>
</tr>
<tr>
<td>Gender</td>
<td>Information on participant’s gender was gathered through a questionnaire completed by each participant’s parents.</td>
</tr>
</tbody>
</table>
Ethics

The Kids'Cam team was granted ethics approval for the Kids'Cam project on May 2014 by the Otago Human Ethics Committee, which gave approval to explore "the world children live in, their environment and how it impacts on them, except teaching" (document reference no 13/220) (Signal et al., 2017, p.1). Further detail on the procedures adopted to protect confidentiality and ensure safety of participants are detailed in Signal et al.'s. (2017) Kids'Cam Methods publication. As I was an extramural student, based overseas, permission was granted by the Otago Human Ethics Committee on 14 July 2016, as an adaptation of this approval, for me to take personal copies of the Kids'Cam images from the server to analyse outside of Otago University Campus. As a member of the Kids'Cam team, I signed a data release form with the University of Otago that outlined clear data security rules. In order to ensure these images remained secure I viewed the images only on a password protected laptop in private or in the presence of other Kids'Cam team members who had also signed the data release agreement. Furthermore, I ensured that the Green Space Study images were stored on an encrypted USB drive and kept in a locked cabinet at all times. I have covered the faces and other identifying information in the photographs presented in this thesis to uphold the confidentiality of the research participants and once all aspects of the Green Space Study research has been completed the images stored on my encrypted USB drive will be deleted.

Coding Method

I coded any images that showed participants interacting with a green space either through physical contact (e.g. standing, sitting or walking), or by using a device on or within the green space, e.g. a bicycle. This included moving through a green space, e.g. in Figures 5, 6 and 7 we can see participants respectively following an adult as they walk along a concrete path that runs through a green space, riding a bicycle on the grass, and playing on a trampoline in a backyard.

Figure 5: Walking path  
Figure 6: Riding bicycle  
Figure 7: On trampoline
Each image was coded using annotation software developed by software engineers at Dublin City University for the Kids’Cam project (Signal et al., 2017). This software platform enabled me to apply codes to each image for the setting, activity and detail. A setting was defined as the type of green space that the participant was in contact with. The activity was the behaviour they were engaging in while in the green space. The detail provided further information about who accompanied them, and if the participant was supervised or not. The methodology on how the software was used to apply codes is detailed in the Annotation Protocol for the Green Space Study in Appendix 1.

**Development of Coding Manual**

To make sure codes were applied to photographs in a consistent manner I developed an Annotation Protocol for the Green Space Study based on the Kids’Cam Annotation Manual. The Annotation Protocol for the Green Space Study included step by step instructions on how to use the annotation software with rules that aligned with the Kids’Cam Annotation Manual (to ensure methods were consistent with the wider Kids’Cam research team) and was extended to provide instructions, definitions and rules on what codes to apply to each image.

I conducted a preliminary analysis of the data to gather the information needed to develop the coding schedule of rules and definitions for applying category codes to images. As photographs were examined, every type of green space setting and activity the participants engaged in was noted to establish a set of categories that encompassed all scenarios of green space engagement. The first iteration of the coding schedule was applied to all photographs in the first full analysis. Due to the small sample size, many of the categories did not have a large enough incident rate to be included in the analysis and images allocated to categories that were found to be rare were combined with others to form broader categories. For example, several types of activities that were conducted while sedentary or exhibiting low levels of activity were coded as ‘inactive’: these included lying around or resting (Figure 8), playing with screen-based devices (Figure 9), reading, drawing, socialising, and eating (Figure 10), waiting to participate in a sports event or watching sport (Figure 11).
Likewise several activities were grouped into the ‘Other activities’ category. These included collecting shellfish (Figure 12), picking berries (Figure 13), participating in a lesson on tent assembly (Figure 14), putting clothes on the line (Figure 15), animal interaction (Figure 16) and helping parents with barbeque cooking (Figure 17).
The final coding schedule used for the analysis is summarised in Table 3 below.

To improve the precision of definitions and instructions within the coding schedule my primary supervisor provided a peer review by independently examining a subset of the participant photographs in tandem with the coding schedule. After the peer review was conducted my Primary Supervisor provided written and oral feedback on the interpretation of the definitions and rules so as to improve their clarity for future application.

Based on the supervisor's feedback, I made the following changes to the annotation manual

- Instruction to apply as many ‘details’ as required per photograph
- Refine the definition of ‘play’
- Refine the definition of ‘structured/non-structured’
- Refine instructions on how to remove an incorrect annotation

Furthermore, as I developed the coding schedule and put it into practice, the following codes were removed or changed:

- **Non-green outdoor recreation spaces:** Non-green outdoor recreation spaces were initially included when examining the frequency and time spent in green space by setting. These were outdoor spaces used for socialising, play or sports, that did not have natural elements such as grass or plants e.g. netball courts and concrete open areas around schools. This was conducted as a control check to see if there was considerable outdoor engagement with non-green settings. However, because results showed that visits to non-green settings were the smallest category, with eight visits in total (accounting for 2.29% of all visits) this provided enough confidence to remove non-green settings from further analysis.

- **Private – not at home (a private garden/backyard that was not at the participant's home):** As the scope of the Green Space Study was limited to image data it was too difficult to determine if a garden was at the participant’s home or another home. For this reason, I recorded both the original settings of ‘garden/backyard home’ and ‘private garden not at home’ with a combined code of ‘private green space’.
Level of Activity (Light, Moderate and Vigorous activity): It was too difficult to determine with the data provided, at what level of activity the participants were engaging. Instead, active or inactive were the only degrees of physical activity that could be clearly identified. Therefore, I combined light, moderate and vigorous activities into the single category of ‘active’.

Structured (organised) vs. Unstructured (length and action of activity defined by those participating) – With the exception of obvious official sports events, the photographs did not provide enough information to know if the activity was structured (were planned in advance with set formats) or unstructured. For this reason, I removed ‘structured’ and ‘unstructured’ from the final analysis.

Public Green Space – For the purpose of the analysis, an additional combined category was created to incorporate all publicly accessible green spaces called ‘public green space.’ Public green space grouped green-natural, beach, playground, field, and garden-public into one category. This category was created to compare the use of these types of green space against the use of private green space that only the participant and their close family and friends had access to.
Furthermore, several unexpected scenarios were encountered that did not fit the original category definitions. Therefore, some of the definitions were expanded based on the following coding rules:

- **Tents** – Some participants spent considerable time inside tents as seen in Figure 18 where the participant is in the tent but can still view green space. In circumstances where a green space was no longer within view (e.g. the tent was zipped up), no code was applied as they were considered to no longer be in contact with a green space. This rule applied even if the tent was located in a green space as when they were inside the tent they could not see or interact with the natural features that are central to the definition of green space.

- **Expansion of Green – Natural** – The definition of ‘green natural’ was expanded to include spaces that had a combination of grass and natural vegetation, e.g. grassed area with trees as depicted in Figure 19.

![Figure 18: Inside tent](image1.png)  
![Figure 19: Grassed area with trees](image2.png)
• **Sport** – On occasion it was too difficult to distinguish whether the activity engaged in was sport or play e.g. in Figure 20 below the participant is either playing with a basketball, playing an informal game of basketball or practicing basketball skills. On such occasions, the image was coded as sport. This is because the act of play in this scenario would still assist in practicing sporting skill and technique.

• **Private Green Space** – The name of this category was originally labelled ‘garden/backyard’ but was changed to ‘private green space’ so as to expand the category to incorporate the private berm/verge or grassed area in front of a private dwelling, as seen in Figure 21. This decision was based on the methodology of previous research e.g. Cameron et al., (2012) and the manner in which the participants appeared to use the grass verge area exclusively in front of their residence, as if it were an extension of their home.

![Figure 20:Informal sport](image1)

![Figure 21: Grass Verge](image2)
Camera removed – On occasion the participant removed the camera without switching it off. This was sometimes difficult to distinguish from times when the participant was lying down. Figure 22 below demonstrates an example of a sequence of pictures that look as though the participant has removed the camera, but eventually images show the participant raise their arms. This confirms that for this sequence of photographs the participant was lying down. In order to ensure consistency in coding such events, the following rules were applied to decisions on camera removal:

- If a sequence of images looking at the sky or wall remained the same for an entire sequence, no code was applied to the sequence of photographs.
- If an action made it obvious that the camera was not being worn (e.g. the camera was left under a pile of clothes), no code was applied to the sequence of photographs.
- If the camera eventually showed movement that indicated the camera was being worn e.g. the participant’s arms or legs came into view, the sequence was coded as inactive.

![Figure 22: Lying down looking at the sky](image)
• **Brief interruptions to sequences**: On occasion, the green space may be obscured from the image (e.g. due to obstructions), or sometimes participants may leave a green space for a short period (e.g. to go to the bathroom or get a drink) and return to it to conduct the same activity. On these occasions, the images of the break were coded (a maximum of 24 images) with the same setting, activity and detail that were seen preceding and after the break. For example, in Figure 23 below, the participant goes inside for 4 photographs (28 seconds) and returns to resume playing in the same location. In this instance all 15 photographs are recorded with the same location and activity so that they are recorded as a single event or visit.

![Figure 23: Manual instruction, break in sequence](image)

**Coding Schedule**

Tables 3, 4, 5 and 6 below outline the final categories codes and definitions that were used for the analysis.

**Table 3: Image code summary**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Activity</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green natural</td>
<td>Gardening</td>
<td>Social contact</td>
</tr>
<tr>
<td>Beach</td>
<td>Play</td>
<td>Supervised</td>
</tr>
<tr>
<td>Playground</td>
<td>Sport</td>
<td>Inactive</td>
</tr>
<tr>
<td>Field</td>
<td>Inactive</td>
<td>Other activity</td>
</tr>
<tr>
<td>Private green space</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garden public</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category Title and Example</td>
<td>Category Definition</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 24: Green natural</strong></td>
<td>Outdoor green space with natural vegetation e.g. bush trail, forest, river bed.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 25: Beach</strong></td>
<td>Coastal environment, near sea or ocean.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 26: Playground</strong></td>
<td>Public green space with identifiable play equipment (the area must have significant presence of natural elements e.g. the play area is on grass, placed in a field or surrounded by a significant number of trees/plants).</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 27: Field</strong></td>
<td>Open grassed area (this could include paddocks or sports fields).</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 28: Private green space</strong></td>
<td>Green space that has limited access to exclusive users e.g. a backyard, garden or grass verge that is part of or contiguous with a residential lot.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 29: Garden public</strong></td>
<td>Publically accessible green space that has the presence of maintained garden/park area, e.g. flower beds or crops.</td>
<td></td>
</tr>
<tr>
<td>Category title and example image</td>
<td>Definition</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 30: Gardening</strong></td>
<td>Maintaining vegetation in a green space.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 31: Play</strong></td>
<td>Free play or unstructured activity.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 32: Sport</strong></td>
<td>Participation in recognised sports whether formal or informal. This includes team sports as well as purposeful solo sports activities such as cycling, skateboarding, running and walking for exercise.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 33: Inactive</strong></td>
<td>Sedentary or extremely low level of activity.</td>
<td></td>
</tr>
<tr>
<td><strong>Figure 34: Other activity</strong></td>
<td>Activity not defined as gardening, play, sport or inactive for example household chores, animal interaction, gathering shellfish.</td>
<td></td>
</tr>
</tbody>
</table>
Table 6: Definitions for Detail

<table>
<thead>
<tr>
<th>Category title and example image</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The participant is in the presence of another person; this can be a child or an adult.</td>
</tr>
<tr>
<td>Figure 35: Social Contact</td>
<td>Subset of social contact. Presence of someone with an estimated age over 15 years.</td>
</tr>
<tr>
<td>Figure 36: Supervised</td>
<td></td>
</tr>
</tbody>
</table>

Analysis

The Statistician for the Kids’Cam team extracted data from the annotation software and imported it into Stata/IC 14.1 for Windows. Using this software I conducted the following analyses (a complete list of analyses and details of the stata commands used are provided in Appendix 2):

- The number and percentage of participants who had contact with green space and those who did not, using the ‘generate table’ command.
- Two Chi-square tests to measure the relationships between gender and NZiDep with BMI were conducted using the ‘tabulate chi2’ command.
- Mean numbers of visits and time spent in green space using the ‘mean’ command.
- A series of linear regression were used to estimate the mean differences by comparing the mean levels of each outcome (number or visits or time spent in green space) according to each demographic group using the ‘reg’ command.
- Mean percentages of time spent in green space by sub-categories were calculated manually after extracting the figures for the total number of photographs in green space and for each sub-category using the ‘total’ command.
4. Results

The Sample: What Were the Characteristics of Participants?
Table 7 shows that there were five more females in the sample than males. However, a much larger proportion of the female participants used green space than male participants. There were more participants from low-decile school groups (high deprivation) than those from high-decile school groups. In addition, participants from middle-decile schools used green space the least. Conversely, there was a greater proportion of participants from low NZiDep groups (low deprivation) in the sample compared to high NZiDep groups. Despite this, the distribution of those that used green space appears to be less for low NZiDep groups compared to high NZiDep groups.

