Assessing the nature and extent of children’s screen time

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A thesis submitted in fulfilment of the requirements for the degree of Master of Public Health

University of Otago, Wellington

2016

Abstract

Background and aims

New Zealand children are currently ranked the third most overweight and obese in the developed world. Further, differences by ethnic and socioeconomic factors are evident, with Māori and Pacific children, and the most deprived, being disproportionately impacted. Although much research has examined the association between watching television and childhood overweight/obesity, less is known about the effects of new media such as smart phones, tablets and iPods. Such research has primarily used self and proxy report, and researcher-observation to estimate children's screen time. Wearable cameras have the potential to overcome some of the limitations of previous methods. This thesis aimed to determine the nature and extent of children's screen time during the after school period on a typical weekday.

Methods

In 2014 and 2015, 169 children from Wellington schools wore cameras on a lanyard around their necks that took pictures every seven seconds for four days, as part of the Kids'Cam study. For this thesis (the Kids'Cam Screen Time study) Kids'Cam data available for the Thursday after school period was analysed. A study-specific annotation protocol and schedule was developed to guide the annotation of 120,780 images from 105 children (45 boys, 59 girls; 45 New Zealand European, 36 Māori and 24 Pacific) using bespoke annotation software, a process that took approximately 150 hours. Each image was reviewed for instances of a screen, and annotated for the setting, the type of screen and the activity being undertaken on the screen. Data were analysed using Stata to determine mean times and rates of screen time, and differences by gender, ethnicity and deprivation.

Results

Children had a mean screen time of 44 minutes, 52 seconds during the after school period. Rate for overall screen time was significantly greater in boys than girls. Overall screen time was greater in non-overweight children than overweight/obese.

Non-overweight children spent considerably more time using computers than overweight/obese children. As deprivation level increased there was a slight decrease in

television use, with the exception of the least deprived children, who had the lowest rate of television use.

Of the activity categories included in the study, the highest mean screen time was watching programmes, followed by games and social activities. Non-overweight children spent significantly more time playing games, while overweight/obese children spent more time using screens for social activities. The rate of screen time was greater in boys than girls for all activities except for watching programmes. Rate of programmes and background television increased somewhat with increasing deprivation.

Conclusion

Wearable cameras are an effective research tool to investigate children's screen time and the types of screens they use, due in part to their objective nature. Study findings suggest that the association between screen time and overweight/obesity in childhood is becoming more complex and that the association is perhaps limited to television. A small negative relationship suggests that new media may potentially be protective against overweight and obesity. The association observed between television use and overweight/obesity was substantially smaller than reported previously. This may be due to the changing nature of television watching. Multiple screen use may be a contributing factor to this observation, as children's hands may be occupied by an additional screen, reducing the opportunity for snacking. This finding may also be due to an association between new media, and low deprivation. Kids'Cam Screen Time was limited to analysing the Thursday after school period only. The study was also limited by compliance of candidates, and the scope of what could be seen in the photos. To gain a better insight on the true association between children's screen use and overweight and obesity, further research should determine screen use on other days of the week, especially the weekend, and over different time periods.

To ensure children are protected from harm from the use of screen, it is important they and their parents are aware of and practise healthy screen behaviours, and that governments ensure they are adequately informed of such behaviours. However, the findings of this study would suggest that interventions to address childhood obesity might be better concentrated on creating healthy food environments to support healthy food behaviours, than those addressing physical activity levels associated with screen time. Given the rising use of screens by children globally, the findings of this study are likely of interest in other countries.

Acknowledgements

This work would not have been possible without a wide range of people. I would firstly like to acknowledge my supervisors, Moira Smith and Richard Jaine from the University of Otago Wellington (UOW). Moira, your knowledge, enthusiasm for the work, generous feedback, and unwavering support were invaluable to the completion of this thesis. Richard, your experience and guidance were instrumental in my research and writing. I can't imagine better supervisors than the two of you. Also, to biostatistician, James Stanley, thank you for your patience and willingness to help. Your contribution to this work was crucial.

I would like to express my deepest gratitude to the Kids'Cam Team, who worked tirelessly to collect the images that were the basis for this thesis. Louise Signal, Moira Smith, James Stanley, Tim Chambers, Michelle Barr and Ryan Gage, it has been a pleasure to work with all of you, and I can't thank you enough for providing me with the data required to complete this project.

I wish to thank staff and students who supported me at various stages during the work, especially Louise Delany who I had the pleasure of sharing an office with, and Kerry Hurley who was there for all my office needs.

Finally, I would like to express my gratitude to my parents, who have supported me every step of the way. I could never have done this without you.

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Chapter One: Background

1.1. Introduction

This thesis explores the issue of childhood obesity, its prevalence worldwide and in New Zealand, its impact on individuals and society, and the causal factors, with a particular focus on the role of screen time.

Childhood obesity is a prominent public health issue worldwide and in New Zealand due to its association with various health consequences. Rates of obesity in childhood have been increasing steadily over the past twenty years in both developed and developing countries. New Zealand children have followed global trends and are currently ranked the third most overweight among developed nations (OECD, 2014). Reasons for this rapid population weight gain are vast and varied. Biological, psychological and social factors interact to cause children to gain excess weight.

Screen time has been identified as a sedentary behaviour, and is thought to be associated with decreased physical activity and passive overconsumption (the consumption of excessive energy due to increased fat content of food, rather than an increase in food volume) of food and beverages. Consequently, it is associated with potential unhealthy weight gain in children (Caroli, Argentieri, Cardone, & Masi, 2004). The 2015 New Zealand *Children's Media Use Study* found that television reaches nine out of ten 6-14 year old New Zealanders every day, and two thirds use the internet daily (Colmar Brunton, 2015). Although television and computers are the most common screen types for children to watch, tablets and smart phones are rapidly becoming part of many children's daily lives. Currently, all information on New Zealand children's screen time is by child self-report, or proxy-report by parents, rather than an objective method. Little information is known about the amount of time children spend using these forms of new media.

This thesis uses a unique method to explore the nature and extent of children's screen time, and its association with overweight and obesity. It investigates the relationship between screen time during the after school period, and overweight and obesity status of a group of children from the Wellington region of New Zealand using data collected using wearable cameras. It specifically considers particular screen types and activities, and their impact on overweight and obesity. To the author's knowledge, wearable cameras have not been used to examine this issue.

This thesis seeks to address the following research question:

1. What is the nature and extent of children's screen time during the after school period on a typical weekday?

In doing so, it also addresses the following sub-questions:

i. What is the association between children's after school screen time and overweight/obesity?
ii. What is the association between the screen type or screen activity children engage with, and overweight/obesity?
iii. What is the association between screen time, type and activity, and a child's gender, ethnicity, and level of deprivation?

1.2. Thesis structure

The remainder of this chapter defines obesity in children, and then outlines the prevalence and trends over time of childhood overweight and obesity internationally, and in New Zealand. The consequences of childhood overweight and obesity are then discussed, including health effects and overall cost to society. This is followed by an exploration of the various causes of childhood overweight and obesity, encompassing biological, psychological and social factors.

Chapter Two reviews the literature on the role of screens and screen time in children's lives, and in childhood obesity and other adverse health outcomes. Chapter Three outlines the methods used in this research to answer the research questions, and Chapter Four presents the results from the study. Finally, Chapter Five interprets the results of this study in the context of the literature reviewed in Chapter Two. Strengths and limitations of the study are discussed, as are the implications for policy and practice, and further research.

1.3. Definition of obesity

The World Health Organization (WHO) defines obesity as "*a condition of abnormal or excess fat accumulation in adipose tissue to the extent that health may be impaired"* (World Health Organization, 2000, p. 2). New Zealand recognises the revised International Obesity Task Force (IOTF) Body Mass Index (BMI) (defined as weight (kg)/height(m)^2) values to classify children and adolescents aged 2-17 years old as overweight or obese (Cole & Lobstein, 2012). The IOTF cut-offs are centiles designed to coincide with WHO's adult BMI cut-offs of underweight, healthy, overweight, obese and morbidly obese (Sharpe & Bradbury, 2015). Centiles are gender and age-specific and are shown below in Table 1.

Table 1 International Obesity Task Force BMI cut offs for adults and children

IOTF Classification	Equivalent BMI value at 18 years (kg/m^2)	Growth chart centile equivalent – boys	Growth chart centile equivalent – girls
Thinness	<18.5	<15.5	<16.5
Healthy weight	18.5 - 24.9	15.5 – 90.4	16.5 – 89.2
Overweight	25.0 - 29.9	90.5 – 98.8	89.3 – 98.5
Obese	≥30.0	98.9 – 99.7	98.6 – 99.7
Morbidly obese	≥35.0	99.8	99.8

Source: Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity (Cole & Lobstein, 2012)

1.4. Childhood obesity prevalence

Internationally

Over recent decades, childhood overweight and obesity has come to affect many countries worldwide, including New Zealand. A systematic review conducted in 2006 highlighted that patterns of change in overweight and obesity rates worldwide vary in both speed and nature (Wang & Lobstein, 2006). In contrast to less economically developed countries, obesity prevalence appears to have increased more rapidly in developed countries over the past 20 to 30 years. Between 1970 and the late 1990s, the prevalence of overweight and obesity in school-aged children increased by up to three times in many developed countries including the United States, Australia and the United Kingdom (Wang & Lobstein, 2006).

Data from the 2013 Organisation for Economic Cooperation Development (OECD) indicates that one in five children across all OECD countries carries excess weight, with countries in the upper range of severity closer to one in three (OECD, 2014). The average prevalence of overweight and obesity in 15 year olds in OECD countries has steadily increased since 2000, rising from 13% to 15% between 2001-02 and 2009-10.

In more recent years, the rate at which childhood obesity has been increasing in some developed countries has begun to plateau (Wabitsch, Moss, & Kromeyer-Hauschild, 2014). In contrast, obesity rates in developing low and middle income countries are increasing rapidly. The latter observation would appear to be largely due to the adoption of a Western lifestyle in those countries, which includes the introduction of labour saving technologies, and the increased availability and promotion of low-cost, nutrient-poor and energy-dense foods (Wabitsch et al., 2014).

An observational study in the US explored whether a person's birth-cohort influenced their odds of obesity (Reither, Hauser, & Yang, 2009). Results showed that obesity in younger birth-cohorts is increasing at a faster rate, potentially because they have been exposed to the obesogenic environment for a greater proportion of their lives than older people. The same observation has been made in New Zealand (Sharpe & Bradbury, 2015). Figure 1 illustrates a steep increase in obesity rates across all birth cohorts in New Zealand, with those born more recently reaching higher obesity rates earlier. This is a powerful indicator that intervention for the younger population is essential (Figure 1).

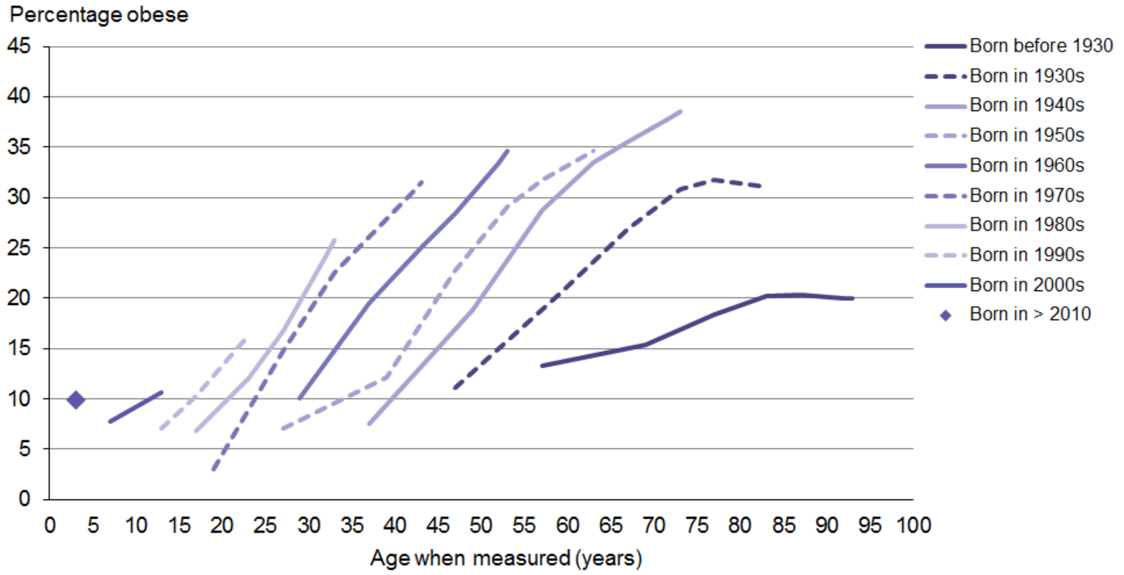


Figure 1 Change in the obesity rate, by birth-cohort and age at time of survey Source: Understanding Excess Body Weight: New Zealand Health survey (Sharpe & Bradbury, 2015)

Increases in the prevalence of obesity among younger people can be concealed by the increase in obesity linked to ageing. Obesity rates tend to increase during middle-age and drop off during older adulthood due to reduced life-expectancy in obese older adults and general deterioration in health.

New Zealand

New Zealand is not immune to the issue of childhood overweight and obesity. In New Zealand, childhood obesity has been recognised as a significant national health issue (Ministry of Health, 2016). Rather than plateauing as in some developed countries, obesity rates in New Zealand have continued to increase significantly since 2006/07 (Ministry of Health, 2014). The 2014/15 New Zealand Health Survey found that approximately 257,000 (32.5%) of New Zealand children (aged 2-14 years), are classified as either overweight (21.7%) or obese (10.8%) (Ministry of Health, 2015). New Zealand children rank poorly in comparison with the rest of the developed world, being the third most overweight of all OECD countries, marginally behind Greece and Italy (OECD, 2014). Furthermore, within the recent decade, there has been a statistically significant increase in overweight and obesity prevalence in children aged 2-14, from 29.4% in 2006/07 to 32.5% in 2014/15.

Similar to other countries, gender, ethnic and socioeconomic disparities in overweight and obesity prevalence are evident in New Zealand children (Deckelbaum & Williams, 2001; Gordon-Larsen, Nelson, Page, & Popkin, 2006; Ji & Cheng, 2009; Wang & Beydoun, 2007). The 2014/15 New Zealand Health Survey found a greater proportion of girls to be overweight or obese than boys (33.8% and 31.2%, respectively) (Ministry of Health, 2015). Furthermore, of great concern is the ethnic disparity in obesity prevalence between Māori and non-Māori, and Pacific and non-Pacific, children. The 2014/15 New Zealand Health Survey found that just over two in five Māori children (41.4%) and just over three in five Pacific children (62.2%) to be overweight or obese, both substantially greater than the national average (32.5%). In contrast to their non-Māori and non-Pacific counterparts, Māori and Pacific children, were two (RR: 1.9) and three (RR: 3.2) times as likely to be obese, respectively (Ministry of Health, 2014). The survey also found that from 2006/07 to 2013/14, the prevalence of obesity increased significantly and more rapidly in Māori children (3.7%) than for all New Zealand children (1.7%) (Ministry of Health, 2014).

Socioeconomic disparities in overweight and obesity are also evident in New Zealand. Almost one in five (18%) children living the most deprived areas is overweight or obese, in contrast to one in 20 (5%) children from low deprivation areas. After adjustment for age, sex and ethnic factors, children living in areas of greatest deprivation were found to be almost three times (RR: 2.7) as likely as those living in the least deprived areas to be obese (Ministry of Health, 2014).

In summary, childhood overweight and obesity prevalence has been increasing internationally over the past 20 to 30 years. Although initially characterised as a health burden of the developed world, recent statistics show that developing countries are now also beginning to experience the burden of excess weight in childhood due to an increasingly Westernised society. Children in New Zealand are more obese than previous generations, and the rate at which prevalence is increasing is greater. Almost a third of New Zealanders aged 2-14 years are classified as obese, with ethnic and socioeconomic disparities evident.

1.5. Consequences of childhood obesity

Overweight and obesity pose substantial threats to the health and well-being of children (Bradford, 2009). As such, childhood overweight and obesity is recognised as a serious public health issue (Serdula et al., 1993). Childhood obesity is related to a number of comorbidities that can impair quality of life and result in increased morbidity (Speiser et al., 2005). As a strong indicator of adult obesity, obesity in childhood is also associated with significant health implications in later life including, but not limited to, cardiovascular disease, stroke, type 2 diabetes, several cancers, and osteoarthritis (Freedman et al., 2005). Furthermore overweight and obesity is associated with substantial financial burdens for New Zealanders and society.

1.5.1. Health impacts of childhood obesity

The health impacts of childhood overweight and obesity are varied. Obese children are more likely to be affected by health problems than children who are of a healthy weight. Overweight and obese children are at greater risk of developing metabolic syndrome (Weiss et al., 2004), a condition largely characterised by insulin resistance, resulting in higher risk of type 2 diabetes and cardiovascular disease (Eckel, Grundy, & Zimmet, 2005). Children who are obese also commonly present with risk factors for cardiovascular disease, such as elevated blood pressure and cholesterol. A cross-sectional study of 10,099 children aged 5-17 years old conducted in the US explored the accuracy of identifying children with excess adiposity, adverse levels of lipids, insulin and blood pressures, and an increased risk of developing severe adulthood obesity, by their BMI (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007). The authors found that of the six risk factors measured, 70% of obese children in the study presented with at least one risk factor for cardiovascular disease. This finding is supported by several other studies that investigated cardiovascular risk factors in overweight and obese children (Chu, Rimm, Wang, Liou, & Shieh, 1998; Franks et al., 2010; Lauer, Lee, & Clarke, 1988), including one recently conducted in New Zealand (Anderson et al., 2016).

Obesity in childhood has also been shown to be an independent risk factor for type 2 diabetes (Goran, Ball, & Cruz, 2003). Obese children are more likely than their non-obese counterparts to have glucose and insulin levels indicative of pre-diabetes[1] (Bacha, Lee, Gungor, & Arslanian, 2010). In New Zealand, Jefferies et al. (2012) retrospectively analysed data from fifty-two diabetes patients aged 15 years and younger collected by the paediatric diabetes service at Auckland Hospital between 1995 and 2007. The authors found that over the study period, the incidence of type 2 diabetes in patients presenting for treatment increased fivefold. The mean BMI at presentation was 33.8 kg/m^2, and authors suggested the increase observed was likely to be attributed to the increase in prevalence of childhood overweight and obesity.

Obese children are also at greater risk of obstructive sleep apnoea, which affects up to 60% of obese children (Narang & Mathew, 2012). Obstructive sleep apnoea is characterised by snoring, and partial or complete obstruction of the upper airway, and is associated with further weight gain in children, as well as having significant effects on learning and memory (Daniels et al., 2005). Furthermore, obese children are at greater risk of joint and bone problems; increased prevalence of asthma; increased risk of gallstones and other gastro-intestinal complications; cirrhosis of the liver and hepatitis; and renal and neurological complications (Daniels et al., 2005). Evidence also shows that obese children are more likely to suffer from social and psychological problems such as low self-confidence, and to be stigmatised by their peers, although direction of causality has not been established (Daniels et al., 2005; Morgen et al., 2010; Xavier & Mandal, 2005).

Additional to the short term consequences, obesity during childhood is also a strong independent predictor for obesity in adulthood (Freedman et al., 2005). In New Zealand, from 1997-2013 there was a 44% increase in the prevalence of adulthood obesity (Social Policy Evaluation and Research Unit, 2015). Increasing obesity in younger people means individuals spend a greater proportion of their life being obese, leading to higher susceptibility to obesity-related health issues. As in children, obesity in adulthood is a key risk factor for a number of associated co-morbidities such as type 2 diabetes, stroke, cardiovascular disease, sleep apnoea, non-alcoholic fatty liver disease, osteoarthritis and other illnesses (Ahima & Lazar, 2013). Additionally, obesity has been

[1] Pre-diabetes: a high risk-state for diabetes (intermediate hyperglycaemia) whereby glycaemic variables are higher than normal, but below the threshold for diabetes (Tabák, Herder, Rathmann, Brunner, & Kivimäki, 2012)

associated with poor prognosis in many common cancers including colorectal, pancreas, breast and endometrium (Goodwin & Stambolic, 2015). This observation is supported by a strong biologic rationale, involving a complex interaction of adipose tissue and physiologic factors that may directly impact on cancers or the tumour microenvironment (Goodwin & Stambolic, 2015).

1.5.2. Societal impacts of childhood obesity

Due to its association with numerous non-communicable diseases, the health consequences of obesity have the potential to overwhelm health systems, and threaten the health and well-being of the global population (Kirk, Penney, & McHugh, 2010). Overweight and obesity place considerable financial burden on society. Based on data from 1991, Swinburn et al. (1997) conservatively estimated that at the time the cost of obesity to the New Zealand health system was $135 million per year. The authors' analysis took into account the health care costs of diseases and conditions including type 2 diabetes, coronary heart disease, and colon cancer, and used relative risks from the literature to assess the cost attributable to obesity. A later analysis by Lal, Moodie, Ashton Siahpush & Swinburn (2012) estimated the cost of obesity in New Zealand, accounting for the increase in prevalence of obesity, and including the cost of lost productivity due to obesity-related illnesses (Lal, Moodie, Ashton, Siahpush, & Swinburn, 2012). The authors estimated that health care and productivity losses attributable to overweight and obesity cost $849 million in 2006, or 4.1% of New Zealand's overall health expenditure (Lal et al., 2012). Given the increases in obesity prevalence outlined previously, this figure is likely to have increased.

A recent systematic analysis of health loss conducted by the New Zealand Ministry of Health found that in 2006, high BMI accounted for 7.9% of health loss in New Zealand (measured in disability adjusted life-years or DALYs) (Ministry of Health, 2013). The report demonstrated that the only greater determinant of health loss was tobacco usage. The authors predicted that high BMI would supersede tobacco use as the leading health loss risk factor by 2016. Heart disease, diabetes, osteoarthritis, certain cancers and ischaemic stroke were identified as the major contributors of health loss from high BMI.

In summary, a range of health consequences exist for childhood overweight/obesity, including a greater chance of high blood pressure, increased cholesterol, insulin and glucose levels indicative of pre-diabetes, and type 2 diabetes. Childhood obesity is also a strong independent risk for adulthood obesity, itself associated with a wide range of comorbidities. Furthermore, the cost of obesity to society is large due to health care cost, and loss of productivity due to obesity-related illnesses. Obesity was the second leading cause of health loss in New Zealand in 2006, and is predicted to be the leading cause by 2016.

1.6. Causes of childhood obesity

The causes of obesity are multifactorial, and complex. Fundamentally, weight gain is a result of energy imbalance whereby energy consumed exceeds energy expended (Spiegelman & Flier, 2001). The energy content of food is referred to as energy density and is expressed as kilojoules[2] per gram, (kJ/g). For example, fat provides 37.7kJ/g compared with carbohydrate and protein which provide 16.7kJ/g (National Health and Medical Research Council, 2005). Increases in energy intake and sedentary behaviour, accompanied by decreases in physical activity, results in a positive energy balance, which in turn leads to weight gain (Spiegelman & Flier, 2001).

However, the reasons for weight gain are more complex than simply energy imbalance. Underlying environmental causes of excess food consumption and increased sedentariness exist that interact with individual biological factors. The etiology of overweight and obesity is commonly understood in a biopsychosocial framework, in which a myriad of factors overlap (Bradford, 2009).

The biopsychosocial framework, shown in Figure 2, illustrates how biological factors interact with psychological and social factors to result in obesity. Biological factors consist of an individual's genetics, metabolism and co-morbidities, and are largely out of an individual's control. Eating behaviours, activity habits and health knowledge contribute to psychological factors. Social factors are those that interact with psychosocial factors and include a person's socioeconomic position, the characteristics

[2] Kilojoules: a unit of energy

of their neighbourhood, food policy and schools. This section provides a more detailed discussion of the various factors in the framework.

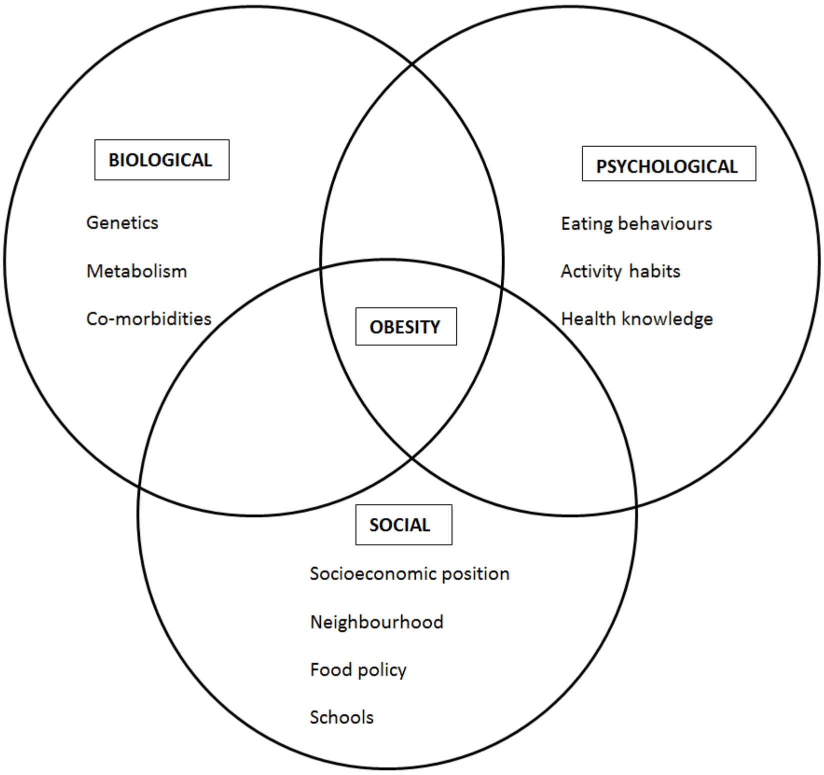


Figure 2 Biopsychosocial Framework of Obesity (Bradford, 2009)

1.6.1. Biological Factors

Biological factors contributing to weight gain are primarily genetic. Hundreds of genes and genetic markers have been identified as having a role in susceptibility to weight gain. Currently, genetic factors that determine obesity are thought to involve a combination of mutations, principally those affecting hormones and receptors that determine appetite and resting energy expenditure (Bradford, 2009). Genes may also influence the amount of fat that an individual stores in their body and where it is carried. It is suggested that some food behaviours that influence weight gain are inherited, such as food preferences, eating disorders and ability to taste fat (Bradford, 2009). Other genetic factors that influence weight gain include medical conditions associated with a tendency to put on weight. These include endocrine disorders such as hypercortisolism, hypothyroidism, growth hormone deficiency, or Cushing's syndrome. Some medications are also responsible for excess weight gain (Bradford, 2009). In general, biological factors cannot be altered, and are therefore not amenable to intervention.

1.6.2. Psychological Factors

The role of dietary patterns in obesity

A key contributory factor to the obesity epidemic is a change in food behaviours. Greater food availability and increases in food choice have been facilitated by urbanisation and globalisation, and may promote over-nutrition and positive energy balance (Malik, Willett, & Hu, 2013). For example, greater reliance on convenience foods is a likely contributing factor to increased rates of overweight and obesity, as such foods are generally energy-dense and high in saturated fats and refined carbohydrates. Furthermore, these foods are typically easily accessible and relatively inexpensive. As such, they are thought to be a major risk factor for overconsumption and weight gain (Malik et al., 2013).