There was a relatively similar number of NZ European and Māori participants; however, the number of Pacific participants was less than half that of the other groups. A slightly larger proportion of Māori participants used green space than was found for other ethnic groups. The majority of participants were in the not overweight category, and only six participants were classified as underweight. There was no clear trend by BMI in the proportion of the sample that used green space.

Table 7: Sample demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. Used Green Space</th>
<th>Total</th>
<th>% Used Green Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
<td>43</td>
<td>67.4</td>
</tr>
<tr>
<td>Male</td>
<td>18</td>
<td>38</td>
<td>47.4</td>
</tr>
<tr>
<td>School Decile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deciles 1-3</td>
<td>23</td>
<td>32</td>
<td>71.9</td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>14</td>
<td>38</td>
<td>36.8</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>10</td>
<td>11</td>
<td>90.9</td>
</tr>
<tr>
<td>NZiDep</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZiDep 1 (low dep)</td>
<td>11</td>
<td>20</td>
<td>55</td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>9</td>
<td>18</td>
<td>50</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>7</td>
<td>12</td>
<td>58.3</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>9</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>NZiDep 5 (high dep)</td>
<td>11</td>
<td>16</td>
<td>68.7</td>
</tr>
<tr>
<td>Ethnic Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ European</td>
<td>20</td>
<td>35</td>
<td>57.1</td>
</tr>
<tr>
<td>Māori</td>
<td>21</td>
<td>33</td>
<td>63.6</td>
</tr>
<tr>
<td>Pacific</td>
<td>6</td>
<td>13</td>
<td>46.1</td>
</tr>
<tr>
<td>BMI Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>5</td>
<td>6</td>
<td>83.3</td>
</tr>
<tr>
<td>Not Overweight</td>
<td>22</td>
<td>43</td>
<td>51.2</td>
</tr>
<tr>
<td>Overweight</td>
<td>11</td>
<td>17</td>
<td>64.7</td>
</tr>
<tr>
<td>Obese</td>
<td>8</td>
<td>13</td>
<td>61.5</td>
</tr>
</tbody>
</table>
Table 8 shows that the proportion of participants in the BMI categories ‘underweight or not overweight’ and ‘overweight and obese’ were relatively similar between males and females in the sample. The chi-squared analysis indicated that the relationship between gender and BMI had a p-value that was not below the critical value for statistical significance of 0.05 ($X^2 (4 \text{ df}) = 0.04$, $p = 0.842$) and therefore it is not certain that this same pattern would be found in the source population.

### Table 8: Cross-tabulation of gender and BMI of participants

<table>
<thead>
<tr>
<th>Gender</th>
<th>% of Participants Underweight and Not Overweight</th>
<th>% of Participants Overweight and Obese</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>61</td>
<td>39</td>
<td>41</td>
</tr>
<tr>
<td>Male</td>
<td>63</td>
<td>37</td>
<td>38</td>
</tr>
</tbody>
</table>

Table 9 shows a pattern that suggests that those from low NZiDep groups (low deprivation) were more likely to be from the underweight or not overweight BMI groups. However, a chi-squared analysis indicated that the relationship between NZiDep and BMI had a p-value that was not below the critical value for statistical significance of 0.05 ($X^2 (4 \text{ df}) = 2.7$, $p = 0.615$) and therefore it is not certain that this pattern would be found in the source population of all 11 to 13-year-olds in the Wellington region.

### Table 9: Cross-tabulation of NZiDep and BMI of participants

<table>
<thead>
<tr>
<th>NZiDep Group</th>
<th>% of Participants Underweight and Not Overweight</th>
<th>% of Participants Overweight and Obese</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZiDep 1 (low dep)</td>
<td>70</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>71</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>58</td>
<td>42</td>
<td>12</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>60</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>NZiDep 5 (high dep)</td>
<td>47</td>
<td>53</td>
<td>15</td>
</tr>
</tbody>
</table>

**Frequency and Time: How Much Did Participants Use Green Space?**

Across the whole Green Space Study sample, 58%, (\(n = 81\), 95% CI 46.5–68.9) of the participants visited green space at least once.

Amongst those who visited green space, the mean frequency for visits to green space was 4.2 (CI 2.6–5.8) over four days and the average time spent in green space per visit was 36.2 minutes (CI 21.9–50.6).
Demographics: How Did Different Types of Participants Use Green Space?

Below is a breakdown of the mean frequency of visits to green space and the mean time spent in green space per participant by different demographic groups. The means for all of the results in this section were calculated from the total number of participants that had used green space at least once.

Gender

Table 10 shows that on average, females visited green space twice as often (5.8) as males (2.4). The data suggests that there is a reliable difference between gender and the mean number of visits to green space based on the p-value ($p = 0.03$).

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean No Visits</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>5.8</td>
<td>(3.0, 8.6)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2.4</td>
<td>(1.3, 3.4)</td>
<td>-3.4</td>
<td>(-6.5, -0.3)</td>
</tr>
</tbody>
</table>

Table 11 shows that on average females spent a mean difference of 31 more minutes per visit to green space (50.3 minutes) than males (20.3 minutes). The data suggests that there is a reliable difference between gender and mean time spent in green space ($p = 0.037$), demonstrating that females visited green space more frequently and spent the most time in green space.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Minutes per Visit</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>50.3</td>
<td>(26.3, 74.3)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20.3</td>
<td>(7.8, 32.8)</td>
<td>-31.0</td>
<td>(-58.1, -1.8)</td>
</tr>
</tbody>
</table>
School Decile

Table 12 shows that participants attending high-decile schools (low deprivation) visited green space on average at least five times more (mean = 10.7 visits) than those from middle-decile schools (1.9) and twice as often as those from low-decile (4.7) schools. The data suggests that there is a reliable difference between school decile groups and number of visits to green space ($p = 0.001$).

Table 12: Cross tabulation for number of visits to green space per participant and school decile

<table>
<thead>
<tr>
<th>School Decile Group</th>
<th>Mean No of Visits</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciles 1-3</td>
<td>4.7</td>
<td>(1.9, 7.5)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>1.9</td>
<td>(0.8, 3.0)</td>
<td>-2.8</td>
<td>(-5.9, 0.4)</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>10.7</td>
<td>(4.5, 16.9)</td>
<td>6.0</td>
<td>(1.4, 10.7)</td>
</tr>
</tbody>
</table>

Likewise, Table 13 shows that participants attending high-decile schools spent more time (mean time = 125.4 minutes) in green space on average per visit, than those from low-decile schools (31.3 minutes) with participants from middle-decile (14.6 minutes) schools spending the least time per visit to green space. This data also suggests that there is a reliable difference between school decile groups and time spent in green space ($p = 0.001$).

Table 13: Cross tabulation for mean time per visit to green space and school decile

<table>
<thead>
<tr>
<th>School Decile Group</th>
<th>Minutes per Visit</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciles 1-3</td>
<td>31.3</td>
<td>(13.9, 48.6)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>14.6</td>
<td>(5.5, 23.7)</td>
<td>-16.7</td>
<td>(-42.6, 9.3)</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>125.4</td>
<td>(58.2, 192.7)</td>
<td>94.1</td>
<td>(56.3, 132.0)</td>
</tr>
</tbody>
</table>
NZiDep

Results for number of visits to green space by NZiDep group shown in Table 14, indicate that those with a lower level of deprivation on average visited green space more often, with NZiDep 1 participants visiting green space on average 5.2 times over four days, compared with NZiDep 5 visits at 2.7. However, a test for whether there was a linear trend in mean number of visits by NZiDep category was not significant ($p = 0.141$).

<table>
<thead>
<tr>
<th>NZiDep Group</th>
<th>Mean No. of Visits</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZiDep 1 (low dep)</td>
<td>5.2</td>
<td>(0.8, 9.7)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>5.7</td>
<td>(1.6, 9.7)</td>
<td>0.4</td>
<td>(-4.3, 5.1)</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>4.4</td>
<td>(0.4, 8.4)</td>
<td>-0.8</td>
<td>(-6.1, 4.4)</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>2.5</td>
<td>(1.0, 4.0)</td>
<td>-2.8</td>
<td>(-7.7, 2.1)</td>
</tr>
<tr>
<td>NZiDep 5 (high dep)</td>
<td>2.7</td>
<td>(1.2, 4.3)</td>
<td>-2.5</td>
<td>(-7.3, 2.3)</td>
</tr>
</tbody>
</table>

Table 14: Cross tabulation of frequency of participants’ visits to green space and NZiDep

Figure 37 provides a graph of the data in Table 14 to show that as NZiDep increased, the number of visits to green space appear to decrease on average per participant. Conversely, Table 15 shows that there was no pattern between the time spent in green space per visit and the NZiDep of participants. In addition, the value returned by a test for whether there was a linear trend in mean time spent in green space by NZiDep category was not significant ($p = 0.572$).

Figure 37: Frequency of visits to green space on average per participant by NZiDep group
Table 15: Cross tabulation for the mean time spent in green space per visit and NZiDep

<table>
<thead>
<tr>
<th>NZiDep Group</th>
<th>Minutes per Visit</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZiDep 1 (low dep)</td>
<td>28.5</td>
<td>(9.0, 48.0)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>60.6</td>
<td>(17.5, 103.6)</td>
<td>32.1</td>
<td>(-9.9, 74.1)</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>38.6</td>
<td>(0.0†, 88.9)</td>
<td>10.1</td>
<td>(-37.1, 57.3)</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>18.8</td>
<td>(1.3, 36.3)</td>
<td>-9.7</td>
<td>(-53.8, 34.4)</td>
</tr>
<tr>
<td>NZiDep 5 (high dep)</td>
<td>33.1</td>
<td>(7.5, 58.8)</td>
<td>4.6</td>
<td>(-38.7, 48.0)</td>
</tr>
</tbody>
</table>

Note: † Confidence interval lower bound set to zero as calculation indicated value < 0

Ethnicity

Table 16 shows that NZ European and Māori participants made visits to green space at a similar frequency, with 5 and 4.2 visits respectively on average per participant, compared with Pacific people, who made visits to green space on average twice. However, it is not certain that this same relationship would be found in the source population ($p = 0.444$).

Table 16: Cross tabulation for the mean frequency of visits to green space per participant and ethnic group

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Mean No of Visits</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ Euro</td>
<td>5.0</td>
<td>(2.1, 7.9)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>4.2</td>
<td>(1.9, 6.6)</td>
<td>-0.8</td>
<td>(-4.2, 2.7)</td>
</tr>
<tr>
<td>Pacific</td>
<td>2.0</td>
<td>(0.4, 3.6)</td>
<td>-3.0</td>
<td>(-7.7, 1.7)</td>
</tr>
</tbody>
</table>

Māori spent the most time while in green space on average per visit (40.7 minutes), followed by NZ Europeans (34.2 minutes) and Pacific people (30.3 minutes). However, based on the p-value ($p = 0.864$), it is not certain that the same relationship would be found in the source population. Tables 16 above and 17 below show different patterns across ethnic groups when comparing time spent in green space and frequency of visits. For example, while NZ European participants made more visits to green space, Māori participants spent the most time in green space on average per visit.

Table 17: Cross tabulation for the mean time spent per visit to green space and ethnic group

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Minutes per Visit</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ Euro</td>
<td>34.2</td>
<td>(13.8, 54.6)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>40.7</td>
<td>(15.3, 66.2)</td>
<td>6.5</td>
<td>(-25.2, 38.2)</td>
</tr>
<tr>
<td>Pacific</td>
<td>30.3</td>
<td>(-0.6, 61.2)</td>
<td>-3.9</td>
<td>(-46.3, 38.5)</td>
</tr>
</tbody>
</table>
Body Mass Index

From Table 18 and Figure 38, there appears to be a linear relationship between the frequency of visits to green space and BMI groups, with the mean number of visits per participant being more often amongst lower BMI groups when compared to those with a higher BMI score. However, a test for whether there was a linear trend in the mean number of visits by BMI category was not significant ($p = 0.075$).

Table 18: Cross tabulation for mean number of visits to green space by BMI groups

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>Mean No of Visits</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>9.8</td>
<td>(0.0†, 20.6)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Not Overweight</td>
<td>4.3</td>
<td>(1.9, 6.8)</td>
<td>-5.5</td>
<td>(-11.7, 0.7)</td>
</tr>
<tr>
<td>Overweight</td>
<td>3.1</td>
<td>(1.3, 4.8)</td>
<td>-6.8</td>
<td>(-13.5, -0.0)</td>
</tr>
<tr>
<td>Obese</td>
<td>2.5</td>
<td>(1.0, 3.9)</td>
<td>-7.4</td>
<td>(-14.4, -0.3)</td>
</tr>
</tbody>
</table>

Note: † Confidence interval lower bound set to zero as calculation indicated value < 0

Figure 38: Mean number of visits to green space per participant by BMI group

There appears to be a linear relationship between the time spent by BMI groups in Table 19 and Figure 39, with the mean time spent per visit being longer amongst lower BMI groups compared to those with a higher BMI score. However, a test for whether there was a linear trend in the mean time per visit to green space by BMI category was not significant ($p = 0.158$).