Research supports the idea that increased rates of overweight and obesity are linked to the changes in the food environment. In US children, a reduction in percentage of energy intake comprising dietary fat has been accompanied by an increase in consumption of refined carbohydrates such as cakes, bread, polished white rice, and refined wheat flour (Ebbeling, Pawlak, & Ludwig, 2002). Refined carbohydrates are produced by milling and processing wholegrains, which consequently removes the fibre and many micronutrients and phytochemicals (Malik et al., 2013). Refined carbohydrates (or sugars) are known to have a high glycaemic index (GI), resulting in a shorter period of satiation after eating. This is due to a more immediate peak in blood sugar levels as opposed to being slowly released over time (Foster-Powell, Holt, & Brand-Miller, 2002). Consumption of high GI foods causes a series of hormonal events that induce the feeling of hunger, which can lead to overeating in adolescents (Ebbeling et al., 2002).

Greater consumption of sugar-sweetened beverages has been identified as another significant contributor to increased rates of childhood obesity. In New Zealand, sugar-sweetened beverages are the leading source of sucrose for children (Beaglehole, 2014). A cross-sectional study of US children by Harnack, Stang, and Story (1999) showed a

10% greater daily energy intake in children who consumed soft drinks than those who did not. Another prospective observational study of US children revealed a 60% increase in the risk of developing obesity for every additional daily serving of soft drink even after adjusting for confounders, providing further evidence for the harmful effects of soft drinks (Ludwig, Peterson, & Gortmaker, 2001). Possible explanations for the associations observed could be due to high GI, or because calories consumed in liquid form are less fulfilling than those consumed as solid food (Ebbeling et al., 2002).

The role of lack of physical activity

With the advancement of technology, Western culture has grown to place a premium on convenient transportation. The car is preferred over active modes of transport such as walking or cycling, the elevator tends to be chosen over the stairs, and a remote is favoured over manual adjustment. These lifestyle changes prescribe a more sedentary lifestyle than has been observed in the past, correlating with the increase in rates of overweight and obesity observed in the past three decades (Golan & Crow, 2004). Television viewing and increasingly the use of other screen types, also plays a significant role in the increase of sedentary behaviour and decrease in physical activity. The role of screen time as a causal factor in the aetiology of childhood overweight and obesity is the focus of this thesis and will be discussed in more detail in Chapter Two.

Children whose lifestyles are characterised by a lack of physical activity, and excessive sedentary behaviour are at a higher risk of obesity than their more active counterparts (Ebbeling et al., 2002). A meta-analysis by Rowlands, Ingledew, and Eston (2000) that analysed fifty studies from 1977 to 1998 found a small to moderate inverse relationship between physical activity and BMI during childhood. Likewise, a systematic review by Rauner, Mess, and Woll (2013) that included twenty cross-sectional studies found an inverse relationship between physical activity and physical fitness, and overweight in adolescents.

A parent’s weight appears to be a determining factor in children’s weight as children naturally tend to adopt their parents eating and physical activity habits (Golan & Crow, 2004). Parental eating patterns are partly influenced by their degree of health knowledge and the importance they place on maintaining healthy eating habits and an active lifestyle. However, studies have also shown that children whose parents place too much restriction around the amount of food consumed at meal times are also at greater risk of becoming obese (Birch & Fisher, 1998). This is thought to be due to an inability to judge levels of satiety.

1.6.3. Social factors

Evidence suggests that people are aware of the causes of obesity; however, food choices and physical activity patterns are strongly influenced by structural factors in the environment (Caraher & Coveney, 2004). A number of societal changes over the past 30 years are likely to be underlying reasons for changes in dietary and physical activity patterns, and in turn the upwards shift in children's average weight. Swinburn, Egger, and Raza (1999) classify the obesogenic environment as *"the sum of influences that the surroundings, opportunities or conditions of life have on promoting obesity in individuals or populations"* (Swinburn et al., 1999, p. 564). An obesogenic environment comprises factors of the environment that are conducive to weight gain (Powell, Spears, & Rebori, 2010). Distance to a supermarket or park, neighbourhood safety and other features of the environment can contribute to an individual's opportunities, as well as hindrances, to access healthy food and physical activity (Powell et al., 2010). The obesogenic environment is largely attributable to the increase in availability and promotion of energy-dense, nutrient-poor foods, and an increasingly sedentary lifestyle (Swinburn & Egger, 2008). There is evidence to suggest that the obesogenic environment has played a major role in the obesity epidemic, and environmental changes are key to addressing the issue of overweight and obesity (Caballero, 2007; Hill & Peters, 1998; Swinburn et al., 2011).

The obesogenic environment is contributed to by factors that promote sedentary behaviour. The growing ubiquity of television over the past 30 years has played a role in the increase in sedentary behaviour, alongside a possible decrease in physical activity (Elgar, Roberts, Moore, & Tudor-Smith, 2005). In more recent years, the use of other screen types including computers, tablets and smart phones, has been identified as sedentary behaviour, and may also contribute to weight gain (Owen, Leslie, Salmon, & Fotheringham, 2000). It has been suggested that screen time may displace time that would otherwise be spent engaging in physical activity, however findings on this association are varied.

As previously discussed, significant inequalities in health are observed between different groups of New Zealanders. Obesity disproportionately affects Māori and Pacific children, and is also strongly correlated with low socioeconomic position (Ministry of Health, 2015). The causal factors of inequalities are complex and systematic, and thus generally beyond the control of those affected. A report by the National Health Committee in 1998 suggested that commitment to tackling underlying socioeconomic conditions was the first step towards improving children's health in New Zealand (The National Advisory Committee on Health and Disability, 1998).

Following the 1998 report, the Ministry of Health released a framework entitled *Reducing Inequalities in Health* (Ministry of Health, 2002). The framework operates at four levels. The first level is structural, targeting the social, economic and historical factors that influence health. The second targets intermediary pathways, which includes addressing material, psychosocial and behavioural factors that mediate the influence of structural factors (food marketing). The third and fourth target specific actions within health and disability services, and reduce the impact that any illness or disability has on socioeconomic position respectively (Ministry of Health, 2002). The report recommended that intervention at each of these levels be incorporated into national, regional and local policy. It also identified the need to cross traditional boundaries, as health outcomes are often determined by factors that lie outside the realm of the health sector.

Summary

In summary, childhood obesity is a prominent public health issue in New Zealand. Overweight and obesity prevalence has been increasing internationally, and in New Zealand, at an alarming rate. The most recent data shows that a third of New Zealand children under 14 years old are either overweight or obese, with Māori and Pacific disproportionately affected.

The health impacts of childhood obesity are vast and varied. They include an increased risk of high blood pressure and cholesterol, abnormal glucose and insulin levels, and

Type 2 diabetes mellitus. Childhood obesity is also a strong indicator for obesity in adulthood, which is associated with numerous co-morbidities, such as stroke, cardiovascular disease, Type 2 diabetes and some cancers.

Disparities in overweight/obese status exist in New Zealand and are due to systematic differences. Māori and Pacific people bear a greater proportion of this health burden than do non-Māori and non-Pacific people. The Ministry of Health has identified that these health inequalities need to be addressed.

The causes of childhood obesity are multifactorial and complex. Biological, psychological and social factors interact to influence an individual's tendency to gain weight. Environment plays an important role in causing obesity. With the advancement of convenience-enhancing technology, children are engaging in less physical activity and spending a greater proportion of time taking part in sedentary activities. Screen watching is a particularly concerning form of sedentary activity, as studies have shown that it is associated with obesity independent of physical activity, and can also impact on children's eating behaviours through food marketing and passive overconsumption.

The following chapter reviews the current literature on children's screen time, including children's use of screens, and the relationship between screen time and childhood overweight and obesity, and other health-related issues. Methods used to measure children's screen time in research to date are also discussed.

Chapter Two: Children's Screen Time

2.1. Introduction

As discussed in the previous chapter, the causal factors for childhood obesity are numerous and complex. Children's screen time is thought to be one such contributing factor (Caroli et al., 2004). This chapter presents a review of the current literature on the prevalence of children's screen time, globally and in New Zealand, including variations in screen time by gender, BMI, ethnicity, and deprivation; and the relationship between screen time and childhood obesity. Experts' suggestions on the mechanisms by which screen time contributes to childhood overweight and obesity, such as how television watching influences physical activity and food intake, are also discussed. Other screen-related health risks, including psychological stress, attention deficit disorders, and psychosocial issues are summarised, and the effects of passive media – when children are exposed but not fully engaged with screens – are outlined. Finally, to inform this study, methods used previously to measure children's screen time are explored.

For the purpose of this thesis, the term 'screen' consists of televisions, computers/laptops, smart phones, and tablets. Screen time is defined as duration of time spent engaged with a screen, such as watching television, playing video games or using a tablet. It also consists of instances where a screen may not be directly engaged with, but where its content is capable of being registered by an individual. Recreational screen time is a sub-set of screen time, and is defined as the viewing or use of anything with a screen for purposes other than homework or education. Historically, television has been the dominant screen type. As such, the majority of current literature, and in turn this review, reports on television-related screen time research. Research on new media is emerging and discussed where relevant.

2.2. Prevalence

Children's screen time has been widely reported. According to the American Academy of Paediatrics (AAP) (2013), screen time has become the most common waking activity for many children and, for some children, can exceed the amount of time spent asleep. In the UK, the *'Media Use and Attitudes Report'* issued by the government's Office of

Communications (Ofcom) measured screen time by asking parents to estimate their children's weekly television, internet and games console use (Ofcom, 2015). Parents reported an average of almost six and a half hours of screen time per day in children aged 12-15 years, while the average US 8-18 year old is estimated to spend seven hours per day engaging with screens (Rideout, Foehr, & Roberts, 2010). The Ofcom report concluded that by age 7 years, the average European or American child will have spent almost an entire year of 24 hour days engaging in recreational screen time, increasing to three years by the age of 18 years.

Screen-based devices have become more commonly used by children in recent years. Parents of 25,142 children aged 11-16 years from 25 European countries were interviewed in the EU Kids Online study (Livingstone & Haddon, 2009). The study found that since 2010, children have greater access to the internet in more places in their daily lives. For example, the authors commented that smart phones have transitioned from an occasional device among privileged children, to a common device in the majority of European youth, allowing children to access the internet more privately, and without the supervision of parents.

New Zealand research on children's screen time reports similar findings to that in the international literature. In the 2014/15 New Zealand Health Survey, children were asked how many hours per day they spent watching television, excluding for the purpose of playing games. While the survey did not report average screen time, it found that close to half (46.1%) of children aged 10-14 years spent more than two hours per day watching television. To date, the New Zealand Ministry of Health has not collected or received information on 'other' screen time (Sigman, 2015), that is computer and tablet usage. It is possible that the latter may be used more for non-recreational activities than television (Sigman, 2015). Similarly, the 2015 *New Zealand Children's Media Use Study* found three quarters of children aged 6-14 years (74%) watched television at home daily. These findings aligned with those of the *2014 New Zealand Physical Activity and Sedentary Behaviour Report Card for Children and Youth*, which found that 67% of 10-14 year olds and 70% of 15-19 year olds reported exceeding two hours per day of television (NIHI, 2014).

New Zealand children are also exposed to a wide range of media. The 2015 New Zealand Children's Media Use Study found that the most popular media among New Zealand children is television (Colmar Brunton, 2015), with almost all homes surveyed (98%) containing at least one television. Computers and laptops are also commonly present in the homes of New Zealand children (88%), as are tablets (78%); smart phones are less commonly available (48%).

2.2.1. Differences by gender

There appears to be differences in screen time between boys and girls. This may partially account for differences in obesity rates by gender discussed previously. The 2014/15 New Zealand Health Survey found no difference overall in television use between boys and girls aged 2-14 years. However, when broken down by age group, results showed that a greater proportion of 10-14 year old boys reported watching more than two hours per day of television than 10-14 year old girls (47.8% and 44.3% respectively) (Ministry of Health, 2015), suggesting that older boys watch more television than girls, but younger boys do not. These findings are somewhat in agreement with a cross-sectional study of US children aged 4-12 years, which used parental-report data from the National Health and Nutrition Examination Surveys to assess children's screen time in relation to sociodemographic and weight status (S. E. Anderson, Economos, & Must, 2008). Study findings showed that a greater proportion of boys reported high screen time use (more than two hours per day) than girls (68% and 62%, respectively).

These findings are also supported by those from a cross-sectional study by Jago, Sebire, Gorely, Cillero, and Biddle (2011) of 990 UK children aged 5-6 years, which investigated parents' screen time in association with children's screen time. Using parental surveys, the authors explored the proportion of boys and girls who had more than two hours of screen time (included television, computers, game consoles, and smart phones). The authors found that on a regular weekday, 12% of boys and 8% of girls watched television for more than two hours per day, and that girls used computers as much as boys. However, there was a significant difference in weekday game console use by gender, with 53% of boys having reported "some use", in contrast to 34% of girls.

A Slovakian cross-sectional study of 8,042 children aged 11-15 years that investigated gender differences in screen based behaviour found that while there was no difference in time spent watching television between girls and boys, boys used computers to play games significantly more. A cross-sectional study carried out among 4,072 Dutch children aged 4-13 years used data from parental and child questionnaires to investigate the relationship between television and computer use, and overweight (de Jong et al., 2013). The authors found that boys used computers more than girls, and were more likely to have a television in their rooms. However, the authors also found no difference in time spent watching television by gender. Another study carried out in the US used data from the HomeNet project, a longitudinal study of 110 children aged 10-19 years investigating the impact of computer use on children's development (Kraut et al., 1998; Subrahmanyam, Greenfield, Kraut, & Gross, 2001). By contrast to the De Jong study, authors found that while boys reported spending more time using computers during school time than girls, they found no gender difference in computer use outside of school time.

Several explanations have been suggested regarding boys' greater engagement with computers. A cross-sectional study of 340 Greek children aged 6-12 years used participant questionnaires to investigate the reasons for gender differences in technology use (Vekiri & Chronaki, 2008). Authors determined that attitude towards computers, and perceived parental and peer support, were important factors for computer use. The authors found that while both boys and girls expressed positive self-efficacy, and positive beliefs around the value of computers, boys' views were somewhat more positive than girls'. Boys were also reported to receive more parental support to use computers than girls, and were more likely to talk about and use computers with their peers. The authors considered gender inequality in information and communications technology (ICT) literacy as an issue, due to growing societal reliance on computers. They recognised that lesser ICT literacy in girls may have the potential to limit future academic and career options (Vekiri & Chronaki, 2008).

Another possible explanation for gender differences in computer use among children is that computer games continue to be considerably more popular among boys (Subrahmanyam et al., 2001). Game producers have admitted their products are designed and marketed almost exclusively to boys (Subrahmanyam et al., 2001). Consequently, it is unclear whether variance in computer use between boys and girls is a cause or effect of such promotion. It has also been suggested that boys enjoy computer games more than girls because they tend to prefer "pretend" play based on fantasy, which is the basis for the majority of computer games, whereas girls prefer more reality-based play (Honey et al., 1991; Tizard, Philips, & Plewis, 1976).

2.2.2. Differences by ethnicity

Chapter One described inequalities in the prevalence of overweight and obesity between Māori and Pacific children, and non-Māori and non-Pacific children, respectively. Screen use may also be implicated in this relationship. The 2014/15 New Zealand Health Survey found ethnic differences in the time children spent watching television. The survey reported that a greater proportion of Māori children (55%) exceeded two hours of television watching per day, than Pacific (51%) and New Zealand European children (42%). The survey also reported that Māori and Pacific children were significantly more likely to exceed two hours of television watching per day than non-Māori and non-Pacific children (RR: 1.32 and 1.15, respectively). Māori and Pacific children are overrepresented in low socioeconomic positions, and the *New Zealand Children's Media Use Study* showed that children from low household income homes watched more television. Thus, the relationship between television watching and ethnicity observed in the New Zealand Health Survey may be mediated by deprivation level.

2.2.3. Differences by deprivation

As discussed in Chapter One, significant socioeconomic inequalities in health outcomes are observed among children, including young New Zealanders. Overweight and obesity is strongly correlated with low socioeconomic position, and it is possible that differential screen use between the most and least deprived children in New Zealand could be a contributing factor. Although a relationship between lower physical activity with increased deprivation has been firmly established, the association between sedentary behaviour, in this case screen use, and deprivation remains largely undefined (Shishehbor, Litaker, Pothier, & Lauer, 2006; Stamatakis, Hillsdon, Mishra, Hamer, & Marmot, 2009). The 2014/15 New Zealand Health Survey showed that the most deprived children in New Zealand were 1.47 times as likely than the least deprived children to watch television for more than two hours per day.

New Zealand findings are supported by international evidence. A cross-sectional study of 6,240 UK children aged 10-15 years using child-administered questionnaires specifically investigated the relationship between screen time and deprivation (Ogunleye, Voss, & Sandercock, 2012). The authors found a small increase in screen time with increased deprivation, although the relationship was not statistically significant. Another cross-sectional study conducted in the US that involved 715 children aged 6-11 years, investigated, by parental report, the relationship between children's home environments, screen time and their socioeconomic position (Tandon et al., 2012). The study concluded that for every unit increase in household income, there was a decrease in daily screen time.

Pagani and Huot (2007) considered explanations for why deprived children are more likely than less deprived children to watch television. The authors suggested that poorer children may be forced to stay indoors due to a greater likelihood of living in unsafe neighbourhoods. Consequently, television viewing may be perceived by parents as a safe and acceptable alternative to playing outside, resulting in decreased physical activity, alongside increased sedentary behaviour. Importantly, the Pagani and Huot (2007) study focused primarily on Canadian children and their neighbourhoods, and thus the findings may not be applicable to the New Zealand context. Presence of a television in the bedroom has also been shown to be associated with increased television watching in children (Dennison, Erb, & Jenkins, 2002). The Tandon et al. (2012) study found that a greater proportion of children from highly deprived households had a television, DVD or game console in their bedrooms than children from less deprived households. It is reasonable to assume that the presence of a television in the bedroom is linked to greater television screen time.

In summary, previous literature from New Zealand and internationally indicates that children are spending an increasing amount of time using screens, with the AAP stating that screen time is the most common waking activity for many children. The 2014/15 New Zealand Health Survey reported that almost half of children spend more than two hours per day watching television. It has also been found that screen time is greater in boys than girls. The most recent New Zealand Health Survey found that Māori and Pacific children are generally more likely to watch more than two hours of television per day than non-Māori and non-Pacific children, and highly deprived children may use screens more than their less deprived peers (Ministry of Health, 2015). The majority of previous literature has focused predominantly on television watching as an indication of screen time.

2.3. Health consequences of children's screen time

Children's screen time has been associated with a range of health consequences, including overweight and obesity. Proposed mechanisms for this association include displacing physical activity, an increase in sedentary behaviour, and increased energy intake due to snacking and food marketing. Furthermore, the health consequences of screen time are not limited exclusively to weight gain. Excessive screen watching has also been associated with psychological stress, attention deficit, and psychosocial stress. As the most common and longstanding form of screen-watching, the majority of research investigating the relationship between screen time and health outcomes has focused on television watching.

2.3.1. Childhood obesity

Screen watching is largely a sedentary activity, a known risk factor for poor health outcomes, independent of lack of physical activity (Hardy, Denney-Wilson, Thrift, Okely, & Baur, 2010). Television viewing has long been identified as a contributor to the childhood obesity epidemic (Caroli et al., 2004). A dose response between hours spent in front of the television and BMI has been observed consistently in the 30 years since television sets have become ubiquitous in the home. One of the earliest studies in this area demonstrated a dose-response relationship in a cross-sectional study of nearly 7000, 6-11 year olds, showing a 2% increase in prevalence of obesity for every additional hour of television watched per day (Dietz & Gortmaker, 1985). Dennison et al. (2002) also identified a cross-sectional relationship association between television watching and obesity in pre-school aged children. A 6% increase in the prevalence of obesity was observed with every additional hour of television viewed per week.

Although the findings of the early television studies are highly valued, they are limited by their cross-sectional design. Direction of causality can therefore only be inferred rather than confirmed (Caroli et al., 2004). It is possible that due to social isolation or low self-esteem, overweight children leave the house less and as a result watch more television, rather than watching television being a direct cause of their weight gain.

Prospective studies can provide an improved indication of causality. Such a study was carried out by Proctor et al. (2003) in the US which followed children from preschool to age 11 years. They found that hours of television watched was an independent risk factor for weight gain in childhood. The prospective nature of this study provides evidence that television is a likely causal factor for childhood overweight; a follow-up period of seven years adds power to this finding. It has been suggested that a combination of poorer diets and greater time spent in sedentary activity is responsible for the relationship (Malik et al., 2013).

Excessive television viewing during early life may also be associated with the development of the metabolic syndrome in later years. A study using data from the Northern Swedish Cohort, comprising of 855 nationally representative participants, investigated the relationship between television watching at ages 16 and 21 years, and the likelihood of metabolic syndrome onset by age 43 years (Wennberg, Gustafsson, Howard, Wennberg, & Hammarström, 2014). Results showed that frequent television viewing at age 16 years was associated with an increased risk for the metabolic syndrome independent of television viewing at 21 years. This result is important as it indicates adolescence as a sensitive period, and sedentary behaviours may have long-term consequences that are not easily reversed in adulthood (McAnally & Hancox, 2014).

Despite substantial evidence showing an independent association between prolonged screen time and increased biomarkers for metabolic and cardiovascular diseases in adults (Hardy et al., 2010), the evidence in children is limited and outcomes are mixed. Hardy et al. (2010) suggest the reason for varied results is due to a failure to adjust for all potential confounding factors, and measuring television viewing only, which is merely one aspect of screen time (Hardy et al., 2010).

It is thought that watching television promotes weight gain in children by displacing physical activity, and through increased energy intake as a consequence of the influence of food marketing and snacking while watching television (Caroli et al., 2004). The evidence to support these mechanisms is now discussed.

Influence of screen time on physical activity

Television viewing is thought to contribute to obesity by displacing time spent in more energy intensive pursuits. Studies exploring this relationship however have been somewhat inconclusive and those that have found an association are generally weak. An observational study of 191, 3-4 year old children by DuRant, Baranowski, Johnson, and Thompson (1994) conducted over one year, identified a weak but statistically significant relationship showing that children who spent the most time in front of the television were less likely to engage in physical activity. However, the study did not find a relationship between level of physical activity and adiposity. It is possible that the subjects were too young, or the sample size too small for such a relationship to be observed.

In contrast to findings by DuRant et al., a cross-sectional study of children aged 9-16 years old by B. Hernandez et al. (1999) found no relationship between activity levels and television viewing time. Studies that do not demonstrate a relationship between physical activity and television watching may be explained by a tendency to measure only moderate to vigorous levels of activity, which is generally not the type of activity that is displaced by television watching (Dennison & Edmunds, 2008). Given the varied findings, the relationship between physical activity and television watching is still largely undefined.

Influence of screen time on sedentary behaviour

Some studies have shown that screen time may be a risk factor for obesity independent of a lack of physical activity (Carson & Janssen, 2011). A study of 2200 Australian children showed that screen time was more strongly associated with overweight and obesity in 9-16 year olds than physical activity. A cross-sectional study of 496 high school students in Sydney, Australia, found that adolescent boys whose screen time was more than two hours, on weekdays, were twice as likely to present with abnormal insulin levels than children who did not exceed the recommended limit, however no significant association was found in girls (Hardy et al., 2010). The authors of the study acknowledged that sedentariness is a distinct category of behaviour, and thus possibly causes disease via a separate metabolic pathway to lack of physical activity.

A cross-sectional study by Rey-López et al. (2012) used data from 2,200 adolescents across 10 different European cities to examine the association between television viewing and abdominal obesity, and whether physical activity attenuates the risk of obesity. They found that children watching excessive amounts of television were at higher risk of obesity regardless of their level of physical activity. Being cross-sectional, the study cannot confirm causality. Therefore the possibility that obese participants were more likely to spend time in sedentary activities than their non-obese counterparts because they were overweight, cannot be ruled out. Despite this, the findings of Rey-López et al. (2012) are supported by a cohort study of older adults that showed those who watched the most television were at greater risk of all-cause and cardiovascular mortality, and cancer independent of physical activity levels (Wijndaele et al., 2011).

Additionally, there is evidence to show that children's screen time is distinct from other sedentary behaviours in terms of its effect on biological markers for disease. Gopinath et al. (2012) reported a positive dose-response relationship, showing an increase in diastolic blood pressure with every additional hour spent watching television or playing video games. By contrast, they found that reading had the opposite effect on blood pressure. These findings are supported by Martinez-Gomez, Tucker, Heelan, Welk, and Eisenmann (2009) who used accelerometers to examine the effect of sedentariness on blood pressure in young children. After adjusting for potential confounders it was found that sedentary activity was not significantly associated with systolic or diastolic blood pressure. However television and screen time, but not computer use, were associated with increased blood pressure. This result suggests that screen use affects blood pressure differently to other sedentary behaviours. A key limitation of this study is that information on television viewing was collected by parental report, whereas overall sedentary behaviour was determined using accelerometers.

It has also been suggested that different screen activities may be associated differentially with various biomarkers and chronic disease risk. For example, Goldfield et al. (2011) found that blood pressure was elevated in overweight children playing games on screens, whereas this effect was not observed for other screen-based activities. As mentioned previously, Martinez-Gomez et al. (2009) also found an association between television watching and blood pressure, but not with computer use.

Influence of screen time on food intake

A number of studies have associated television viewing with both increased energy intake and decreased consumption of fruits and vegetables. There is also a growing body of evidence suggesting that television viewing and consequent exposure to food advertising is a mechanism by which television viewing may have an adverse effect on quality of dietary intake.

Research demonstrates a relationship between children's television viewing and increased energy intake. A prospective study of school-aged children by Wiecha et al. (2006) aimed to determine whether increased television viewing was associated with increased energy intake. The authors found that energy intake increased by almost 700 kJ for every additional hour of television watched per day. They concluded that this observation was largely due to increased consumption of foods that were energy-dense and nutrient-poor by children who watched more television. Similarly, a cross-sectional study of children 8-16 years old conducted by Crespo et al. (2001) found a positive association between hours of television watched and energy intake in girls. It was found that girls who watched five or more hours of television per day had significantly greater energy intake (732 kJ on average) than those who watched less than one hour per day. The relationship observed in boys was found to be in the same direction, however did not reach statistical significance.

It is possible that different screen types vary in their influence on weight gain. A theory that television enables weight gain to a greater extent than other screen types is supported by a randomised cross-over trial conducted in Auckland, New Zealand, that investigated the differences in energy intake in 9-13 year old boys while watching television, recreational computer use and playing video games (Marsh, Mhurchu, Jiang,

& Maddison, 2014). The authors found that despite equal access to food and drink, energy intake was higher in the group watching television than those using computers. They also found that energy intake from soft drink was significantly greater when children were watching television than during recreational computer usage (Marsh et al., 2014). The authors proposed associative learning as a possible mechanism for this observation, whereby screen time becomes a conditioned cue to eat (Chapman, Benedict, Brooks, & Birgir Schiöth, 2012; Marsh, Mhurchu, & Maddison, 2013). Furthermore, Marsh et al. (2013) acknowledged that television watching during meal times is common in adolescents whereas video games and computer use may be less common. It was suggested that this may be due to video games and computers requiring the use of both hands for a mouse/keyboard or controller (Marsh et al., 2014). The authors also identified the possibility of stricter parent-enforced rules around eating while using "hands on" screen types, and food advertising on television, as contributing factors in establishing the relationship between watching television and eating.

A similar cross-sectional study was conducted in Finland using self-report data to assess the association between computer use and overweight in 14, 16 and 18 year olds (Kautiainen, Koivusilta, Lintonen, Virtanen, & Rimpela, 2005). The study found a statistically significant positive trend between television viewing and overweight. However the only positive relationship found between computer usage and overweight was for 16 year old girls. These findings suggest that no association between computer use and overweight exists for the majority of adolescents. It has been suggested that a person becomes more fully immersed in the story when watching television compared with computer use, distracting attention away from the physiological cues of satiation and leading to passive overconsumption (Bellissimo, Pencharz, Thomas, & Anderson, 2007; Lyons, Tate, & Ward, 2013; Temple, Giacomelli, Kent, Roemmich, & Epstein, 2007).