Table 19: Cross tabulation for mean time spent in green space per visit by BMI groups

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>Minutes per Visits</th>
<th>95% CI</th>
<th>Mean Difference</th>
<th>95% CI Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>88.9</td>
<td>(0.0†, 193.7)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Not Overweight</td>
<td>33.9</td>
<td>(14.9, 53.0)</td>
<td>-55.0</td>
<td>(-110.9, 0.9)</td>
</tr>
<tr>
<td>Overweight</td>
<td>30.4</td>
<td>(5.5, 55.3)</td>
<td>-58.5</td>
<td>(-119.5, 2.4)</td>
</tr>
<tr>
<td>Obese</td>
<td>24.7</td>
<td>(1.8, 47.7)</td>
<td>-64.2</td>
<td>(-127.5, 0.8)</td>
</tr>
</tbody>
</table>

Note: † Confidence interval lower bound set to zero as calculation indicated value < 0
Social Contact: Did Participants Have Contact with Other People in Green Space?
Below is a breakdown showing the proportion of the time spent in all green spaces that was spent in the company of one or more people (this could be an adult or a child) as opposed to being alone. This is described in the Methodology chapter as ‘social contact’. The means for all results in this section were calculated from the total number of participants that had used green space at least once.

Average Time Exposed to Social Contact

On average, participants were exposed to social contact 84.7% of the time, each time they were in green space (CI 75.5–93.8).

Social Contact by Demographics

Table 20 shows that on average females and males spent a similar proportion of time exposed to social contact when in green space.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>85.0</td>
<td>73.3</td>
</tr>
<tr>
<td>Male</td>
<td>84.2</td>
<td>69.2</td>
</tr>
</tbody>
</table>

Figure 39: Mean time spent in green space per visit by BMI group
Table 21 shows that those from higher-decile schools spent a larger proportion of time exposed to social contact when visiting green space than those from lower-decile schools. This indicates that the higher the deprivation of the school that a participant attended, the less time they spent with other people in green space, per event. However, because the confidence intervals (CI) for these categories overlapped, it is not certain that a similar pattern between groups would be found in the source population.

Table 21: Mean proportion of time spent with others per visit to green space by school decile

<table>
<thead>
<tr>
<th>School Decile Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciles 1-3</td>
<td>77.9</td>
<td>62.0</td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>87.4</td>
<td>72.4</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>96.6</td>
<td>91.4</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value > 100

Table 22 shows that there was no pattern between the NZIDep category of participants and the average time spent exposed to social contact in green space (per event).

Table 22: Mean proportion of time spent with others per visit to green space by NZIDep

<table>
<thead>
<tr>
<th>NZIDep Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZIDep 1</td>
<td>88.4</td>
<td>70.8</td>
</tr>
<tr>
<td>NZIDep 2</td>
<td>92.0</td>
<td>80.7</td>
</tr>
<tr>
<td>NZIDep 3</td>
<td>94.3</td>
<td>86.5</td>
</tr>
<tr>
<td>NZIDep 4</td>
<td>67.7</td>
<td>35.7</td>
</tr>
<tr>
<td>NZIDep 5</td>
<td>82.8</td>
<td>62.4</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value > 100

Table 23 shows that on average Māori spent the highest proportion of time exposed to social contact when visiting green space, at 95.4%. However, because the CIs for ethnic groups overlapped, it is not certain that a similar pattern between groups would be found in the source population.

Table 23: Mean percentage of time spent with others per visit to green space by ethnic group

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ European</td>
<td>74.5</td>
<td>58.5</td>
</tr>
<tr>
<td>Māori</td>
<td>95.4</td>
<td>86.6</td>
</tr>
<tr>
<td>Pacific</td>
<td>81.2</td>
<td>48.2</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value > 100
When looking at the pattern of those who were exposed to social contact across BMI groups in Table 24, those with lower BMIs spent a slightly greater proportion of time with others across all groups compared to those with higher BMIs. However, because the CIs for all BMI categories overlapped, it is not certain that a similar pattern between groups would be found in the source population.

Table 24: The mean percentage of time participants spent exposed to social contact in green space by BMI group

<table>
<thead>
<tr>
<th>BMI Group</th>
<th>Mean %</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>96.0</td>
<td>88.6 - 100.0*</td>
</tr>
<tr>
<td>Not overweight</td>
<td>86.7</td>
<td>74.3 - 99.1</td>
</tr>
<tr>
<td>Overweight</td>
<td>80.4</td>
<td>56.8 - 100.0*</td>
</tr>
<tr>
<td>Obese</td>
<td>79.3</td>
<td>51.8 - 100.0*</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >

Supervision: Were Participants Supervised by an Adult in Green Space?

Supervision is a subcategory of social contact, and represents the proportion of the time spent in contact with others in green spaces that was in the presence of an adult (someone over the age of 15). All results in this section were calculated from the total number of participants that had used green space at least once.

When looking at the time participants spent in green space per visit, on average participants were supervised by an adult 59.1% of the time (CI 46.8 – 71.3).

Supervision by Demographics

Table 25 shows that on average males spent a higher proportion of their time (67.6%) in green space with supervision than females, who were supervised 54.4% of the time. However, because the CIs for male and female overlapped, it is not certain that a similar pattern between gender groups would be found in the source population.

Table 25: Mean percentage of time supervised in green space per visit by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean %</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>54.4</td>
<td>37.9 - 70.9</td>
</tr>
<tr>
<td>Male</td>
<td>67.6</td>
<td>49.4 - 85.7</td>
</tr>
</tbody>
</table>
Table 26 shows that those from higher-decile schools (low deprivation) spent a larger proportion of time supervised in green space than those from lower-decile schools. This indicates that the lower the deprivation of the school participants attended, the more time they spent supervised in green space, per event. However, because the CIs for low and middle-decile groups overlapped, it is not certain that a similar pattern between groups would be found in the source population.

<table>
<thead>
<tr>
<th>School Decile Group</th>
<th>Mean %</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciles 1-3</td>
<td>47.2</td>
<td>29.5 - 64.8</td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>59.5</td>
<td>36.9 - 82.1</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>57.6</td>
<td>68.7 - 100.0*</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >

Table 27 shows that participants with lower NZiDep (low deprivation) spent a greater proportion of time supervised in green space with NZiDep 1 at 74.2%, reducing to 37.4% at NZiDep 5. This indicates that those from lower deprivation areas were more likely to spend time supervised in green space than those from high deprivation areas. However, because the CIs for these categories overlapped, it is not certain that a similar pattern between groups would be found in the source population.

<table>
<thead>
<tr>
<th>NZiDep Group</th>
<th>Mean %</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZiDep 1</td>
<td>74.2</td>
<td>50.9 - 97.5</td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>69.0</td>
<td>43.9 - 94.1</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>50.7</td>
<td>20.2 - 81.3</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>65.5</td>
<td>34.3 - 96.7</td>
</tr>
<tr>
<td>NZiDep 5</td>
<td>37.4</td>
<td>11.0 - 63.8</td>
</tr>
</tbody>
</table>

Table 28 shows that on average Māori spent the highest proportion of time supervised in green space at 65.4%. However, because the CIs for ethnic categories overlapped, it is not certain that a similar pattern between groups would be found in the source population.

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Mean %</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ European</td>
<td>55.2</td>
<td>37.2 - 73.2</td>
</tr>
<tr>
<td>Māori</td>
<td>65.4</td>
<td>46.2 - 84.6</td>
</tr>
<tr>
<td>Pacific</td>
<td>52.7</td>
<td>14.2 - 91.3</td>
</tr>
</tbody>
</table>
Table 29 shows that on average those in the lower BMI categories spent a greater proportion of time supervised in green space than those with higher BMIs. However, because the CIs for BMI categories overlapped, it is not certain that a similar pattern between groups would be found in the source population.

<table>
<thead>
<tr>
<th>BMI Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>60.5</td>
<td>19.2</td>
</tr>
<tr>
<td>Not overweight</td>
<td>69.3</td>
<td>53.7</td>
</tr>
<tr>
<td>Overweight</td>
<td>52.1</td>
<td>22.2</td>
</tr>
<tr>
<td>Obese</td>
<td>48.5</td>
<td>16.7</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >

**Table 29: Mean percentage of time supervised per visit to green space by BMI group**

**Setting: What Types of Green Spaces Did Participants Use?**

Amongst those who visited green space the mean percentage of time in public green space was 81.7% (CI 76.9–85.8) compared to time spent in private green space.

Table 30 shows that fields and private green space were the most common green space settings visited by participants with 1.88 and 1.45 visits on average respectively per participant. All other settings had fewer than 0.3 visits on average, with participants visiting ‘non-green outdoor recreation spaces’ the least. The mean frequency calculation for each setting included only the portion of the sample who visited that type of setting.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Mean No of Visits</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Field</td>
<td>1.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Private green space</td>
<td>1.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Garden Public</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Green Natural</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Outdoor Recreation not green</td>
<td>0.1</td>
<td>0.0†</td>
</tr>
<tr>
<td>Playground</td>
<td>0.2</td>
<td>0.0†</td>
</tr>
</tbody>
</table>

Total of mean number of visits 4.22

†Confidence interval lower bound set to zero as calculation indicated value < 0
Table 31 shows that on average participants spent most of their time in playgrounds, with an average of 12.2 minutes per visit, followed closely by time at the beach, at 11.2 minutes. They spent the least amount of time in green natural settings, at 4.8 minutes per visit. The mean time calculation for each setting included only the portion of the sample who visited that setting.

Table 31: Mean time per visit for different types of green space

<table>
<thead>
<tr>
<th>Setting</th>
<th>Minutes per Visit</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach</td>
<td>11.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Field</td>
<td>9.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Private green space</td>
<td>6.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Garden Public</td>
<td>5.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Green Natural</td>
<td>4.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Outdoor Recreation Not Green</td>
<td>6.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Playground</td>
<td>12.2</td>
<td>0.0†</td>
</tr>
<tr>
<td>Total of mean times per visit</td>
<td><strong>57</strong></td>
<td></td>
</tr>
</tbody>
</table>

†Confidence interval lower bound set to zero as calculation indicated value < 0

Figure 40 below was calculated by dividing the mean frequency of visits to each setting by the total of means. The same method was applied for the mean time spent in each type of setting. The figure demonstrates that different types of green space were used in a diverse manner by participants, with some being more likely to be visited on a frequent basis for a short period of time e.g. fields and private green space and others being more likely to be infrequently used, but for a long period of time e.g. beaches and playgrounds.

![Figure 40: Percentage of participants who used different types of green space by time and frequency](image-url)
There were eight visits in total to non-green outdoor recreation spaces. These events account for 2.3% of all visits, at an average of 6.6 minutes per visit. Because the study’s main focus was to examine the use of green space specifically, all non-green outdoor recreation space has been excluded from the remaining analysis. Please refer to the methodology for further information.

Setting by Demographics

Below is a breakdown of what proportion of the time spent in all green spaces was spent in public green spaces, as opposed to private green spaces. The means for all results in this section were calculated from the total number of participants that had used green space at least once. Please refer to the methodology chapter for further information about the definitions of public green space and private green space.

Table 32 shows that females spent a higher proportion of their time in public green space (compared to private green spaces) at 77%, than males at 48.3%. Furthermore, the CIs do not overlap, suggesting that there is a reliable difference between gender and the mean percentage of time spent in public green space.

Table 32: Mean percentage of time spent in public green space by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean % of Time in Public Green Space</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>77.0</td>
<td>63.1 - 90.9</td>
</tr>
<tr>
<td>Males</td>
<td>48.3</td>
<td>25.2 - 71.4</td>
</tr>
</tbody>
</table>

Table 33 shows that participants from middle-decile schools (Deciles 4-7), spent the least proportion of time in public green space at 47.1%, with those from high-decile schools (Deciles 8-10) spending the most time in public green space (87.9%) followed by those from low-decile schools (68%). However, because the CIs overlapped between decile groups, we cannot be sure that this pattern would be found in the wider population.

Table 33: Mean percentage of time spent in public green space by school decile

<table>
<thead>
<tr>
<th>School Decile Group</th>
<th>Mean % of Time in Public Green Space</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciles 1-3</td>
<td>68.0</td>
<td>50.5 - 85.4</td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>47.1</td>
<td>20.6 - 73.6</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>87.9</td>
<td>67.9 - 100.0*</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >
Table 34 shows that those with low NZiDep scores spent a greater proportion of time in public green spaces than those with high NZiDep scores. On average the proportion of time spent in public green space for NZiDep 1 was 74.7%, while NZiDep 5 participants only spent 53.4% of their time in public green spaces. However, as the CIs for these categories overlapped, it is not certain that a similar pattern between groups would be found in the source population.