Food marketing - television

There is now unequivocal evidence to demonstrate that the promotion of unhealthy foods and beverages is associated with childhood obesity (Borzekowski & Robinson, 2001; Cairns, Angus, & Hastings, 2009; Gorn & Goldberg, 1982). Children appear to be exposed to substantial levels of food marketing. An analysis of the extent of food marketing aimed at children conducted in the United States, estimated that 8-12 year olds were subject to, on average, 21 food advertisements per day on television (Gantz, 2007). From these findings the authors were able to extrapolate that over the course of one year, children were exposed to 7,600 food advertisements - equating to over 50 hours of food marketing exposure, the majority of which has been shown to be counter to improved health (Gantz, 2007). In New Zealand, Wilson, Signal, Nicholls, and Thomson (2006) conducted an observational study that investigated the food advertisements on the two most popular television channels, TV2 and TV3. The authors found that, on average, for the two channels, 70.3% of food advertising was for foods counter to improved nutrition. Advertisements for food that promoted improved nutrition were only 5.1% of the total, with the rest being made up by food that did not fit into either category.

Television advertisements have been shown to influence children's food requests, preferences, usual dietary intake and short term consumption (Cairns et al., 2009). For example, a randomised controlled trial of 46 children aged 2-6 years by Borzekowski and Robinson (2001) investigated the effect that exposure to food advertisements had on children's food choices. When children were shown a cartoon that was embedded with food advertisements, they were significantly more likely to choose the advertised items, than children who were shown the cartoon without the advertisements. Further evidence of the impact of food marketing on children's food preferences was demonstrated by Gorn and Goldberg (1982) who carried out an experimental study on approximately 36 children aged 5-8 years. Children at a low-income camp in Montreal were shown a cartoon that was embedded with either advertisements for sugary foods, advertisements for fruit, a public service announcement promoting the healthy benefits of fruit, or nothing. Following this, they were given snack options that consisted of either sugary foods or fruit. Study findings showed that children who were shown sugary food advertisements chose significantly less fruit (25% less) than other children in the study (Gorn & Goldberg, 1982). Importantly, very young children participated in in each of these studies and these observations may not apply to older children.

Another means by which television food marketing can affect diet is through children's attempts at influencing parental food purchases. A positive correlation between time spent watching food commercials and the number of times children attempt to influence their mother's purchases has been observed as early as the 1970s (Galst & White, 1976). A systematic review by Coon and Tucker (2002) reviewed eight studies looking at the effects of food advertising on child's food preferences. The review concluded that children who were exposed to food advertising consistently chose and requested the advertised products at higher rates than those who were not exposed. However, they also observed that preferences were generally tested shortly after exposure, which may have led to results showing a greater association than reality.

Food marketing restrictions - television

Food marketing in New Zealand is self-regulated by the advertising and food industries through a voluntary Children's Code for Advertising Food. The Advertising Standards Authority (ASA) Code sets principles and guidelines for advertisers. In addition, thinkTV, a group representing free-to-air television broadcasters, provides guidance for television advertising and children's programming in its policy document *Getting it Right for Children*. The document states that only healthy food is permitted to be advertised during children's television programming for children aged 5-13 years, defined by thinkTV as finishing at 5pm on a weekday, and only for two television channels in New Zealand (thinkTV, 2011). That children's programming times in New Zealand are determined by the marketing industry presents a conflict of interest. Advertisers' and food manufacturers' prime interest is in advertising foods to increase sales and generate profit, rather than promoting health.

Under ASA broadcasting codes, television channels do not air adult content until after 8.30pm, referred to as the '8.30pm watershed' (Colmar Brunton, 2015). However, the 2015 New Zealand Children's Media Use Study found that less than one in four children aged 12-14 years (23%) were aware of the watershed, and that knowledge was slightly higher among girls (25%). The study also found that just over half of parents of 12-14 year olds (54%) were aware of the watershed. The 2008 New Zealand Children's Media Use Study found that one in three children aged 6-13 years (31%) was still watching television after the 8.30pm Monday to Thursday, and that half were watching television after 8.30 pm on Friday nights (Colmar Brunton, 2008). As TV channels recognise children's viewing hours the current study will be able to provide valuable information on what time children are actually unlikely to be watching television.

Food marketing – new media

More recently, other screen types, such as smart phones and tablets, have been used to promote food and beverages. Consequently, they have been identified as potential contributors to obesity in childhood (Kelly, Vandevijvere, Freeman, & Jenkin, 2015). The internet and mobile devices such as tablets, smart phones and laptops are characterised by interactivity, virtuality, globalisation and "many-to-many" communication, making them a powerful tool for marketers (Kelly et al., 2015). Despite limited evidence, it has been predicted that new forms of marketing may have an even greater impact than television on influencing children's food preferences, purchases and consumption and, therefore, on the consequences of these decisions. Compound effects are also being observed, whereby children are spending an increasing amount of time with 'new media' such as iPods and tablets, without decreasing their use of 'old media' such as television (Ofcom, 2014). Additionally, as screens become more portable, children are routinely engaging in more than one form of screen media at a time (Jago et al., 2011) adding to potential marketing exposure.

A small number of studies have investigated new media food marketing in terms of its effect on behaviour and attitude towards food. The majority of these studies assess the impact that branded online games (also known as advergames) have on a child's food preferences and choices. In an Australian study by Mallinckrodt and Mizerski (2007), it was found that children were significantly more likely to report preferring Kellogg's Froot Loops to other cereals and other foods after exposure to a branded online game that used Froot Loops as rewards, compared with those who were not. Other studies investigating the same relationship have reported similar findings for products including M&Ms, Oreos and other confectionary (Folkvord, Anschütz, Buijzen, & Valkenburg, 2013; M. Hernandez & Chapa, 2010; Redondo, 2012). Correspondingly, some studies have reported that advergames embedded with healthy foods can increase a child's preference for these foods compared with children who are exposed to advergames promoting unhealthy foods (Dias & Agante, 2011).

Despite the recognised potential of new media as an effective marketing tool, any potential relationship between new media and overweight has not yet been established, largely due to their relatively short period of availability. A self-report, cross-sectional study of 482 U.S. children with a mean age of 12 years investigated whether BMI could be predicted from information technology (IT) use (Jackson, von Eye, Fitzgerald, Witt, & Zhao, 2011). The study specifically investigated internet, cellphone and video game use. After adjusting for gender, race, age and household income, the study found no association with any of these forms of IT. Interestingly, another cross-sectional study using a population-based sample of Finnish twins found a weak correlation between cellphone use and BMI (Lajunen et al., 2007). Further research into the association between new media and overweight is required to provide greater certainty of the relationship.

There are a number of explanations for the predicted greater impact of new media on children food behaviours. First, that new media allows children to recognise peer endorsement of brands, and also enables personal communication between customers (Mangold & Faulds, 2009). Some forms of new media such as branded online gaming, persuade children to engage for much longer periods of time (Mallinckrodt & Mizerski, 2007). Second, children have been found less able to identify food advertisements on websites than on television (Ali, Blades, Oates, & Blumberg, 2009). Sophisticated web analytics are capable of tracking user web history which can be used to obtain information on user interests to generate personalised marketing. Finally, parents are less aware of what their children are exposed to on the internet compared with the more communal nature of television (Cairns et al., 2009).

In summary, while based largely on television, a dose response between screen time and childhood overweight and obesity has been observed. The proposed mechanisms by which this occurs are a combination of displacing physical activity, increasing sedentary behaviour, and causing an increase in energy intake. Television is thought to increase energy intake by distracting the viewer's attention from physiological cues of satiation, and through habitual eating. Evidence has also shown that food advertising on television is associated with child's food preferences and requests. New media such as tablets and smart phones have been identified as a new and effective form of marketing to children.

It has been suggested that this form of marketing may have the potential to be even more persuasive than traditional television advertisements, however further research is required to determine the relationship between overweight and obesity, and new media. As restrictions around marketing to children via other screen-based media (non-television) are not recognised, there is also potential to build a case for these restrictions to be more heavily implemented.

2.3.2. Other health consequences of excessive screen watching

Several other adverse health outcomes have been shown to be associated with children's excessive screen watching, including psychological stress, attention deficit disorder, and psychosocial issues. Passive screen watching, that is in the background, also appears to be detrimental to a child's normal development. These adverse outcomes are now discussed.

Psychological stress

A study by Wallenius et al. (2010) investigated the relationship between Information and Communication Technology (ICT) and psycho-physiological stress. In this study, the stress hormone cortisol was used as an indicator of stress levels in children aged 10 and 13 years old (Wallenius et al., 2010). It was found that children who used ICT for more than three hours the preceding day showed significantly different salivary cortisol an hour after waking than those who had used ICT for less than one hour. These results indicate that excessive ICT use may initiate a stress response that can persist overnight and have an effect on the stress-regulation system the next morning. Researchers suggest that this sort of stress affects the normal function of the Hypothalamic Pituitary-Adrenal (HPA) stress-regulation system, which may predispose children to the development of allostatic load (deterioration of the body), contributing to adverse physical health outcomes in adolescence and later life. This phenomenon may also partially explain the relationship between screen time and cardio-metabolic disease (Sigman, 2015).

Attention deficit

Children's screen time has also been shown to be associated with consequent attention problems in a dose-response manner. Landhuis, Poulton, Welch, and Hancox (2007) used data from the Dunedin cohort, a longitudinal birth cohort consisting of 1,037 study members who were born in Dunedin, New Zealand between April 1972 and March 1973. The authors found that television viewing in childhood was significantly associated with attention problems in adolescence, independent of early attention problems and other confounders (Landhuis et al., 2007). They proposed two possible explanations for their observation. First, due to brain plasticity in young children, rapid images and scene changes experienced on television may overstimulate the brain leading to adverse development. A second explanation may be that children find real life tasks such as school work mundane compared with the excitement that is often portrayed on television. Most likely, the actual mechanism is an interaction between the two. The study's advantage is its longitudinal nature, which provides an indication of causality as well as evidence that the effects of watching television during childhood are long lasting.

Findings by Landhuis et al. (2007) are supported by another prospective epidemiological study conducted in New York by Johnson, Cohen, Kasen, and Brook (2007), who concluded that frequent television viewing was associated with an elevated risk for learning and overall attention difficulties. The study found that 14 year olds who watched more than one hour of television per day were more likely to have a negative attitude towards school, poor grades and homework completion, and long-term academic failures. This association was strengthened when children watched more than three hours of television per day.

Psychosocial

Robertson, McAnally, and Hancox (2013) examined data from the Dunedin cohort study described previously, from birth to age 26 years to investigate whether excessive television viewing in childhood and adolescence led to increased antisocial behaviour during adulthood. The authors reported a positive association between excessive television, and long-term psychosocial consequences and antisocial behaviour during adulthood. The authors went on to state that the associations observed were not due to any pre-existing antisocial propensities or other confounders, and were consistent with a causal relationship. It has been proposed that children require a certain amount of real-life interactions and regular eye contact for optimal physical and mental health (Holt-

Lunstad, Smith, & Layton, 2010). Furthermore, the ability to adequately relate to others relies on social and emotional skills that are developed through regular social interaction not provided by watching screens.

Influence of children's passive exposure to media

Background media, defined as media that the child is not actively engaging with, has been shown to have some adverse effects on development, more especially in young children (Kirkorian, Pempek, Murphy, Schmidt, & Anderson, 2009; Schmidt, Pempek, Kirkorian, Lund, & Anderson, 2008). For example, a study of children aged 5-6 years, showed that passive television exposure was significantly associated with a higher risk of sleep disorders, shorter sleep duration and overall sleep disturbances (Paavonen, Pennonen, Roine, Valkonen, & Lahikainen, 2006). Explanations for how screens can affect sleep have been suggested. More time in front of screens leads to more light exposure from electronic displays, an experimental study by (Higuchi, Motohashi, Liu, Ahara, & Kaneko, 2003) suggested that this may delay melatonin production delaying sleep onset. Cain and Gradisar (2010) have also suggested the stimulative nature of screen content as an explanation for why screen time may be disruptive to sleep patterns.

2.4. Recommendations on children's screen time

Given the apparent impact of children's screen time on their health, in particular, overweight and obesity, experts have identified excess screen time as a cause for concern and recommend that children's screen time, including passive exposure, be reduced. The American Academy of Pediatrics (AAP) recommends that parents *"limit children's total media time (with entertainment media) to no more than 1 to 2 hours of quality programming per day"* (Bar-On et al., 2001). The Australian Government's Department of Health explicitly states that lower levels of screen usage are associated with a reduced risk of adverse health outcomes (Australian Department of Health, 2010), and also recommend that children 5-17 years old limit their time spent using electronic media for entertainment to less than two hours per day (NIHI, 2014). Consistent with such recommendations, the New Zealand Ministry of Health recommends that children aged 5-18 years old should spend less than two hours per day outside of school time using television or gaming consoles (Ministry of Health, 2012).

Despite general agreement among experts (Australian Department of Health, 2010; Ministry of Health 2012; NIHI, 2014), it seems there is little scientific evidence to support the current recommendations. Rather, the two hour period appears to have been arbitrarily chosen. Additionally, the two-hour recommendation was developed when screen time essentially consisted of television and 1990's style computer games. The AAP appears to have recognised that the evolution of screen time has prompted the need to revise current recommendations around screen guidelines. In a press release in October 2015 the AAP issued the statement:

> *In a world where "screen time" is becoming simply "time," our policies must evolve or become obsolete. The public needs to know that the Academy's advice is science-driven, not based merely on the precautionary principle.* (Brown, Shifrin, & Hill, 2015)

As such, the AAP is currently in the process of reviewing their stance on screen time, and are expected to extend the two hour limit in new guidelines, set to be released in late 2016. Given the international uptake of previous recommendations, it is likely that in due course, other countries will also amend their guidelines.

2.5. Methods used to measure children's screen time

The review of the literature on children's screen time identified a number of methods that have been used to collect data on screen time, each of which has benefits and limitations. Previous studies to investigate children's screen time have relied heavily on self-report data including phone interviews, parental report and child self-report. Videotaping families during meal times has also been used as a research tool in determining children's screen time. The various data collection methods, and their advantages and disadvantages, are now discussed.

2.5.1. Parental report

Interviews, by phone or face-to-face, are commonly used tools for determining information on children's screen behaviour. For example, in 2003, a cross-sectional study was conducted in Washington, US, which used phone interviews to determine the level of media exposure that children younger than age 11 years old were subject to each week (Christakis, Ebel, Rivara, & Zimmerman, 2004). Parents were asked to report on how long their child had spent in front of each television, computer and video games in the past seven days. Phone interviews are a relatively inexpensive and quick way of obtaining information without being too intrusive. For example, van Zutphen, Bell, Kremer, and Swinburn (2007) investigated the association between screen time and the family environment in Australian children. The authors stated that parent-reported data was used because it was most easily incorporated into a telephone interview. As phone interviews are relatively non-intrusive, it is possible they may elicit a higher response rate, adding to the study's overall power. However, face-to-face interviews may have the advantage of providing more truthful answers from parents about their children's screen time, as typically they have less time to think of an alternative answer, and the interviewer can observe facial expressions.

A limitation of parental report is its tendency to be prone to social desirability bias, where interviewees tell the interviewers how much screen time they think their child should be watching, as opposed to the actual time. The consequence of social desirability bias is that parents may under-report unhealthy behaviours to interviewers (Christakis et al., 2004; van Zutphen et al., 2007). For example, Gable, Chang, and Krull (2007) used parental interviews to gather information on television watching and eating behaviours, in association with the onset of overweight and obesity. The authors discussed how the strength of the relationship they observed may have been weakened by the indirect method of collecting information on children's behaviours, as parents are more likely to underreport their children's unhealthy behaviours, such as watching television excessively. The researchers acknowledged that although parental report of television viewing has been proven to be correlated with actual usage, the data may still be prone to social-desirability bias (Gable et al., 2007). Another limitation of parental interviews may occur when more than one interviewer is carrying out interviews. If interviewing style varies between interviewers, it is possible they may be eliciting slightly different responses between participants. Age, gender, and social skills of the interviewer and participant may also contribute to varied responses.

Parental report may be a useful tool when exploring younger children's screen time, as parents are likely to be aware of their child's activities throughout the day. However, as children grow older it is likely that parents are less aware of their children's screen time.

Thus, parental report of older children may be more prone to misclassification bias, whereby information provided is incorrect because parents are unaware of their child's exposure, or they cannot remember. Furthermore, despite obtaining information on time spent in front of screens, unless participants are asked about content, researchers will not obtain information on activity carried out on the screen. For gathering information on food advertising on screens, it is unlikely that parents would be aware of all the advertisements their children are exposed to.

2.5.2. Child self-report

Another commonly used method for collecting data on screen time is interviewing the children themselves. Steffen, Dai, Fulton, and Labarthe (2009) conducted a cross-sectional study of 8, 11 and 14 year olds that examined the association between television and computer usage, and overweight in children and their parents. The researchers used self-reported 24-hour recall data to determine children's screen time. As this method of measuring screen time is direct, it may be a more accurate representation of actual screen time than parental report. However, there are other methodological issues that limit the interpretation of the data. The authors stated that television viewing was assessed for one 24-hour period and thus may not be representative of typical television habits. A similar method was used in a study by Sisson, Shay, Broyles, and Leyva (2012) that explored the relationship between television viewing and dietary quality among US children and adults. Participants were asked a series of questions relating to their frequency of television viewing. The authors acknowledged that self-report may have been a source of error due to misclassification and social-desirability bias particularly in older children who may report the amount of screen time they think they should be viewing. Authors recognised that electronic television-viewing time monitors or observation would have provided a more accurate result (Sisson et al., 2012). In terms of using child self-report for gathering information on food advertising on screens, it is unlikely that children would be able to recall all advertisements they are exposed to.

Another cross-sectional study conducted in Canada between 2005 and 2008 also used child self-report data to analyse the relationship between screen time and dietary intake in overweight children (Borghese et al., 2014). Children reported on their screen usage via a written questionnaire. Although a detailed manual of procedure was followed to ensure that questionnaires were of a high quality, authors discussed that it is still possible that this method of data collection could have been a potential source of bias and error due to people not understanding questions properly. Misclassification bias may also be an issue in child self-report, especially in younger children, as it may be more difficult for them to recall their screen time. Social desirability bias may also exist where children report the amount of television they believe they should be watching as opposed to the actual value.

2.5.3. Video recording

A 2013 observational study investigated the effects of watching television during meal times in children with type 1 diabetes (Patton, Dolan, & Powers, 2013). Meals were videotaped to analyse for television viewing. Although this method used a direct measure to ascertain screen time, the authors acknowledged that the Hawthorne effect may have biased the study findings. The Hawthorne effect is characterised by a change in behaviour as a result of taking part in the study (Schwartz, Fischhoff, Krishnamurti, & Sowell, 2013); in this case, the presence of the video camera may have altered parent-child meal time behaviours and consequently the results of the study.

2.6. Wearable cameras as a potential method of measuring screen time

An emerging method of data collection in observational studies is the use of wearable cameras to analyse a person's behaviour and environment. Wearable cameras are worn on a lanyard around the neck, and the exposure set to automatically capture images from the wearer's perspective at regular intervals. The use of wearable cameras in research is a form of ecological momentary assessment (EMA). Ecological momentary assessment involves repeated assessments of a participant's surroundings in real time, in contrast with the self-report methods discussed previously that require participants to recall experiences retrospectively (Shiffman, Stone, & Hufford, 2008). Ecological momentary assessment minimises recall bias, maximises ecological validity, and makes it possible to document variation of the environment over time (Shiffman et al., 2008).

Increasingly, wearable cameras are being used in health-related research to assess aspects of people's lives such as food environments and physical activity (Barr, Signal, Jenkin, & Smith, 2015; Doherty et al., 2013). Doherty et al. (2012) used SenseCam wearable cameras in conjunction with accelerometers in an experiment that assessed the extent and nature of physical activity in a sample of 52 university workers (Doherty et al., 2012). The authors established that wearable cameras were a useful tool for objective categorisation of accelerometer-defined episodes of activity in everyday life situations. However they also recognised the need for further validation of these devices against other methods such as direct observation (Doherty et al., 2012).

Similarly, a feasibility study by Gemming, Doherty, Kelly, Utter, and Mhurchu (2013) explored the use of wearable cameras to reduce under-reporting of energy intake in a 24-hour dietary recall. Participant feedback in this study indicated that although images taken by the wearable camera were valuable for recalling portion sizes, wearing the camera may have affected dietary behaviour; thus the camera may have caused results to vary from usual intake (Gemming et al., 2013). Despite the limitations, the authors concluded that wearable cameras are a promising tool for enhancing the accuracy of self-reported dietary assessments (Gemming et al., 2013).

More recently, a feasibility study by Barr et al. (2015) assessed the viability of using SenseCam wearable cameras as a tool for documenting children's exposure to food marketing. The study findings indicated wearable cameras were extremely useful in gaining insight into a child's daily life, and that participant experiences with the camera were acceptable and enjoyable (Barr et al., 2015). As noted by Gemming et al. (2013), it is possible that the presence of the camera may produce a Hawthorne effect and subsequently bias study finding. Barr et al. (2015) reduced the possibility of the Hawthorne effect by informing the participants the study aimed to learn about children's day-to-day lives and how aspects of their environment impact on their health. Study participants were informed of the study's specific objective at the conclusion of the study. Their feedback on being blinded was positive and their comments suggested that it was beneficial to the reliability of the study findings (Barr et al., 2015).

The use of wearable cameras can present a number of ethical dilemmas, especially for privacy and confidentiality. Kelly et al. (2013) developed an ethical framework for wearable cameras in health behaviour research. The authors concluded that when informed consent, respect for autonomy, and procedures to adequately protect privacy and confidentiality were employed, wearable cameras had the potential to provide substantial benefits for health behaviour research. These findings are supported by Barr et al (2015) who also explored the ethical issues of wearable camera use. They concluded that ethical and practical implications of wearable camera use could be adequately addressed by ensuring participants received sufficient information, gave informed consent and that appropriate protocol was used to ensure privacy, confidentiality and anonymity.

Wearable cameras are likely to also be a suitable method for assessing the nature of children's screen time. As children's environments are constantly changing, and some screen types, for example mobile devices, are used often, but for short periods of time, they may be able to capture a more accurate representation of children's actual screen time. Furthermore, their use may overcome the limitations of the data collection methods used to date.

In summary, several methods of data collection have been used to assess children's screen time, including parental and child report, and video recording. However, such methods are associated with limitations that may impact the reliability of study findings. Wearable cameras are an emerging research tool that has been shown to be a valuable means of assessing an individual's environment. As such, they may be equally useful in objectively measuring screen time in children. Table 2 summarises the advantages and disadvantages of methods used to measure children's screen time.

Table 2 Advantages and disadvantages of methods to measure children's screen time

Method	Advantages	Disadvantages
Phone Interviews	Non-intrusive, which can improve response rate Inexpensive Simple Can be reasonably accurate if interviewers are trained correctly	Vulnerable to social desirability bias Prone to misclassification bias i.e. participants inaccurately recalling screen time Responses may vary for different interviewers based on technique (interviewer bias)
Parental report	Can be easily administered as a questionnaire Parent may be a good proxy for the child, depending on age	Indirect, a parent does not necessarily know every time their child encounters a screen Social desirability bias Misclassification bias
Child self-report	Can be easily administered as a questionnaire Direct measure of screen time Relatively simple Can be reasonably accurate if the right questions are asked	Often relies on a 24 hour recall which may not be an accurate representation of actual exposure Social desirability bias Misclassification bias Not as suitable for young children
Videoing meal times	Direct observation of screen time Could be easy to blind subjects to aim of experiment- i.e. researchers wouldn't need to explicitly state they are looking for screen time	Expensive Intrusive Relies on high compliance of participants Hawthorne effect - participants adapt their behaviour because they know they are being watched
Wearable cameras	Direct observation of child's screen time Objective measure of screen time Ease of use of camera Easy to blind subjects to aim of experiment Requires less effort than videotaping every meal	Cameras can be expensive Lengthy process to analyse data Difficult to get large sample size Many ethical issues to take into consideration

Summary

As in most other countries, childhood obesity in New Zealand has been identified as a major public health threat due to its strong association with a number of co-morbidities and subsequent burden to the individual and society. Children's screen time has been identified as a potential contributor to childhood obesity. The mechanism by which this occurs has not been fully defined, however, it is thought to be a combination of reduced physical activity, an increase in sedentary behaviours, and increased energy intake. Screen time is thought to displace physical activity resulting in weight gain; however it has also been found that sedentary behaviour is a risk factor for the development of obesity independent of level of physical activity. Passive overconsumption associated with screen watching, and the volume of food marketing children are exposed to while watching screens are also thought to be contributors to this relationship.

Although much research has been carried out in the field of health risks associated with watching television, less is known about the effects of new media such as smart phones, tablets and iPods. It has been suggested that new media has the potential to facilitate targeted marketing, whereby advertisements are tailored specifically to the viewer based on previous content. There is also little knowledge on the types of activities that children carry out while they are using screens.

There is also substantial evidence that screen watching can cause other health issues including psychological stress, attention deficits, and psychosocial issues. Some studies have also shown that children do not necessarily need to be fully engaged with a screen to be influenced; passive exposure has also been associated with some developmental consequences.

A number of methods have been used in the literature to measure screen time in children. Such methods include parental and child report, and videotaping, which have advantages and disadvantages. Emerging data collection methods have the potential to address some of these disadvantages. Wearable cameras are one such method, which has yet to be used to investigate screen time in children.

The following chapter describes the methods used in this study to determine the nature and extent of children's screen time using wearable cameras.

Chapter Three: Methods

This chapter describes the methods used in this thesis to determine the nature and extent of children's screen time. Kids'Cam Screen Time used data collected as part of the Kids'Cam project, a study that utilised new technologies – wearable cameras and global positioning system (GPS) recorders – to achieve a more accurate and objective representation of children's environments. Although initially funded to determine children's daily exposure to food and beverage marketing, the dataset is unique and provides valuable insights to other aspects of children's lives that are of public health interest.

In this chapter, the sampling and data collection methods for the Kids'Cam project are first outlined. The research questions specific to Kids'Cam Screen Time are then restated, and the process of data selection for Kids'Cam Screen Time is described. A description of the scoping study that underpinned the development of the annotation schedule used in this study follows. Reasons for choosing the Thursday after school time period are identified. The annotation protocol, including definitions of the various settings, screen types and screen activities, and rules for blocked images, screens that are visible but not actively being engaged with, and images that are partially blocked in the images, are discussed. Finally, the method of statistically analysing the data outputs from the annotations is described.

3.1. The Kids'Cam Project

The Kids'Cam project is a University of Otago project based on a feasibility study by Barr et al. (2015). It was conducted in 2014 and 2015 by researchers from the Health Promotion and Policy Research Unit, Department of Public Health, University of Otago, Wellington. It is a project within the Dietary Interventions Evidence and Translation (DIET) Programme, a larger programme of research, directed by Professor Cliona Ni Mhurchu, National Institute of Health Innovation, University of Auckland, and funded by the Health Research Council of New Zealand. In Kids'Cam, 169 randomly-selected children from sixteen randomly-selected schools in the Wellington region of New Zealand wore Autographers, a type of wearable camera, and a GPS recorder, for four days (two weekdays and two weekend days). Kids'Cam initially aimed to determine the nature and extent of children's exposure to food and non-alcoholic beverages in their everyday environments, and the difference in exposure by ethnicity and deprivation. The objective of the study was to develop a more comprehensive picture of the extent, duration and nature of the food and non-alcoholic beverage marketing to which children are exposed, and the impact it has on them.

Ethical approval for Kids'Cam was granted by the University of Otago Human Ethics Committee (Health #13/220) to study any aspect of children's environments of public health interest, including children's screen time.