Table 34: Mean percentage of time spent in public green space by NZiDep

<table>
<thead>
<tr>
<th>NZiDep Group</th>
<th>Mean % of Time in Public Green Space</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZiDep 1</td>
<td>74.7</td>
<td>50.8 - 98.7</td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>73.9</td>
<td>45.2 - 100.0*</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>76.9</td>
<td>50.1 - 100.0*</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>54.3</td>
<td>21.5 - 87.1</td>
</tr>
<tr>
<td>NZiDep 5</td>
<td>53.4</td>
<td>22.3 - 84.5</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >

Table 35 shows that Māori spent a higher proportion of time in public green spaces (compared to private green spaces) at 71.3% than NZ European at 60.3% and Pacific at 66.5%. However, as the CIs for these categories overlapped in particular for Pacific participants, it is not certain that a similar pattern between groups would be found in the source population.

Table 35: Mean percentage time spent in public green space by ethnic group

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>Mean % of Time in Public Green Space</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ European</td>
<td>60.3</td>
<td>41.4 - 79.1</td>
</tr>
<tr>
<td>Māori</td>
<td>71.3</td>
<td>51.6 - 91.0</td>
</tr>
<tr>
<td>Pacific</td>
<td>66.5</td>
<td>24.2 - 100.0*</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >

Table 36 shows that there was no pattern between the proportion of time spent in public green space per visit and the BMI of participants. In addition, as the CIs between BMI groups overlapped, we cannot be sure that these results would be found in the source population.

Table 36: Mean percentage of time spent in public green space by BMI group

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>Mean % of Time in Public Green Space</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>73.0</td>
<td>35.1 - 100.0*</td>
</tr>
<tr>
<td>Not overweight</td>
<td>66.9</td>
<td>48.8 - 85.0</td>
</tr>
<tr>
<td>Overweight</td>
<td>52.4</td>
<td>21.7 - 83.0</td>
</tr>
<tr>
<td>Obese</td>
<td>74.1</td>
<td>41.5 - 100.0*</td>
</tr>
</tbody>
</table>

*Confidence interval upper bound set to 100 as calculation indicated value >
Activity: What Did Participants Do When in Green Space?

Table 37 shows that on average, participants were most frequently ‘inactive’ or doing ‘other activities’ (activities that were undefined) when in green space, with participants engaging in both activities 1.6 times on average over the four days. Participants engaged in gardening least often, with an average of 0.1 recorded events across participants. The mean frequency calculation for each activity included only the portion of the sample who participated in that activity.

### Table 37 Mean frequency participants engaged in different activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mean frequency</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gardening</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Inactive</td>
<td>1.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Play</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Sport</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Other</td>
<td>1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Activities*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total of Mean freq</td>
<td>4.97</td>
<td></td>
</tr>
</tbody>
</table>

*Other Activity = Activity not defined as gardening, play, sport or inactive. Refer to methods for further description.

Table 38 shows that on average participants spent more time gardening than any other activity, with participants who gardened spending on average 19.7 minutes gardening. This was more than twice that of all other categories. Participants spent the least amount of time doing ‘other activities’ at 5.1 minutes per visit. The mean time calculation for each activity included only the portion of the sample who participated in that activity.

### Table 38: Mean time spent participating in different activities per visit

<table>
<thead>
<tr>
<th>Activity</th>
<th>Minutes per Visit</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gardening</td>
<td>19.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Inactive</td>
<td>7.8</td>
<td>5.7</td>
</tr>
<tr>
<td>Play</td>
<td>7.9</td>
<td>5.8</td>
</tr>
<tr>
<td>Sport</td>
<td>8.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Other Activity¹</td>
<td>5.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Total Mean time</td>
<td>48.9</td>
<td></td>
</tr>
</tbody>
</table>

*Other Activity = Activity not defined as gardening, play, sport or inactive. Refer to methods for further description.
Figure 41 below was calculated by dividing the mean frequency of engagement in an activity by the total of means, the same method as that applied for the mean time spent for each activity. Figure 41 shows that the time spent engaging in different activities followed a dissimilar pattern to the frequency with which each participant engaged in different activities. For example, participants engaged in gardening the least often, but spent on average more time gardening per event, than on any other activity. This disparity between the frequency of an activity and time spent in that activity excludes the activities of play and sport, as they both had a relatively even proportion of time spent and frequency of events.

![Bar chart showing the percentage of time spent and frequency of events for different activities.]

**Figure 41: The percentage of the sample that engaged in different activities by mean time and frequency of events**

**Level of Activity by Demographic Characteristics**

Below is a breakdown of what proportion of the time spent in all green spaces was spent inactive, as opposed to engaging in other activities. The means for all results in this section were calculated from the total number of participants that had used green space at least once.

On average, when participants were using green space they were inactive for 25.4% of the time (CI 16.3–34.6).
Table 39 shows that on average, females were inactive for almost half the time that males were inactive when in green space. However, because the CIs for these categories overlapped, it is not certain that similar results would be found in the source population.

Table 39: The mean percentage of time participants were inactive while in green space by gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>18.8</td>
<td>9.5</td>
</tr>
<tr>
<td>Male</td>
<td>36.1</td>
<td>18.3</td>
</tr>
</tbody>
</table>

Table 40 shows that those from low-decile schools spent the greatest proportion of time inactive in green space at 31%, while middle-decile schools spent the least amount of time inactive while in green space, at 16%. However, because the CIs across all school decile groups overlapped, it is not certain that a similar pattern between groups would be found in the source population.

Table 40: Mean percentage of time participants spent inactive in green space by school decile group

<table>
<thead>
<tr>
<th>School Decile Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciles 1-3</td>
<td>31.0</td>
<td>15.3</td>
</tr>
<tr>
<td>Deciles 4-7</td>
<td>16.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Deciles 8-10</td>
<td>25.8</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Table 41 below does not show any pattern between the proportions of time participants were inactive by their NZiDep grouping. In addition, because the CIs for these categories overlapped, it is not certain that similar results would be found in the source population.

Table 41: The mean percentage of time inactive in green space by participants NZiDep score

<table>
<thead>
<tr>
<th>NZiDep Category</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZiDep 1</td>
<td>19.7</td>
<td>4.6</td>
</tr>
<tr>
<td>NZiDep 2</td>
<td>36.7</td>
<td>13.2</td>
</tr>
<tr>
<td>NZiDep 3</td>
<td>21.2</td>
<td>0.0 ▲</td>
</tr>
<tr>
<td>NZiDep 4</td>
<td>39.0</td>
<td>12.0</td>
</tr>
<tr>
<td>NZiDep 5</td>
<td>14.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

▲Confidence interval lower bound set to zero as calculation indicated value < 0
Table 42 shows that on average, Pacific and Māori spent the highest proportion of time inactive when in green space at 35.1% and 30.6% respectively, while NZ European participants spent the least amount of time inactive while in green space at 17.2%. However, because the CIs for these categories overlapped, it is not certain that similar results would be found in the source population.

**Table 42: Mean percentage of time participants spent inactive in green space by ethnic group**

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ European</td>
<td>17.2</td>
<td>5.7 28.6</td>
</tr>
<tr>
<td>Māori</td>
<td>30.6</td>
<td>15.0 46.1</td>
</tr>
<tr>
<td>Pacific</td>
<td>35.1</td>
<td>10.1 60.0</td>
</tr>
</tbody>
</table>

Table 43 below does not show a pattern between the proportions of time spent inactive while in green space by participants BMI categories. In addition, because the CIs for these categories overlapped, it is not certain that similar results would be found in the source population.

**Table 43: The mean percentage of time participants were inactive in green space by BMI group**

<table>
<thead>
<tr>
<th>BMI Group</th>
<th>Mean % Time</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>31.4</td>
<td>0.0† 7.1</td>
</tr>
<tr>
<td>Not overweight</td>
<td>27.2</td>
<td>4.1 13.6</td>
</tr>
<tr>
<td>Overweight</td>
<td>19.7</td>
<td>3.2 3.6</td>
</tr>
<tr>
<td>Obese</td>
<td>25.0</td>
<td>1.4 4.9</td>
</tr>
</tbody>
</table>

†Confidence interval lower bound set to zero as calculation indicated value < 0

**Summary of Results**

Amongst this sub-sample of 81 participants, 47 participants used a green space at least once within four days. Participants who visited a green space did so on average 4.2 times for an average of 36.2 minutes per visit.

One of the significant findings included that females visited green spaces twice as often (5.8) as males (2.4), and for a greater length of time at 50.3 minutes in comparison to males at 20.3 minutes. Females also spent 77% of their time in public green spaces (as opposed to private green spaces) compared to male participants who spent 48.3% of their time in public green spaces.
Participants from high-decile schools (low deprivation) visited a green space the most frequently with a mean of 10.7 visits compared to middle-decile schools (1.9) and low-decile (4.7) schools. On average, high-decile schools also spent the most time in green spaces at 125.4 minutes per visit, compared to those from low-decile schools (31.3 minutes) and from middle-decile (14.6 minutes) schools.

All remaining results broken down by demographers were not reliable enough to apply to the wider population with p-values above 0.05 or CI’s that overlapped. However, results for NZiDep indicated a trend for the number of visits to a green space, with those with a lower level of deprivation reporting more visits on average than those with higher levels of deprivation. Likewise, there appeared to be trends in both the mean number of visits to a green space and time spent in a green space by BMI, with the lower the BMI the more visits and more time spent in a green space.

On average participants were in social contact for 84.7% of the time they were in a green space and on average they were supervised by an adult 59.1% of the time. While the CI’s across demographic groups overlapped, social contact in a green space appeared to be high at above 67.7% for all demographic subcategories.

Amongst those who visited a green space the mean percentage of time in a public green space was 81.7% (CI 76.9–85.8) compared to time spent in private green space. Fields were the most commonly visited green space with a mean of 1.88 visits, however participants spent more time in playgrounds (mean of 12.2 minutes per visit) and at the beach (11.2 minutes per visit).

On average, when participants were using a green space they were inactive for 25.4% of the time (CI 16.3–34.6). Participants were most often ‘inactive’ or doing ‘other activities’ while in a green space with participants engaging in both activities 1.6 times on average. However, on average participants spent more time gardening (19.7 minutes per event), than any other activity.
5. Discussion

The Green Space Study attempted to examine health inequalities relating to green space use and disadvantaged demographic groups. This question was investigated by observing children’s use of green space through the mode of wearable cameras that 81 children wore for a four-day period between October 2014 and April 2015. This was a unique method that was able to provide information on the use of green space that has previously been reliant on the mapping of green space availability and density or self-reported green space use. In addition, by examining all of the participant’s activities, the study was able to measure all types of green spaces, including those that few studies have explored, such as smaller green spaces and private green spaces.

Of the 81 children who participated in the Kids’Cam study during the summer school terms, only 58% used green space at least once (47 participants). Therefore, all the results discussed in this chapter are in reference to analysis that has been derived from the sample of 47 participants that had contact with green space.

This chapter will summarise and examine the analysis reported in the previous chapter in relation to different patterns of engagement with green space by gender, school decile, NZDep, ethnic group and BMI. It will also discuss in detail the differences in levels of supervision, social contact and type of activities participants engaged in while in green space and the types of green spaces used by demographic groups. The relatively small sample size of 47 participants has limited the statistical power of the breakdowns presented in the results, in particular amongst categories with very low participant numbers e.g. Pacific participants, and those who were underweight. For this reason a large proportion of the results produced wide confidence intervals or showed p-values from linear regressions below the 95% threshold, therefore limiting the applicability of the results to the wider population. The discussion highlights the results that have strong statistical power and comments on the trends that appeared amongst results that were of low statistical power. Later in the chapter the limitations caused by the sample size and other aspects of the methodology will be reviewed.
Overview of Green Space use

From the complete Kids’Cam sample of 169 participants, 81 participated during the summer period of term 4 2014 (October to December) and term 1 2015 (February to April). Amongst this sub-sample, 58% used green space at least once (47 participants).

The 47 participants who made visits to green space used green space on average 4.2 times over the four-day study period; and on average they spent 36.2 minutes in green space per visit. The demographics of those who used green space more often and for greater lengths of time will be discussed in detail in the sections below, along with the type of activity they participated in while in green space and the types of green spaces they used.

Gender

Overall the sample had a relatively even distribution of males and females, yet 67.4% of the females used green space compared to only 47.4% of males. This contradicts a large body of literature that has found that males are more likely to engage with outdoor spaces than are females (Cherney & London, 2006; Faulkner et al., 2015; Mauldin & Meeks, 1990; Wen et al., 2009).