3.1.1. Sampling

Sampling for Kids'Cam was a two-stage process. First, schools were randomly selected from a list of Wellington schools that included Year 8 students. Then children were randomly selected from within the participating schools according to a protocol devised by the project biostatistician.

Schools

A list of schools in the Greater Wellington region that included Year 8 students was obtained from the Ministry of Education. For inclusion in Kids'Cam, schools were required to have an assigned decile[3] ranking. For pragmatic reasons, schools had to be located in the central Wellington region; this excluded schools located in the Wairarapa area. Given these criteria, 93 schools were eligible for selection. Eligible schools were then stratified by decile ranking and ethnicity, and sampled using a probability-proportional-to-size method, whereby larger schools were more likely to be selected than smaller schools. After sampling, 24 schools were approached to take part in Kids'Cam, of which 16 agreed to participate.

Children

Once a school consented to participate, researchers obtained the Year 8 roll and the ethnicity of each child in that year according to the Ministry of Education records. For each school, a randomised list was developed from which the first 20 children were

[3] New Zealand index of ranking schools from 1-10 in terms of the extent it draws students from low-socioeconomic communities, with 1 being from mostly low, and 10 being mostly high

selected. The list was then sent to the facilitating teacher who could confirm the children who met the study's exclusion criteria. Children were excluded if participant or parent consent was not given, or researchers were unable to collect data due to disability or circumstance. Children meeting the exclusion criteria were replaced with the next child on the list. The sample size calculation indicated that for each selected ethnicity, between four and six students should be selected from each school. Thus, the first six children on the list who returned completed consent forms were accepted as participants in the study. Over-inviting children to participate in the study increased the chance of six children consenting. Demographic characteristics of the children included in the Kids'Cam study are summarised in Table 3.

3.1.2. Data collection

Data collection for Kids'Cam took place over the course of a week for each school. Kids'Cam researchers first held briefing sessions with the participating children to discuss the ethical, legal and practical issues of data collection. Participants were asked to wear an Autographer camera GPS recorder for four days – Thursday to Sunday. The Autographer camera, pictured in Figure 3, is a 5 megapixel camera with a 136º lens, and is worn around the neck on a lanyard. It is approximately 9cm long, 4cm in width, and weighs around 400g. The cameras used for the Kids'Cam project were set to take a photograph approximately every 7-10 seconds. Children were asked to wear the cameras from the beginning of the day until they went to bed as shown in Figure 4. They were advised to remove the camera at any time they felt they, or others, would be uncomfortable being photographed, for example in changing rooms or public toilets. Participants were also briefed on how to manage any attention they received whilst wearing the camera. To reduce the possibility of the Hawthorne effect and to reduce the risk of introducing bias, the children were advised that the aim of the study was to learn more about their day-to-day environments from their perspective and the impact the environmental features have on their health.

Figure 3 Autographer camera worn by children in Kids'Cam

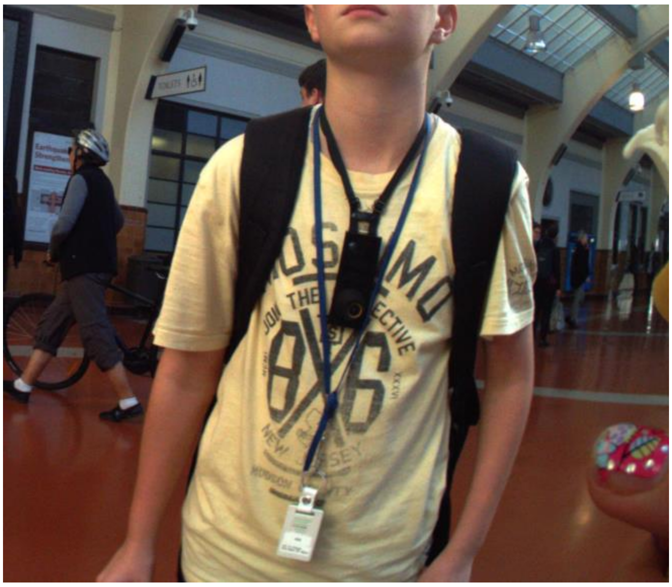


Figure 4 Child wearing the Autographer camera

Devices were collected on the first weekday after the children's data collection period and data were uploaded onto password-protected laptops. Children were then given the opportunity to review their images in privacy and remove any they were uncomfortable with. The height and weight of each participant was collected during this session using standardised and calibrated instruments, from which BMI was calculated and Cole cut off weights subsequently determined. Demographic information was also obtained from participants' parents on behalf of their children during the consent process. Information collected included date of birth, gender, ethnicity and deprivation.

3.1.3. Analysis of image data

Prior to analysis of the raw image data, an annotation protocol and schedule for food marketing was developed by members of the Kids'Cam team. Images were then annotated by members of the Kids'Cam team, according to the study annotation protocol, using bespoke software developed by computer engineers at Dublin City University (DCU), Ireland. Further information on Kids'Cam can be obtained by contacting the study's primary investigator, Associate Professor Louise Signal.

My involvement in Kids'Cam

It should be noted that I was not involved in the design of, or data collection or analysis for, Kids'Cam. I contributed to the development of the Kids'Cam annotation protocol and schedule. The remainder of the chapter presents the method for Kids'Cam Screen Time, which is the focus of this thesis, and under supervision, I completed.

3.2. Kids'Cam Screen Time

Kids'Cam Screen Time used Kids'Cam image data to answer the following research question:

1. What is the nature and extent of children's screen time during the after school period on a typical weekday?

And the following sub-questions:

i. What is the association between children's after school screen time and overweight/obesity?
ii. What is the association between the screen type or screen activity children engage with, and overweight/obesity?
iii. What is the association between screen time, type and activity, and a child's gender, ethnicity, and level of deprivation?

3.2.1. Inclusion criteria for Kids'Cam Screen Time

To achieve the best estimation of the extent and nature of screen time among children on an average day after school, every Kids'Cam participant was eligible for inclusion in Kids'Cam Screen Time. Following discussions with my supervisors, it was decided that data from the after school period on a Thursday was to be analysed in this study. This decision was based largely on the time estimations for coding. In the main Kids'Cam project, four annotators worked full-time for four months to complete annotation of the whole dataset.

The initial inclusion criteria for Kids'Cam Screen Time required that participants have some data for Thursday after school. Of the 169 children who participated in the main Kids'Cam project, 134 met the initial inclusion criteria for Kids'Cam Screen Time. After discussion with supervisors, it was decided that total data of less than thirty minutes was not representative of a full afternoon. Thus, the inclusion criteria were amended to include those children with thirty-one or more minutes of image data. This amendment resulted in 105 children eligible participants in Kids'Cam Screen Time.

3.2.2. Kids'Cam Screen Time sample

Of the 105 Kids'Cam Screen Time participants, 59 were female (56%) and 46 were male (44%). Kids'Cam Screen Time aggregated weight categories into non-overweight (comprising underweight and healthy weight), and overweight/obese (comprising overweight, obese, and morbidly obese); 57 (54%) participants were classified as non-overweight, and 48 (46%) were overweight/obese. The mean BMI of the sample was 22 (healthy); the mean BMI for non-overweight children was 19, whereas mean BMI for overweight/obese children was 28. The sample consisted of 45 children who identified as New Zealand European (43%), 36 as Māori (34%) and 24 as Pacific (23%). In terms of deprivation, 37 children were classified as NZiDep 1 (35%), 21 as NZiDep 2 (20%), 16 as NZiDep 3 (16%), 13 as NZiDep 4 (13%), and 16 as NZiDep 5 (16%). The characteristics of Kids'Cam Screen Time participants are shown in Table 3.

Table 3 Participant characteristics of Kids'Cam and Kids'Cam Screen Time

Demographic variable	Kids'Cam N (%)	Kids'Cam Screen Time N (%)
Age		
Mean (years)	12.57	12.62
Gender		
Female	89 (53)	59 (56)
Male	80 (47)	46 (44)
Overweight Status		
Not overweight	100 (59)	57 (54)
Overweight/obese	69 (41)	48 (46)
Ethnicity		
NZ European	67 (40)	45 (43)
Māori	60 (36)	36 (34)
Pacific	42 (24)	24 (23)
Deprivation (NZiDep[4])		
1	37 (35)	52 (31)
2	21 (20)	34 (20)
3	16 (15)	24 (14)
4	13 (13)	26 (15)
5	16 (15)	26 (15)
Unknown	2 (2)	5 (3)

3.2.3. Scoping study

To inform the study protocol and annotation (coding) schedule for Kids'Cam Screen Time, a scoping study was conducted. The Thursday after school image data for 25 children were reviewed using Windows Picture Viewer. Screen type and activity was

[4] NZiDep: an index calculated based on eight questions to determine an individual's socioeconomic position (Salmond, Crampton, & Atkinson, 2007)

recorded in an Excel spreadsheet, and the duration of time spent using a screen was also calculated and recorded. The scoping study provided insight into the different types of screens children were likely to be using and the activities they were likely to be carrying out on them. It was also instrumental in defining the 'after school' period and thus finalising the timeframe that would be analysed in Kids'Cam Screen Time. Annotation rules for images that did not contain usable data, such as those that were blocked or blurry, were also developed in light of the scoping study. It was also decided that an initial scroll-through approach would be used in the study, whereby the annotator was required to scroll through an hour of images before commencing annotation to gain insight into the context of the images.

Time frame

Two consequences of the scoping study were a change to the analysis time frame and the redefinition of the 'after school' period. Initially, the time frame of 3.30pm to 6.30pm was chosen as the 'after school' period. However, during the scoping study it was observed that in some instances children were using mobile devices immediately after school finished, which was often before 3.30pm. Children also appeared to be using a range of screens for a substantial period of time beyond 6.30pm. Therefore, it was decided that the period in which children had collected data immediately after school finished, which commenced when the child appeared to leave school property - onto the street or some form of transport – until the last image recorded that evening, would be analysed. An additional reason for analysing images past 6.30pm was to fully assess the latest time children were likely to be watching television. As discussed in Chapter Two, this feature has implications for children's exposure to food advertising and corresponding industry guidelines. Time slots were also determined, representing the afternoon period (after school-5.30pm), early evening period (5.31pm-8pm), and the late time period (8.01pm onwards) to determine when children were using screens most.

On initiation of data analysis, a decision had to be made on the time frame to be used as the denominator for the project. Options considered were (i) the time period a participant had codable images for or (ii) the entire evening regardless of whether the participant had photographs for the period or not. There were benefits for reporting both possibilities. However, in the interest of providing the most conservative estimate, an entire evening was chosen. It was at this time that it was decided to exclude the participants (n=41) who did not provide any codable images for the Thursday after school period.

3.3. Annotation

The development of the annotation schedule specific to Kids'Cam Screen Time was based predominantly on observations made during the scoping study. The annotation schedule was further informed by some aspects of the annotation protocols and schedules of the Kids'Cam project, and other projects that used wearable cameras, where relevant (Barr et al., 2015; Doherty et al., 2012; Gemming et al., 2013). The bespoke software developed by Dublin City University for Kids'Cam was also used for annotation in Kids'Cam Screen Time. It required a three-tiered, 'tree' > 'branch' > 'leaf' annotation scheme. An example of the software is shown in Figure 5. The left panel shows the three-tier annotation panel, while images for each hour are shown on the right. A calendar can be seen in the top left corner to navigate day and date of the images shown. Images captured during the designated time period from every eligible participant totalled 120,780. Every image was reviewed for the instance of a screen, the screen type, and activity carried out, and annotated accordingly. For Kids'Cam Screen Time the three-tiered annotation scheme of 'setting' > 'screen category' > 'activity' was used. The elements and development of the annotation schedule are now described.

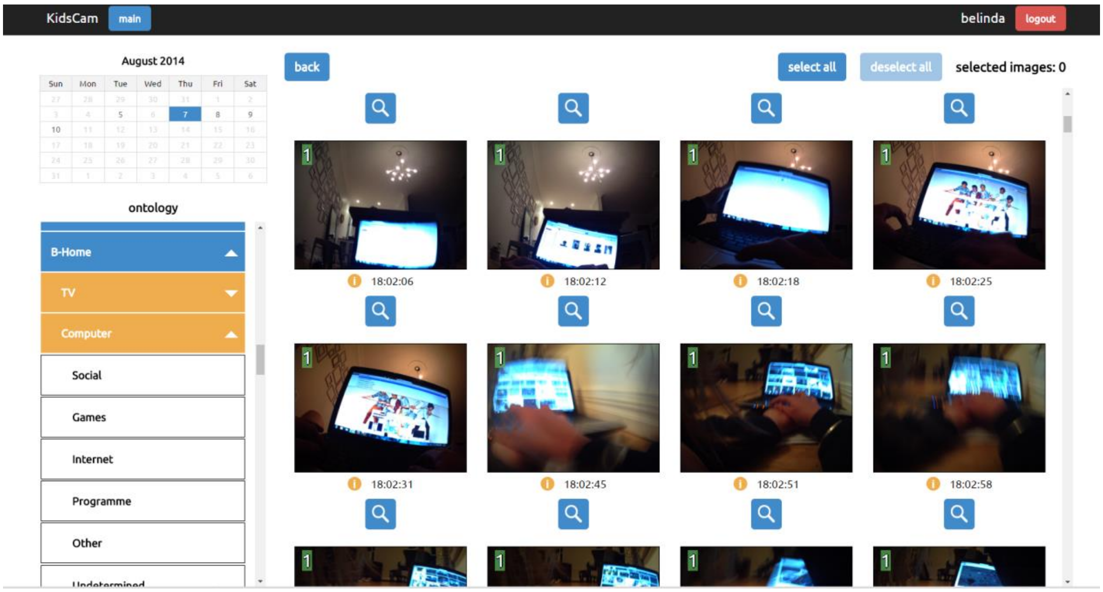


Figure 5 Example of annotation software interface

3.3.1. 'Setting' categories

During the scoping study it was observed that although the majority of screen viewing occurred in the home, screens were used in a variety of other locations. The Kids'Cam Screen Time 'setting' annotations were guided by those developed for Kids'Cam and amended for Kids'Cam Screen Time. The Kids'Cam Screen Time settings recorded were: 'home', 'street', 'community venue', 'food retail', 'other retail', 'outdoor recreational space', and 'sport'. Several of the Kids'Cam settings annotations were either removed or conflated to fit the needs of the Kids'Cam Screen Time schedule. For example, the Kids'Cam schedule included: 'bakery', 'fast food outlet', 'supermarket', and 'convenience store'. It was agreed that this level of detail was not necessary when measuring screen time, therefore, they were condensed into one setting - 'food retail'. Similarly, the 'school' setting was not required in Kids'Cam Screen Time given the study's focus did not include school time. The 'home' setting was extended in Kids'Cam Screen Time to include homes other than the participant's (in Kids'Cam this setting only included the participants own home). In instances where a screen was not present in an image, the image was annotated as 'setting' > 'default' > 'default'. Table 4 presents the setting annotations and corresponding definitions used in Kids'Cam Screen Time.