Not only did a larger proportion of female participants visit green space compared to the male participants, they visited green space twice as often as males, with females recorded, from the photographs taken over the four day period of the study, as visiting green space on average 5.8 times compared to males, who had an average of 2.5 visits. Furthermore, females spent significantly more time in green space on average per visit to green spaces at 50.3 minutes, compared to males, who had an average visit length of 20.3 minutes. These results directly oppose findings from research conducted in the USA and Denmark that found that male children and youth spent more time engaging in outdoor activity than female children and youth (Klinker et al., 2014; Mauldin & Meeks, 1990; The Outdoor Foundation, 2013).

In addition, results also showed that females engaged in physical activity more frequently while in green space than males, with females spending 17% less time inactive than males while in green space. However, the CIs for these results were too wide to be sure that this result could be applied to the wider population and the BMIs of female and male participants were relatively similar, indicating that any difference in physical activity between males and females did not appear to have a relationship with BMI.
It is possible that engagement with green space and participation in physical activity among males was underestimated in the Green Space Study, as the participants were instructed to remove their camera when participating in vigorous activity. This may have reduced the amount of observed contact with green space among males as previous research has found that males have higher rates of participation in sports and vigorous physical activity than females (Joseph & Maddock, 2016; Mauldin & Meeks, 1990; The Outdoor Foundation, 2013). For example, a survey that was administered to 8,500 secondary school students aged between 12 – 18 years across New Zealand found engagement in vigorous activity was more common among males (69%) than females (57%) (Clark, 2013). Similar results were found by the New Zealand Health Survey, in which 46.1% of females aged 15-17 identified as physically active compared to 53.3% of males (Ministry of Health, 2015). However, females in the Green Space Study were also instructed to remove their cameras during vigorous physical activity. Therefore, although it is likely that taking part in physical activity while in green space by males may have been underestimated in this study, this explanation cannot entirely account for the large differences found for green space engagement between genders.

Instead, the difference in results between the Green Space Study and those previously conducted on gender engagement with green space may also be explained by changing trends in female use of green space. For example, female participation in outdoor activities has been on the rise, with the USA Outdoor Participation report noting an increase in female participation in outdoor activities of 2% among 11 to 15-year-olds, whereas boys' participation in outdoor activities decreased across all age groups (The Outdoor Foundation, 2013). Large-scale survey data on outdoor or green space engagement was not available for New Zealand. However, The New Zealand Youth 2000 survey found increases in physical activity amongst females over time. The survey results reported that although engagement in 29 minutes or more of vigorous physical activity on three or more occasions per week was higher amongst males, it increased by 13% for females between 2001 (45%) to 2012 (57%). This compares to a 6% increase in vigorous physical activity amongst males from 2001 (63%) to 2012 (69%) (Clark, 2013).

It may also be that the results from the Green Space Study differed from other studies because most research relied on self-reported engagement instead of observed use of green space. It is possible that the use of self-report as a method of measuring green space activity may be subject to difficulties recalling instances of contact with green space, or even
social desirability bias if male participants over estimated their engagement with green space (Lachowycz & Jones, 2011). In addition, the difference between results could be because self-report methods may be more likely to under-report non-sports related engagement with green space, such as the social use of green space or free play. This may have diminished female reporting of green space use or physical activity in previous research, as females have been found to use green space for social activities more often than boys (Powell et al., 2016). Also, social activities have been found to be a higher predictor of mild to vigorous physical activity in green space among girls than boys (Bailey et al., 2004).

On average, when females used green space, they spent 77% of their time in public green spaces, as opposed to private green spaces, while males on average spent more of their green space time in private green spaces, with a mean percentage of 48.3%. The CIs for these results did not overlap, indicating that it is reasonably likely that females aged 11 to 13 years in the Wellington region may be more likely to spend time in public green spaces than males aged 11 to 13 years. Unfortunately, there is little information that can be gleaned from this study or others to indicate why females used public green spaces more often than private green spaces. However, this difference in the green space setting use between genders may be related to females’ preference to engage in social activities while in green space (Bailey et al., 2004; Cherney & London, 2006; Mauldin & Meeks, 1990), as private green space engagement would have reduced opportunities for social interactions in comparison to public green spaces.

When examining the results for social contact in the Green Space Study, it was found that females and males spent similar amounts of time in social contact while in green space at 85% and 84.2% respectively. However, a large proportion of the male social contact was with an adult, with on average 67.7% of male time in green space supervised (accompanied by an adult) compared to females at 54.4%; indicating that female social contact in green space was more often with other children. Although the CIs for supervision were too wide to be sure if similar results would be found in the wider population, it is interesting that these results differ from studies that have found parents are less likely to allow girls to visit green space or play outdoors unattended than boys (Carver et al., 2010; Stone et al., 2014). The findings from the Green Space Study could be attributed to males having a higher likelihood of participating in organised sports, which are most often supervised by adults (Joseph & Maddock, 2016).
School Decile

New Zealand schools are ranked in deciles according to levels of deprivation, which are determined by census data from the areas in which the school’s students live. For this analysis the ten deciles were categorised into low (highest proportion of students from high deprivation areas), medium and high (lowest proportion of students from high deprivation areas) (Ministry of Education, 2016).

The relationship between overall green space use and the decile of the school that participants attended was not a linear relationship. Instead the percentage of participants from middle-decile schools that used green space at all was lower at 36.8%, than the percentage of participants that attended low-decile schools (at 71.9%) and high-decile schools at (90.9%). This trend also occurred for the frequency of visits to green space and time spent in green space, with those from middle-decile schools visiting green space on average 1.9 times over the four-day study period, compared to those from low-decile schools at 4.7 times and high-decile schools at 10.71. Likewise, students from middle-decile schools spent the least amount of time in green space at 14.6 minutes on average per visit to green space, compared to students from low-decile schools at 31.3 minutes and those from high-decile schools at 125.4 minutes. However, it should be noted that the mean time spent in green space and frequency of visits among participants from high-decile schools is very high in comparison to low and middle-decile schools. It is possible that those from high-decile schools in this sample spent entire days at events located in green spaces, where they would be in and out of the same green space throughout the day. Further analysis of why this high mean rate of green space use occurred amongst participants from high-decile schools would benefit from further investigation.

The results consistently showed that those from high-decile schools visited green space at a very high frequency and for very long periods of time in comparison to those from both low and middle-decile schools. There have been no studies that compared green space use by school decile; however, as school decile is based on the socioeconomic determinants of the pupils at the school, this measure can be related to household income and other socioeconomic deprivation measures. For this reason, it is possible to argue that the high use of green space amongst those from high-decile schools is consistent with the larger body of evidence that has found greater access to green space resources among high socioeconomic groups in both New Zealand and other countries (Astell-Burt et al., 2014; Hand et al., 2016; Wolch et al., 2011). In addition, it is likely that the participants from high-
decile schools may be from households that have more disposable income, and thereby have increased opportunities to participate in green space activities that may incur fees e.g. access to recreation facilities that have entry fees or sports club memberships.

There is little literature that might explain why those from middle-decile schools have the lowest level of interaction with green space. However, the results on the use of public green space show that those from middle-decile schools also spent a lower proportion of their time in green space using public green spaces (47.1%) than students from low-decile schools (68%) or from high-decile schools (87.9%). These results suggest that children from middle-decile schools might face more barriers to using public green spaces than those from low and high-decile schools. One such barrier might be the difference in levels of supervision between school decile categories, as those from middle-decile schools were supervised more often (59.5%) than those from high-decile schools (57.6%) and those from low-decile schools (47.2%). Although the CIs across all decile categories overlapped, Valentine & McKendrick (1997) also found that high-income families had stronger requirements for child supervision in outdoor spaces than low-income families, who were more likely to place a greater level of importance on maintaining their child’s independence. The results in the Green Space Study may reflect a lack of available time to accompany children to green spaces amongst caregivers in middle-income families compared to those in high-income families, or a lack access to childcare resources, which high-income families might use to facilitate opportunities for visits to green spaces.

Furthermore, it is possible that the lower engagement with green space amongst those from middle-decile schools could be a reflection of resource allocation for green spaces in middle-decile schools. Low-decile schools receive extra funding for resources, while high-decile schools might be more likely to gather additional funds through school donations and the attraction of international fee-paying students (Ministry of Education, 2016; Wylie & Bonne, 2015).

Those from middle-decile schools spent a higher percentage of time physically active in green space than those from low and high-decile schools. Participants from middle-decile schools were observed to spend only 16% of their time in green space being inactive, compared to those from low-decile schools at 31% and high-decile schools at 25.8%. Although the CIs between results overlapped, it is possible that those from middle-decile schools are more likely to use their limited time in green space for sports, play and other forms of physical activity rather than for rest and relaxation.
Unlike all of the previous school decile results, the pattern between social contact and school decile categories was linear. Children from low-decile schools spent 77.9% of their time with other people, compared to 87.4% of those from middle-decile schools and 96.6% of those from high-decile schools. Once again the CIs for these categories overlapped and we cannot be certain that a similar pattern would be found in the wider population. However, this could have implications with regard to the benefits of social capital, which is believed to arise from social contact. Those with low incomes may have the most to gain from social capital, which leads to increased opportunities in employment, and to societal participation, reduced isolation, improved wellbeing and self-rated health (Baur & Tynon, 2010; Matsunaga, 2015; Neal et al., 2015; Piracha et al., 2013; Wang & Lu, 2016; Wolfe et al., 2014; Yamaguchi, 2015).

New Zealand Index of Socioeconomic Deprivation for Individuals

NZiDep was measured by asking the Kids’Cam participants' parents to answer a series of eight questions that included topics related to food security, employment of caregivers, use of heating, quality of footwear and other measures. This is a standardized approach to measuring deprivation based on Salmond et al.'s (2006) index. Although School Decile and NZiDep are both indicators of social deprivation, there were differences between these results that may be due to sample selection. The Kids’Cam study sample was constructed to ensure an even distribution of participants from each school decile category, but did not apply the same sampling distribution to NZiDep categories.

The Green Space Study found that the greater the level of deprivation the higher the proportion of participants who had used green space at least once, with 68.7% of participants classified as NZiDep 5 using green space, compared to 55% of those classified as NZiDep1. However, having contact with green space on one occasion does not equate to greater use of green space; for example, participants from NZiDep categories with the least deprivation visited green space nearly twice as often as participants from NZiDep categories with greater deprivation, with an almost linear relationship between the frequency of visits to green space and NZiDep. In addition, even though the CIs between categories overlapped and we cannot be sure that the same pattern between NZiDep and visits to green space would be found in the wider population, the results show some similarity to those on school decile that had greater statistical precision than the results for NZiDep. For example, as with NZiDep, participants from high-decile schools used green space more frequently than other participants did. This pattern also aligns with the findings from previous studies that have
examined deprivation, access to and use of green space. Such studies include Astell-Burt et al. (2014) who found that there was less access to green space amongst the population at large in low socioeconomic areas in Sydney, Perth and Adelaide, although access to green space in New Zealand is considered to be evenly distributed, with most New Zealanders living within close proximity to public green space (Witten et al., 2008).

When visiting green space, participants categorised as least deprived (NZiDep 1, 2 and 3) were also found to have spent a greater proportion of their time in public green spaces, as opposed to private green spaces. While the CIs for these results overlapped, these results align with the results on school decile, which showed that those from the schools with the least deprivation spent a higher proportion of their time in public green spaces. In addition, a survey conducted in Wellington regional parks found that a larger proportion of Regional Park users came from high-income groups (Waititi & Cox, 2009).

There was no clear pattern between NZiDep categories and the time spent in green space or the mean percentage of time that participants were inactive while in green space. This does not align with the results for school decile in the Green Space Study or epidemiological studies that have found that those from high socioeconomic households were more likely to engage in physical activity (Stephens et al., 1985).

Participants categorised as least deprived spent a higher proportion of their time in green space under the supervision of an adult or older peer, compared to those categorised as most deprived. However, the wide CIs mean that we cannot be sure that same pattern between deprivation and the level of supervision in green space would be found in the wider population. Similar results were not found when the percentage of time that participants were in social contact was calculated, with the results for social contact varying across NZiDep categories and with a clear overlap in the CIs between NZiDep categories.

Results for both the duration and frequency of visits by school decile and frequency of visits by NZiDep indicate that use of green space may be greater among those who are from higher socioeconomic households. This raises a potential topic for addressing health inequities, as a significant body of research indicates that improved access and use green space can lead to reduced indicators of poor health (Astell-Burt et al., 2014; Holtan et al., 2014; Maas et al., 2008; Maas et al., 2006; Mitchell et al., 2015; Mitchell & Popham, 2008; Powell et al., 2004). For example, Mitchell & Popham’s (2008) study of mortality records in England found that income-related health inequalities were lower amongst those with greater
access to public green spaces. Similar results have been found in the Netherlands with pronounced benefits to self-perceived general health among those living in close proximity to public green space (Maas et al., 2006), and by Mitchell et al. (2015) who in a survey of 21,294 participants from 34 European countries found that greater availability of green space was associated with reduced mental wellbeing inequalities.

**Ethnic Group**

The Kids’Cam study selected participants of Māori, Pacific and NZ European descent, because Māori and Pacific groups have a disproportionate prevalence of childhood obesity compared with the majority population of NZ Europeans (Ministry of Health, 2012). The sample for the Green Space Study had a relatively even distribution of Māori and NZ European participants at 33 and 35 respectively; however, there were only 13 Pacific participants in the Green Space Study sample. The substantially smaller number of Pacific participants reduced the statistical power of all results for Pacific participants.

At an initial glance, there was a higher proportion of Māori participants who used green space (63.6%) than NZ European (57.1%) and Pacific (46.1%) participants. Māori were also found to spend more time in green space with an average time of 40.7 minutes per visit to green space compared to NZ Europeans at 34.2 minutes and Pacific people at 30 minutes. However, NZ Europeans visited green space most frequently with an average of five visits over the four day observation period across NZ European participants, compared to an average of 4.2 visits by Māori participants and 2 by Pacific participants. Unfortunately, we cannot be sure if similar differences would be found in the source population as the linear regression analysis for both the frequency of visits and time spent in green space by ethnicity reported p-values above the significance threshold of 0.05.

While the low number of Pacific participants has reduced the statistical power of the analysis, the results did find an alarmingly low number of visits to green space amongst the Pacific participants in comparison to Māori and NZ Europeans. This aligns with New Zealand statistics on outdoor sports participation and with international research on the use of green space that has identified disparities between ethnic minorities and their use of green space (Lovelock et al., 2011; Roe et al., 2016). This may be of concern, as access and use of green space has been found to have a stronger association with health amongst minority ethnicities than those in majority groups (Roe et al., 2016). Further research, with a larger sample of Pacific participants, could help to clarify whether green space engagement is a concern for Pacific children living in New Zealand.
Several studies in the USA and UK have found that minority ethnic groups have less access to green spaces and that there is a lower tree canopy density in the areas in which they live compared to those from majority ethnic groups (Comber et al., 2008; Dai, 2011; Roe et al., 2016; Zhou & Kim, 2013). However, these studies did not consider access to private green space, which accounts for a large proportion of green space provision in New Zealand (Mathieu et al., 2007). This is an important consideration, as private green spaces were the second most common green space (after fields) that participants visited in the Green Space Study. Although the CIs overlapped, the results showed that even though NZ Europeans spent the most time in green space, they spent the lowest proportion of their time in public green spaces at 60.3%, followed by Pacific participants 66.5% and Māori, who spent 71.3% of their time in green space in public green space.

The high proportion of time spent in public green space and the number of visits to green spaces amongst Māori participants might be related to a greater involvement in organised sports as both participants and bystanders. This theory would explain why Māori participants spent a higher proportion of their time (65.4%) in supervised activity, compared to NZ Europeans at (55.2%) and Pacific participants at (52.7%) as, typically, organised sports activities are facilitated by adults; however, the CIs between ethnic groups for supervision overlapped.

Although nearly three-quarters of the time participants spent in green space was active, Pacific and Māori participants spent a higher proportion of their time inactive at 35.1% and 30.6%, respectively, followed by NZ Europeans who on average spent only 17.1% of their time in green space being inactive. Even though the CIs for these categories overlapped, New Zealand-wide surveys on physical activity have also found Pacific people to be less likely to engage in physical activity than non-Pacific people (Ministry of Health, 2015).

It is possible that time spent being inactive in green space is an indicator of time spent engaged in social activity instead. This may in part explain why Māori and Pacific participants had substantially more social contact when in green space, at 95.4% and 81.2% respectively, compared to NZ Europeans at 74.5%. The CIs for these categories overlapped but these results are consistent with previous research that has drawn strong connections between green spaces and social connection for Māori and Pacific people (Harmsworth & Awatere, 2013; Lovelock et al., 2011).
While the data comparing green space by ethnic groups was not strong enough to be sure that similar patterns would be found in the wider population, they raise key points of interest. It is promising to see a frequent number of visits amongst Māori participants to green spaces when we consider the high level of importance that natural spaces have for Māoridom with regard to whakapapa and the Nga Pou Mana wellbeing model (Royal Commission, 1998).

Conversely, the data raises a potential concern for Pacific children if similar results were to be found in the wider population. The New Zealand Pacific population has a dramatic shift in urbanisation, with over 80% of New Zealand’s Pacific population now living in either Auckland or Wellington (Ministry of Health, 2012). When we compare the urban environments of Wellington and Auckland to the abundance of green and natural environmental exposure available in Pacific countries, it is likely that new Pacific migrants would experience a substantial reduction in exposure to green space upon moving to New Zealand. Further research on the impact that this divergence in environmental exposure to green space may have for Pacific people is needed, especially as health disparities that have been linked to the use of green space, such as obesity, physical inactivity and high blood pressure, are disproportionately present amongst Pacific people living in New Zealand (Ministry of Health, 2015).

**Body Mass Index**

The Kids’Cam team categorised BMI results into four categories based on the Ministry of Health’s recommended BMI levels adjusted for age and gender. The first category was ‘underweight’ (below the range of a healthy BMI), the second ‘not overweight’ (within the range of a healthy BMI), followed by the categories ‘overweight’ and ‘obese’. Amongst the sample used for the Green Space Study, 54% (43 participants) had a healthy BMI and were categorised as not overweight. This is reflective of the wider population, with 58.3% of children aged 10 to 14 years in New Zealand considered to have healthy BMIs (Ministry of Health, 2015). The other BMI categories had much smaller numbers, with only six participants categorised as underweight, 17 as overweight and 13 as obese. There was no clear trend in the proportion of those who used green space at least once across BMI categories.

None of the results concerning BMI in the Green Space Study can be confidently applied to the wider population, as the linear regression analysis found p-values to be above the significance threshold of 0.05 and CIs overlapped across categories. However, consistent trends between the Green Space Study data and previous research indicate that there might
be a relationship between variables that is worth further investigation. For example, a smaller proportion of those within categories with greater levels of deprivation had healthy BMIs than those from categories with less deprivation; e.g. only 30% of those classified as NZiDep 1 were overweight or obese compared to 53.3% of those classified as NZiDep 5. A chi square analysis found that the relationship between NZiDep and BMI had a p-value that was not statistically significant, but statistics from the Ministry of Health show that children living in the most deprived areas of New Zealand were three times more likely to be obese than those from the least deprived areas (Ministry of Health, 2015).

Furthermore, the lower the BMI amongst participants, the more frequent the visits to green spaces, with results appearing to show a linear relationship. A similar but weaker trend was found for the time spent in green spaces by BMI category. These results contribute to previous research that has found reduced weight gain and obesity amongst populations that had more exposure to vegetation and green space for both adults and children (Dyment & Bell, 2008; Lovasia et al., 2013; Potestio et al., 2009; Wolch et al., 2011). However, several studies have found there is no significant association. For example, Jones & Lachowycz’s (2011) systematic review identified ten out of 13 articles that found no significant relationship between the availability and use of green space and BMI, in particular after controlling for socioeconomic disparities. The current study may contribute to the body of evidence that supports a relationship between the use of green space and BMI, as unlike most of the studies mentioned, the Green Space Study examines children’s use of private green space as well as public green space.

Linear relationships also appeared to be present between BMI and social contact and BMI and supervision, with those who had lower BMIs having on average more social contact while in green space, and those who had a lower BMI having higher rates of supervision while in green space. The CIs for these results were too wide to apply them to the wider population; however, the lower level of social contact with other people amongst those with a higher BMI might be due to social stigmas. A survey across the USA of 90,118 children aged 13 to 18 years old found that overweight participants had significantly fewer social connections (friendships) than those classified as having normal weight, and were more likely to have no friends than those of normal weight (Strauss & Pollack, 2003). Similar results have been reflected when measuring formal forms of social capital (including workplace and community connections) among adults in the USA and Canada, with fewer social connections measured amongst those with an unhealthy BMI (Kim, Subramanian, Gortmaker, & Kawachi, 2006; Moore, Daniel, Paquet, Dubé, & Gauvin, 2009).
However, due to the small number of participants across categories, further trends between BMI categories were not identified. For example, there was no pattern between the time spent in public green space and BMI, with results presenting very wide CIs; and likewise there was no pattern between BMI category and the time spent being inactive while in green space. A portion of these results may be due to participants being required to remove their camera when participating in vigorous physical activity, but the results also highlight that the relationship between BMI and green space use may be influenced by a range of factors not associated with physical activity. In support of this theory Cummins & Fagg (2012) found that applying physical activity as a control for measuring the relationship between BMI and green space made no change to the results.

Although the sample size in the Green Space Study lacked the suitable level of power to draw conclusions for the wider population, it raises a need to further investigate the relationship between BMI and green space and the range of factors that influence this relationship, including but not limited to physical activity, social contact and restorative practices that enhance wellbeing.

**Social Contact and Supervision**

The Green Space Study measured social contact by the presence of another person, who could be another child or a supervisor. On average, participants spent 84.7% of the time they were in green space in social contact with at least one other person. Males and females had a relatively similar level of social contact. However, social contact altered with school decile category: the greater the deprivation level amongst school decile categories, the higher the results for social contact in green space, although the CIs were very wide and no trend was found amongst NZiDep categories.

Māori, followed by Pacific participants, had on average more social contact in green space than NZ European participants did. These results align with previous research, which has identified that minority groups in deprived areas are more likely to engage in social activities in green spaces than majority ethnic groups (Roe et al., 2016).

Supervision was measured as a subcategory of social contact, with all green space engagement in the presence of an adult coded as ‘supervised’. Overall, participants were supervised for 59.1% of the time they were in green space. The amount of time participants were supervised showed different patterns across social demographics when compared to
the results for social contact, with those categorised as having the lowest levels of deprivation having the most time supervised, although the CIs were too wide to be applied to the wider population.

Males spent a greater proportion of their time in green space supervised than females did by an average of 13.2 percentage points. Also, Māori participants recorded more time in green space supervised than other ethnic groups, spending on average 10.2 percentage points more time in green space supervised than NZ European participants.

The results for BMI are an exception to the difference in trends between social contact and supervision. On average, those with lower BMIs spent a greater proportion of their time accompanied by another person (social contact) than those with higher BMIs, much like the results for supervision, with those not overweight spending a higher proportion of time supervised in green space compared to those categorised as overweight or obese. The results for supervision and BMI do not align with previous research that has associated increased levels of supervision with reduced levels of physical activity, and therefore presumed to increase the risk of having a higher BMI (Brussoni et al., 2015; Carver et al., 2010; Stone et al., 2014).

The high rate of social contact amongst groups that did not have high rates of supervision reflects previous research conducted in New Zealand that found that independent mobility was stronger amongst children who had more friends who lived close to their residence (Freeman et al., 2015). Previous research also found that caregivers were more likely to let their child use green space unsupervised if they were with peers or older siblings (Brown & Paskins, 2007). However, this perception of safety amongst peers may be misguided, as previous research has found higher rates of injuries amongst children who were accompanied by a peer, because peer supervised children were more likely to take risks or be distracted around potential hazards than when they were on their own (Wills et al., 1997).

Nevertheless, the high rate of social contact while visiting green space can be considered a positive finding for the health of green spaces users, as a high rate of social contact has been identified as a tool for reducing health inequities, because individuals can share knowledge and cultural norms, extend networks, collaborate, and find social support through social connections (Holtan et al., 2014; Neal et al., 2015; Porter & McIlvaine-Newsad, 2014). Social contact is also negatively associated with prejudice and loneliness (Matsunaga, 2015; Neal et al., 2015; Piracha et al., 2013; Wang & Lu, 2016).
Due to the small sample size, the types of activities and specific settings that participants had social contact in or were supervised in could not be extracted in a meaningful way. Without this information the implications of social contact and supervision rates on health outcomes cannot be deduced. Furthermore, the limitations of the data from the Green Space Study prevented further analysis of the quality of social contact and supervision that participants received while in green space.

**Settings**

A large proportion of research on green space examines the availability or density of green space rather than the use of green space. While this method enables researchers to audit the access that large cross sections of the population have to green space, it does not measure how often or for what duration people use green space (Lachowycz & Jones, 2011). The few studies that have quantified green space use have relied on self-reported records of green space use through surveys, diaries and interviews. However, these methods are reliant on participants’ recall of visits to green space, and may be subject to bias if participants believe visiting green space is a desirable behaviour (Lachowycz & Jones, 2011). In the case of studies on children’s use of green space there are further challenges with collecting reliable data, as often the research has relied on caregivers’ knowledge and recollection of their child’s use of green space, with many parents finding it difficult to recall the types of settings their children played in (Valentine & Mckendrickt, 1997).

The Green Space Study is one of the few studies that have observed children’s use of green space through images captured on a camera that the participants wore. While it is possible that different circumstances may have impacted on when children chose to turn off their camera or remembered to turn their camera on, this method has a much lower likelihood of the recall and social desirability bias than self-report methods. In addition, this method of data collection has gathered information on the types of green space settings that children visit, which may be useful in the promotion of interaction with nature and physical activity (Veitch et al., 2006).

Amongst those who made visits to green space, 81.7% of the time spent in green space was in public spaces, with the most time spent in playgrounds at an average of 12.2 minutes per visit, followed by beaches (11.2 mins) and fields (9.8 mins), compared to 6.7 minutes in private green space. Playgrounds were also cited as the most commonly used green space in Veitch et al.’s (2006) qualitative interviews with parents in Melbourne, Australia. This
differs from Freeman et al.’s (2015) qualitative study of New Zealand children, which identified private green spaces to be the green spaces that most children had the easiest access to on a day-to-day basis.

Fields and private gardens were most frequently used, with an average of 1.88 and 1.45 visits respectively, over the four-day data collection period. Fields were a broad category that encompassed all flat, grassed areas including sports fields, paddocks/meadows, and empty grass lots. It is possible that these settings were used most frequently due to their wide availability within residential areas or due to their diversity of use. For example, such spaces can be used for sports, for school and community events and for animal interactions such as walking the dog or horse riding. While participants did not spend as much time in private gardens as they spent in public settings, it is likely that the ease of access to private gardens enabled participants to visit them frequently.

Participants spent the most time in playgrounds and at beaches compared to other green spaces, with an average of 12.2 and 11.2 minutes per visit respectively. This may indicate that playgrounds and beaches are valued resources for children. However, visits to playground and beaches were infrequent, at an average of 0.18 and 0.22 visits per participant. While it is understood that beaches may not be close enough to participants’ homes to visit at regular intervals, it would be expected that playgrounds are more common place in most neighbourhoods. Instead, the low frequency of playground use may be related to a limited number of playgrounds that cater to 11 to 13-year-olds in the region, as research has identified that playgrounds are often designed for younger children and can overlook the importance of catering to needs of older children (Veitch et al., 2006). Figure 42 below provides an example of a playground that provides limited use to an older child.

Figure 42: Example children’s playground only suitable for young children
A behaviour not captured separately in the results is that some participants made use of grass verges. For the Green Space Study, these incidents were classified under private green space, as the participants in this study appeared to use the green spaces exclusively in front of their own house as if they were an extension of their home. This categorisation followed the methodology of previous research (Cameron et al., 2012). However, there are arguments that these spaces may not be private spaces as they are accessible to other members of the public, do not have the same privacy as a backyard and may be considered less safe than traditional private spaces as they are close to the street. Instead, grass verges play a similar role to other third spaces that have been referred to in the literature such as cul-de-sacs and courts, which have been found to encourage outdoor activity and social connection amongst children in the neighbourhood (Veitch et al., 2006).

It is difficult to determine what aspects of the green spaces visited influenced the frequency and duration of visits to that space, as the images from the cameras did not always provide a complete view of the green spaces that the participants were using. Due to this limitation, the quality of the green spaces they visited could not be measured using Kids’Cam image data alone. This is a key gap in the Green Space Study data, as proximity of green space to residence is not always a reliable predictor of green space use. This is particularly relevant in New Zealand, where neighbourhoods are on average 2.4 minutes driving distance to a green space (Witten et al., 2008) and in Wellington where residents are 1.7% more likely to have access to a motor vehicle than the wider New Zealand population (Statistics New Zealand, 2013b). Therefore it is likely that other factors, including the quality and type of facilities provided could influence the frequency and duration of green space use. For instance, some research suggests that children are more likely to use natural green spaces that feature mud, grass, and trees (Muñoz, 2009). But the settings that were identified as ‘natural’ in the Green Space Study had a low frequency of visits (0.22 times on average over the four-day period) and the least time spent in them at 4.8 minutes per visit. Instead, other research has identified amenities such as seating, toilets, and safety as well as aesthetic elements such as number of trees and variety of plant life to influence how often and how long people may spend in green space (Bell et al., 2008; Edwards, Hooper, Knuiman, Foster, & Giles-Corti, 2015; Giles-Coti et al., 2005; Jones & Lachowycz, 2011; Oldfield, Warren, Felson, & Bradford, 2013). Figure 43 below is an example of a green space where there are several amenities in the one green space facility.
These aspects also had an influence on whether the green spaces were used for physical activity and the length of time the participants were able to spend in green space. Further research to observe the quality of the green spaces that children actually visit would be valuable in making decisions on the provision of public green space facilities. This may have particular importance to reducing health inequities if the quality of green spaces differs between socioeconomic areas of the region, in particular if we consider the cultural importance amongst Māori of maintaining natural resources. Currently, the maintenance of public green spaces is managed by territorial Councils and the Department of Conservation and is governed principally by the Resource Management Act 1991, Conservation Act 1987 and Reserves Act 1977. These laws recognise the principles of the Treaty of Waitangi and within that territorial Councils are obliged to undertake co-management of public national spaces in partnership with Māori (Lovelock et al., 2011). The Treaty of Waitangi, which was signed in 1840, gave governance rights of New Zealand to the Crown, while allowing Māori to retain chieftainship over their lands, forest and fisheries (Ruru, 2004). However, historically, conservation priorities for Māori have not always been applied in green space management. A history of this neglect from 1840 to the present day is documented by Ruru (2004).

**Activity**

While inactive pursuits (sedentary activities) were the most common activity that participants engaged in, at an average 1.63 events for an average 7.8 minutes per event, when we compare all categories that involved mild to vigorous activity, on average participants spent 74.6% of their time active while in green space. In addition, physical activity is likely to have
been under-reported, as participants were instructed to remove their camera when engaging in vigorous activity. Likewise it is possible that inactivity may have been over-reported, as in some cases where it appeared as though the child was lying down (e.g. the camera was pointing at the sky or grass), they could have in fact not been wearing the camera at all. In these instances, it was not always obvious whether the camera was removed unless the angle of the image did not change over a long time.

All time in green space, including time spent inactive, has the potential to provide health benefits. Previous research has found time in green space, in addition to promoting physical activity, is positively related to wellbeing through rest and the restorative effects of natural settings and through providing opportunities for social contact and the building of social capital (Holtan et al., 2014; Irvine et al., 2013; Roe et al., 2016; Thompson et al., 2014; Wolfe et al., 2014). This was demonstrated by the range of examples of inactivity listed in the methodology chapter, such as resting, socialising, eating and watching sport/entertainment.

Amongst those who gardened, participants spent, on average, 19.7 minutes gardening. This was the highest average across all categories. However, participants gardened less frequently than any other activity at an average frequency of 0.14 across those who gardened during the four-day period. The second category that participants spent the most time engaged in was sport, at an average of 8.4 minutes per event. However the time spent engaged in sport may be under-reported, as participants were instructed to remove their cameras when engaging in vigorous activity. For this reason a large portion of sports engagement and physical activity may not have been recorded. This is discussed further in the section on strengths and limitations.

‘Other activities’ (activities that did not occur often enough to have their own category) accounted for the lowest average time spent in green space, but had the highest frequency of visits among the ‘physical active’ categories, at an average of 1.6 observed per participant. These uncategorised photographs were coded as ‘other activities’ and included a range of activities including collecting shellfish, picking berries, outdoor lessons, and chores. Each of these observed activities provided an insightful window into the wide variety of green space interactions that children can engage in through gaining experience in household tasks, gathering food, and learning about outdoor survival that unfortunately could not be captured within the quantitative methods of the Green Space Study. Future studies could potentially explore examples of these ‘uncategorised’ activities and how they
contribute to child development, their understanding of their environments and health and wellbeing.

**Strengths and Limitations**

The overall Kids’Cam project was not designed to collect information on children’s use of green space, and for the purpose of this study I developed a new set of definitions and annotation rules to be applied to the data coding and analysis.

The Green Space Study provides data on observations of children’s actual use of green space and will contribute to and strengthen the growing body of research on children and green space. In the past such research has predominantly relied upon comparing proximity of public green spaces and green density to children’s place of residence, or recollection of children’s use of green space through surveys and interviews with caregivers and children. The Green Space Study provides valuable information on children’s use of private green space, which has been largely absent from most of the available literature on children and green space. This contributes to completing a large gap in our knowledge of children’s use of green space, given that private green space makes up a substantial proportion of the available green space resources for children in New Zealand (Mathieu et al., 2007). Understanding the role of all types of green space in the daily lives of children might assist in providing key information to urban developers on whether to prioritise private green spaces or invest more in communal green spaces. There is a growing need for further evidence in this field as urbanisation increases globally and with that, a movement towards higher density living in which newer housing developments have fewer and/or smaller private gardens.

The Kids’Cam sample selection provided a wide cross-section of schools from across the Wellington region. This was enhanced by ensuring an even distribution of high, medium and low-decile schools were included in the sample and by applying random sampling techniques to select participants within each school. This is also why the confidence intervals and linear regression results based on school decile were more reliable than those for NZiDep.

Despite robust sampling techniques, the Green Space Study also had several limitations, the primary limitation being the sample size. While the initial Kids’Cam sample was for 169 participants, this used for this research was 81 after limiting inclusion to only those children who participated in the study during term one and term four. Time constraints prevented
analysis of the entire Kids'Cam sample and for this reason the decision was made to limit the analysis to term one and term four because these terms were are predominantly drier times of the year when children are more likely to go outside. This was demonstrated by a preliminary analysis of a subset of the data that found participants visited a green space approximately 50% less often in winter than in summer. Likewise previous research by Ergler et al (2016) found that New Zealand children spent more time playing outdoors in summer than in winter. However, it should be acknowledged that not only did this reduce the statistical power of the study, it is also possible that the activities witnessed in green spaces during summer would have differed from those participated in during the winter. For example, the Green Space study would have missed any potential participation in winter sports such as grass hockey and rugby.

The sample size was further reduced for much of the analysis as only 47 of the selected participants used green space. This reduced sample size led to many of the demographic categories being limited to a small number of participants, with categories ranging from five to 29 participants across demographic variables and even lower numbers when variables such as activity, setting, level of supervision or social contact were broken down by demographics. This may be one of the reasons a large proportion of the results showed that p-values were above the 95% threshold and confidence intervals overlapped, leading to a low confidence that similar findings would occur in the wider population of 11 to 13-year-olds attending school in the Wellington region. Instead this research has identified potential inequalities in the patterns of green space use between demographic groups in Wellington, which may provide a basis for further investigation.

The data relied on photographs taken every seven seconds by cameras that were worn on a lanyard around the neck of participants. This is the first time automated cameras have been attached to participants to measure green space use, and for this reason there were no previous guidelines on how to identify when an event began and finished. If, for example, a participant leaves and returns to the same green space to engage in the same activity, is this considered to be the same event? A participant may spend an hour in their private garden/backyard, but this time could be interrupted by short intervals where they may get something to eat or drink, visit the toilet or fetch a piece of play equipment, etc. For this reason the Green Space Study methods deemed an event that was interrupted for less than 24 images (2.8 minutes) be counted as one event rather than two. However, some of the results indicate that a 2.8 minute time limit may not have been enough to accurately reflect the number of visits to green space e.g. those from high-decile schools visited green space
on average 10.7 times for an average of 125.4 minutes per event. These results do not appear to be an accurate reflection of green space use as they indicate that those from high-decile school spent on average of 22.4 hours in green space over four days. Instead, it is likely that several of the participants from high-decile schools spent entire days at school or community events where they were in and out of the same green space throughout the day, possibly inflating the number of visits to green space among the high-decile school category.

The Kids’Cam image data presented an opportunity to measure children’s use of green space without relying on self-report methods that may be vulnerable to recall bias. However, the quantity of image data varied between participants, as on some occasions participants either forgot or chose not to have their camera on, and the study did not examine images taken during school hours. It is possible that this led to an underestimation on the mean frequency of visits to green space. In addition, results that reported on mean time may have been underestimated or overestimated if it were found that multiple short duration visits or long duration visits occurred in the times that were not captured or from analysis.

This was the first study of its kind and therefore it was difficult to set parameters for behaviour that may be outside the normal range. This made it difficult to identify any outliers in the data. Furthermore, the sample was too small to establish a clear pattern of distribution in order to identify outliers. For this reason it is possible that some of the results may be skewed causing the mean time spent in a green space to be higher than the median, for example, if one or two participants were to spend an unusual amount of time in one green space by going on holiday to a rural location. For the Green Space Study up to four participants from each school were included in the sample; this meant that school-related activities were likely to have had a direct effect on the time spent in and frequency of visits to a green space. This may explain why there is an unusually high average number of visits and average time spent in green spaces among participants from high-decile schools. For example, if a school hosted a weekend school fair that all four participants from the school attended, this would involve several hours in a green space that participants may not ordinarily have spent in green spaces in a regular week. Such events, may have affected the results for time spent in green spaces by school decile and there is no way to be sure if this time spent in green spaces is a true reflection of the participant’s usual choice of activity during free time. However, as out-of-school time events in a green space are a typical part of children’s activities during summer, it is still appropriate that they remain part of the data presented.
While the information collected by the Green Space Study provides useful insight into what types of green spaces children visited most frequently and spent the most time in, there were some limitations for observing the activities they engaged in while in green space. For example, it is possible that a large proportion of children’s time spent engaging in physical activity and sport will have been under-represented in the results as participants were instructed to take off the cameras when engaging in vigorous activity and sport. This may in part explain why males were found to have spent less time in public green space and more time inactive than females, despite findings from research that indicates that males are more likely to engage in sports and vigorous activity than females (Joseph & Maddock, 2016; Mauldin & Meeks, 1990; The Outdoor Foundation, 2013).

Furthermore, the images captured by the cameras in the Kids’Cam study were constrained by the direction that participants were facing and the angle of the camera. Therefore the quality of the green spaces that participants visited could not always be established, e.g. the full array of the facilities within a green space, diversity of plant life and safety of the surroundings could not always be seen. In addition, as the photographs were restricted to a view from the camera’s perspective, they did not provide images of the participant themselves. This limitation made it difficult to identify the type of activity the participant was engaging in, e.g. if they were running or walking and how they were engaging with the people around them, etc. Instead, the results only provided information on whether the participant was active (showed some form of movement) or inactive (sedentary). This also applied when measuring the quality of social contact, and supervision, as the photographs did not provide reliable accounts of who was present (e.g. if someone was standing behind the participant they were out of view of the camera), how much participants interacted with peers and supervisors, the type of interaction, or the nature of their relationship. For this reason, the descriptions of activities were basic and focussed on the presence and absence of variables such as inactivity (participant is sedentary), social contact (another person is present) and supervision (if the other person present appears to be over the age of 15 years). Without this information the benefits of the relationship between green space use, physical activity and social contact could not be measured.
6. Summary and Conclusion

Green space can provide several environmental benefits to neighbourhoods and has been linked to multiple health benefits for physical, developmental, social and mental well-being. However, the results from the Green Space Study have highlighted possible socioeconomic inequalities in the use of green space, with participants from disadvantaged and minority groups found to use green spaces less frequently.

The Green Space Study found relationships existed between contact with green space and several of the effect modifiers identified in the diagram in Figure 1, with the strongest of these being for gender and socio-economic status (school decile). The results also indicate that there may be relationships between BMI and engagement with green space and other effect modifiers outlined in Figure 1, including ethnicity, social contact, level of supervision, physical activity and the type of green space. While the Green Space Study did not measure the outcomes of these interactions, previous research indicates that these effect modifiers can influence the degree to which the use and availability of green space can facilitate benefits for social contact, mental health, cognitive development and general health outcomes.

The Green Space Study observed higher rates of green space use amongst females compared to males for both the frequency of visits and the duration of time spent in green space. This contradicts previous research that found lower levels of female engagement in outdoor activities compared to males, and could in part be explained by the Green Space Study’s methodological limitations, that restricted data collection on vigorous physical activity. However, it is also possible the observational methods of the Green Space Study were able to capture female green space engagement that had not been previously recorded by other research e.g. social activities in green space.

The Green Space Study found that participants from high-decile (low deprivation) schools spent more time in green space and visited green space more frequently than other participants. These results indicate a potentially overlooked health inequality in the Wellington region, as green space availability, density and use has been linked to several health benefits and has been identified as a resource for reducing health inequities. The results also showed that those from middle-decile schools spent the least amount of time in green space and visited it the least often. It is unknown why this category had the lowest use of green space and it is worth further investigation into the resource distribution of green
space and green space activities amongst schools, the availability of caregiver time across
decile categories and other possible influencing factors.

The results also showed further trends that may provide insight into green space inequalities
amongst NZiDep, BMI and ethnicity categories that would benefit from further research.
However, the sample was too small to provide strong enough results to be sure that these
trends would be found in the wider population of 11 to 13-year-olds in the Wellington region.
The results showed linear trends that indicated that as deprivation and BMI increased, green
space use decreased. These results highlight potential inequalities that warrant more
investigation. Likewise, the low number of visits and duration of time spent in green space
amongst Pacific participants raises concerns for health inequities for Pacific children living in
urban environments that should be studied using a larger sample and including other key
migrant groups in New Zealand such as migrants from Asia.

Overall children were most often physically active when in green space, highlighting the
strong role that green spaces have to play as facilities that promote physical activity and
recreation. In addition, participants spent a large majority of their time in public green space,
visiting fields most often and spending longer durations of time in playgrounds and at the
beach. This confirms assumptions on the importance of public green spaces for children,
despite the fact that many households in New Zealand have private gardens and backyards.
Although the results suggest that the way children use green space differs based on
functionality and access to green space. For example, participants visited playgrounds and
beaches infrequently but spent the most time in these locations. This variation between
visits and use may be because these types of spaces are preferred by children but may not
be easy to access or that playgrounds in close proximity to schools and residential
neighbourhoods may not cater to all age groups.

On average, participants spent a large majority of their time in green space in contact with
another person, with just over half of the time they were in green space under the
supervision of an adult or an older peer. These results reflect the growing view that
children’s independent play is limited, although it presents evidence that children do spend
some time unsupervised if they are in the company of other peers.

The use of wearable cameras has proven valuable in measuring green space use. It is
recommended that future studies could build upon this framework by incorporating the use of
accelerometers to measure levels of physical activity and comparing GPS data with
locations visited frequently to further understand how far participants travel to a specific
green space. The methodology could also be improved by identifying ways to keep the
camera on when engaging in physical activities without damaging the camera or risking injury to the participant.

Furthermore, the qualitative data captured by the cameras provides detailed information that has not been explored in this study. It is feasible that similar research could be carried out using qualitative analysis methods to gain a greater insight into the health and social benefits of green space use including the quality and type of social interactions, novel use of green space, participation in activities that foster learning and wellbeing, as well as building awareness of variables that may encourage green space use. If researched, such information could provide complementary data that may be useful in developing a deeper understanding of the results presented in the Green Space Study including the higher rate of female green space use in comparison to males.

The key purpose of the research was to identify whether there were inequalities relating to green space use. While only 58% of the Green Space Study sample used green space, highlighting a potential need to improve engagement with green space for all children aged 11-12 in the Wellington region, the results for school decile have shown inequities between high and low deprivation schools in terms of the frequency of visits and duration of time spent in green space. If we consider the trends between the use of green space and the BMI of participants in the Green Space Study and previous research that has linked green space to several health outcomes, further investigation into whether there are health inequities that could be addressed by improving opportunities for engagement with green space amongst children living in areas of high deprivation would be of value. It is recommended that future research build upon the results of the Green Space Study by using a larger sample and investigating variables that encourage the use of green space, such as the quality of public green space facilities and whether they cater to different age groups and genders as this could be useful for informing city planning priorities and policies.
7. References


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Appendix 1: Green Space Study Annotation Manual

This appendix outlines the instructions developed specifically for the Green Space Study. The instructions provide detail on the processes followed to code images that showed participant contact with green space, the type of green space setting they were in, the kind of activity they engaged in while in a green space and who participants were accompanied by.

Key definitions:

**Green Space:** An outdoor space where a dominant feature of the environment is vegetation (both natural and landscaped) e.g. public gardens, bush reserves, sports grounds, urban parkland, playgrounds, forests and private gardens/yards and coastal or riparian areas near the ocean or a river/stream.

**Contact with Green Space:** When a participant is interacting with green space either through physical contact (standing, sitting, walking on), or by using a device on or with the green space e.g. a bicycle. This includes moving through a green space (e.g. walking a concrete path that runs through a green space).

**Setting:** The place or type of surroundings where something is positioned or where an event takes place.

**Activity:** Action the participant it undertaking while in contact with the identified setting.

**Detail:** Who the participant is accompanied by while in the identified setting.

**Green Space Study annotation rules**

1) Coding begins from the first image that the participant is in contact with green space (or other outdoor recreation space) until the last image of the participant in green space.

2) Once you identify that the participant is in contact with green space (or other outdoor recreation space) you must magnify the first image in the sequence.

3) You **MUST** take a short break every 30 minutes of annotation as continuous spells of annotation over this time are prone to measurement error.

4) In some cases participants may take short breaks from a green space and return again (e.g. to get a glass of water). For this study, this will be considered as one
event and coded as such. ‘A break’ is defined as a break between contact with green space for 24 images (approximately 2.8 minutes) or more consecutive images without any view of the green space. If a ‘break’ of 24 or more images occurs, finish coding on the last image in the sequence where the participant had contact with green space (signalling the end of the event). For example, in Figure i below, the participant goes inside for four photographs (28 seconds) and returns to resume playing in the same location. In this instance all 15 photographs are recorded with the same location and activity so that they are recorded as a single event or visit.

Figure i: Brief interruptions

5) If you observe contact with a green space and then cannot view the green space for a section of the sequence e.g. because the camera’s view is obstructed by clothing, or the child is looking inside their bag. As long as you can tell that the participant has not moved location (and is therefore in contact with a green space), then continue to code the obstructed images with the same code as the beginning and end of the sequence.

6) If the participant is not in contact with green space or other outdoor recreation space, then do not code the image.

7) If unsure what setting to code because the image is obscured, distorted or the setting lacks identifiable features of a green space or other outdoor recreation space, then do not code it.
8) If the participant is inside a building or tent and green space is no longer within view for more than 24 images do not code these images. Even if the tent is located in green space the participants is considered to no longer be in engaged with a green space during the time submerged inside the tent (without view of the green space).

9) Do not code images where it appears as though the camera has been removed e.g. as in Figure ii below. Use the following rules to guide decisions on whether the camera has been removed or not.

- If a sequence of images looking at the sky or wall remained the same for an entire sequence, do apply any codes to the sequence of photographs.
- If an action made it obvious that the camera was not being worn (e.g. the camera was left under a pile of clothes), do not apply any codes to the sequence of photographs.
- If the camera eventually showed movement that indicated the camera was being worn e.g. the participant’s arms or legs came into view, code the sequence as inactive.

Figure ii: Camera removed
Appendix 2: Stata commands used for analysis

The following analysis were conducted by using statistical software Stat.

<table>
<thead>
<tr>
<th>Information need</th>
<th>Stata Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of participants who had contact with green space</td>
<td>generate table (total photos in green space)</td>
</tr>
<tr>
<td></td>
<td>cii proportion</td>
</tr>
<tr>
<td>Number of participants who did not have contact with green space</td>
<td>tabulate(all participants) if (total photos in green space) == 0</td>
</tr>
<tr>
<td>Number of participant who had at least one photo where the participant was in contact with green space</td>
<td>tabulate(all participants) if (total photos in green space) &gt; 0</td>
</tr>
<tr>
<td>Chi-square test to measure the significance of the relationship between two demographic characteristics in the sample</td>
<td>tabulate (category 1 and category 2), chi2 row</td>
</tr>
</tbody>
</table>

Each of the analysis below, were only conducted amongst the participants who had used green space at least once.

<table>
<thead>
<tr>
<th>Information need</th>
<th>Stata Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number of visits to green space - per participant.</td>
<td>mean (total visits to green space)</td>
</tr>
<tr>
<td>Mean time spent in green space - per visit</td>
<td>mean (total photos in green space)</td>
</tr>
<tr>
<td>Mean time spent in green space - per visit, by demographic characteristic</td>
<td>mean (total photos in green space), over(demographic category)</td>
</tr>
<tr>
<td>Mean number of visits to green space – per participant, by demographic characteristic</td>
<td>mean (total visits to green space), over(demographic category)</td>
</tr>
<tr>
<td>Estimate the mean differences for the mean number of visits and the mean time spent in green space, by demographic group.</td>
<td>xi: reg (total visits/photos in green space) i.(demographic category)</td>
</tr>
<tr>
<td>Mean percentage of time spent in green</td>
<td>Generate (new category) = (total photos sub-</td>
</tr>
</tbody>
</table>

129
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>space by sub-category e.g. social contact, supervision, public</td>
<td>category)/(total photos in green space)</td>
</tr>
<tr>
<td>green space use, inactive.</td>
<td>mean (new category)</td>
</tr>
<tr>
<td>Mean percentage of time in green space by sub category for each</td>
<td>Mean (new category), over (demographic category)</td>
</tr>
<tr>
<td>demographic characteristic.</td>
<td></td>
</tr>
<tr>
<td>Mean number of visits to green space by setting and activity</td>
<td>Mean (total visits to location 1, total visits to location 2 etc..)</td>
</tr>
<tr>
<td>Mean time spent in green space by setting and activity</td>
<td>Mean (total number of photos location 1, total number of photos location 2 etc..)</td>
</tr>
</tbody>
</table>