Table 4 Kids'Cam Screen Time setting annotations and corresponding definitions

Setting	Definition
Home	Includes all spaces within the home gates and boundaries i.e. indoor and outdoor spaces; or someone else's home
Community venue	Library Recreation centre/community hall - a public space where meetings are held Marae - includes the meeting house, dining hall, education and associated facilities and residential accommodation associated with the marae. Church
Street	On the street, outside private property or a community venue or retail store
Food Retail	A retail store that sells food. Includes supermarkets, cafes, bakeries etc.
Other retail	General product retailers whose primary purpose is something other than food retail
Outdoor recreation space	Parks - characterized by the presence of large open grassed spaces possibly with some equipment such as climbing frames or playgrounds (not primarily used for organised sport). Walking track - characterized by in-bush or off-road areas such as the town belt. Beach River
Private transport	Inside a car, van or truck
Public transport - facility	Associated with public transport facilities – e.g. bus shelters, train stations, airports etc.
Public transport – vehicle	Inside a bus, train, airplane, ferry

Sport	Swimming pool - council facility/publically accessible swimming pool Indoor sports stadium - sports stadiums that are used for recreational sporting games e.g. ASB stadium Outdoor sports stadium - large regional stadiums where professional matches are held e.g. Westpac Stadium Sports clubrooms - club emblems and colours are on display Sports ground - outdoor area designed primarily for the purpose of playing sport (buildings and other associated structures)

3.3.2. 'Screen' categories

Kids'Cam used the annotation 'screen' to record any screen-based marketing. For Kids'Cam Screen Time, it was necessary to further develop the 'screen' annotation. Following observations of common screen types during the scoping study, four screen categories were developed. These were: 'television', 'computer', 'mobile device', and 'tablet'.

Identifying televisions in the images was relatively straightforward. 'Television' consisted of any electronic screen that could stand alone, or was mounted to the wall. Televisions were generally characterised by the ability for multiple people to watch at the same time, and encompassed situations where gaming consoles were being used through television screens. Figure 6 shows an example of an image that would be annotated as 'television'.

Figure 6 Example of an image containing a television

Computers were also easy to identify. The category was used to encompass laptops as well as desk top computers because of the similar types of activities engaged in while on this type of screen. The 'computer' annotation was used for electronic screens with attached key pads; desk top computers also generally permitted the use of a mouse. Figure 7 shows an example of an image that would be annotated for 'computer'.

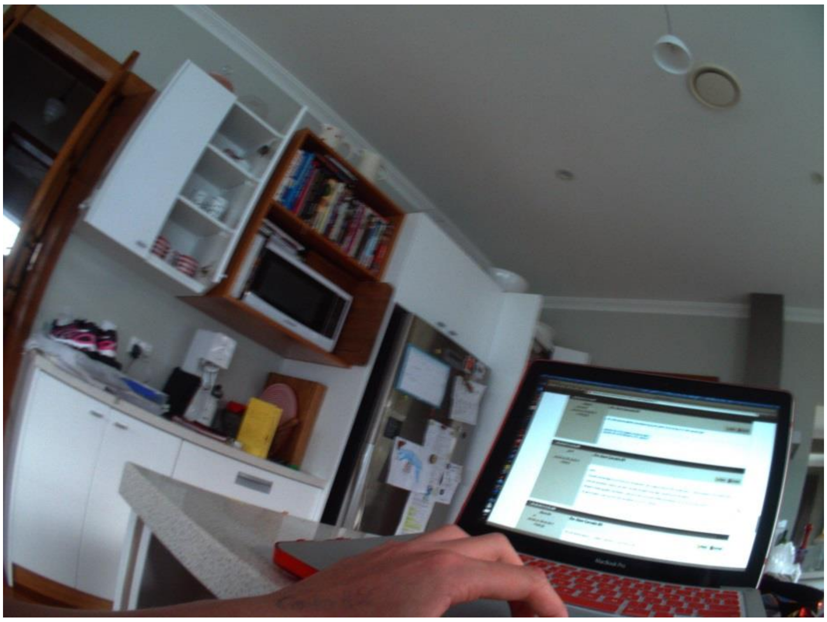


Figure 7 Example of an image containing a computer

Initially, the 'mobile device' category comprised of smart phones only. However, during the scoping study it appeared that iPods performed an almost identical function as smart phones in terms of running applications and sending messages. In a number of images it was also difficult to discern whether a device had phoning capabilities or not, and children were very rarely observed using smart phones for their phoning functions. For these reasons the 'mobile device' category was used to describe any handheld device that could connect to the internet but could not be classified as a tablet. Figure 8 shows an example of an image that would be annotated for 'mobile device'.

Figure 8 Example of an image containing a mobile device

To determine the range of mobile devices available on the market, electronic store websites were searched. From those investigations, it was decided that a screen would be annotated as ‘tablet’ if it was at least the size of an iPad mini, and required two hands to be held and used at the same time. Figure 9 shows an example of a tablet.

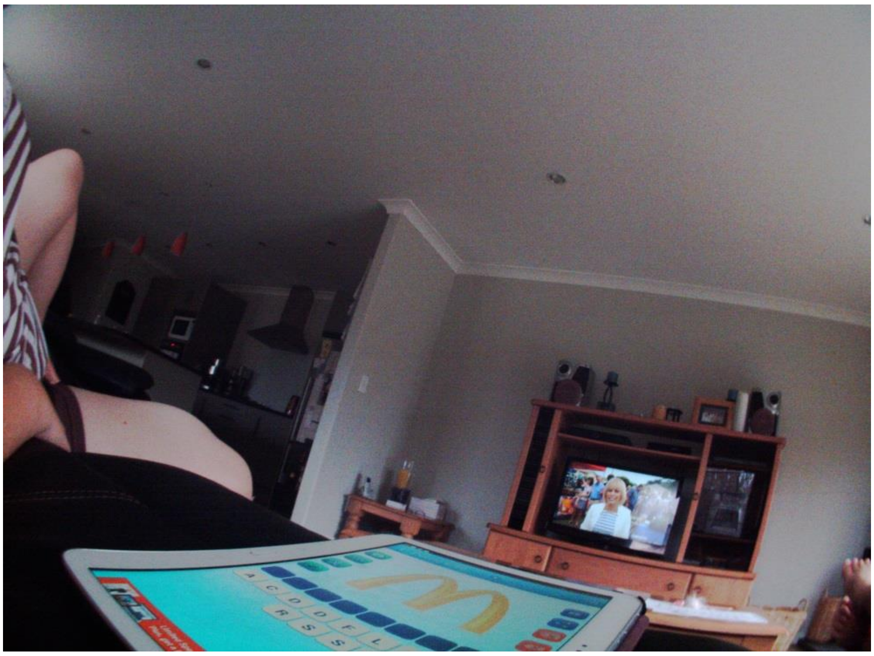


Figure 9 Example of an image containing a tablet

Table 5 presents the ‘screen’ categories and the corresponding definitions used in Kids’Cam Screen Time.

Table 5 Kids’Cam ‘screen’ categories and corresponding definitions

Medium	Definition
Television (TV)	Generally an electronic screen that could stand alone, or mounted to the wall
Computer	Includes desktop computer and laptops
Tablet	An electronic screen that does not require a keyboard or mouse, most commonly used for surfing the internet and running applications. E.g. iPads or Samsung Galaxy tabs
Mobile Device	A handheld device, most commonly used for surfing the internet and running applications. Includes smart phones and iPods

3.3.3. 'Activity' categories

To encompass the different activities that children used screens for, and allow for the overlap in screen-based activities on varying devices observed during the scoping study, annotations for screen-based activities were developed that could be used for any screen type. These were: 'programme', 'games', 'social', 'internet', 'other', 'undetermined', 'not in frame', and 'background'.

'Programme' was used to describe the activity when the child was watching any form of programme or movie; this activity was most common on a television screen. Figure 10 shows a child watching a 'programme' on television.

Figure 10 Example of an image that would be annotated 'Home' > 'Television' > 'Programme'

Activity was annotated as 'games' if the content of the screen appeared to present some goal or objective, with rules and restrictions around obtaining it. Games most often required the use of one or both hands. Figure 11 is an example of a child playing a game on a laptop.

Figure 11 Example of an image that would be annotated as 'Home' > 'Computer' > 'Game'

'Social' was defined as activities that involved interaction with others. 'Social' encompassed activities such as Facebook, Instagram, Snapchat, and text-messaging. They were most often carried out on mobile devices, tablets and computers. Figure 12 shows a child using a computer to access the social network site 'Facebook'.

Figure 12 Example of an image that would be annotated as 'Home' > 'Computer' > 'Social'

The 'internet' annotation was defined as using websites other than those used for social or gaming activity, and included online shopping and watching videos on YouTube. Figure 13 shows an image of a child watching a video on YouTube.

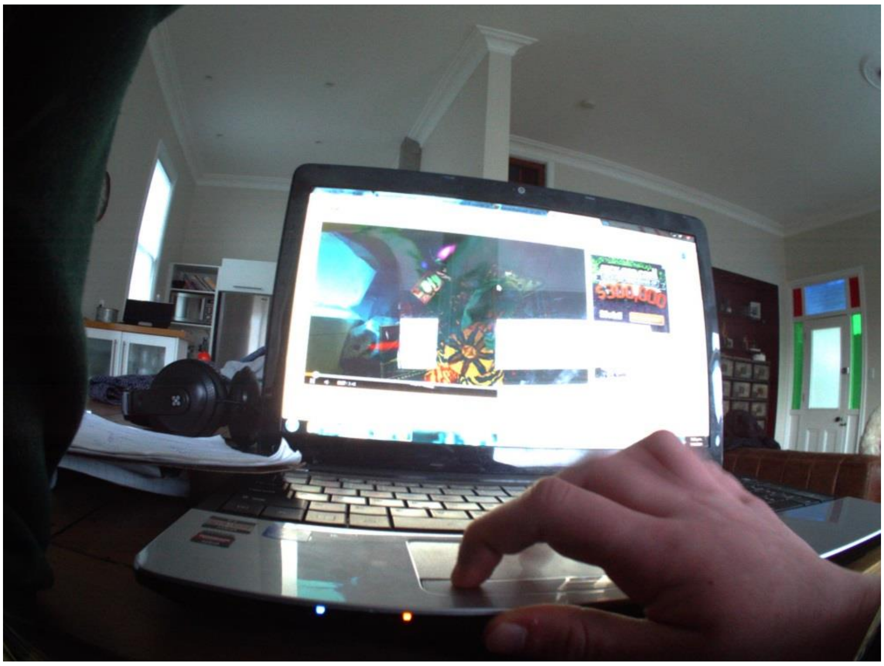


Figure 13 Example of an image that would be annotated as 'Home' > 'Computer' > 'Internet'

During the scoping study it was determined that an 'other' annotation would be required to describe any screen-based activity other than those described above such as listening to music on iTunes, or running offline programmes such as Microsoft Word and Microsoft PowerPoint. Figure 14 shows an image of a child using Microsoft Word.

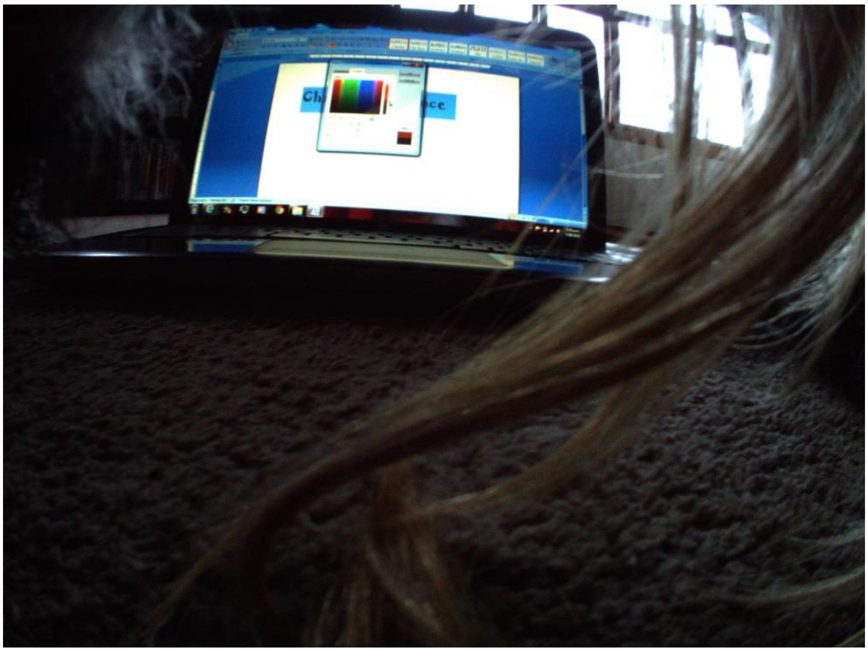


Figure 14 Example of an image that would be annotated as ‘Home’ > ‘Computer’ > ‘Other’

‘Undetermined’ was used to annotate images where it was uncertain what was occurring on the screen. This situation most commonly occurred due to an interference of light. Figure 15 shows an image where the interference of light means it is not possible to determine what activity the child is carrying out.

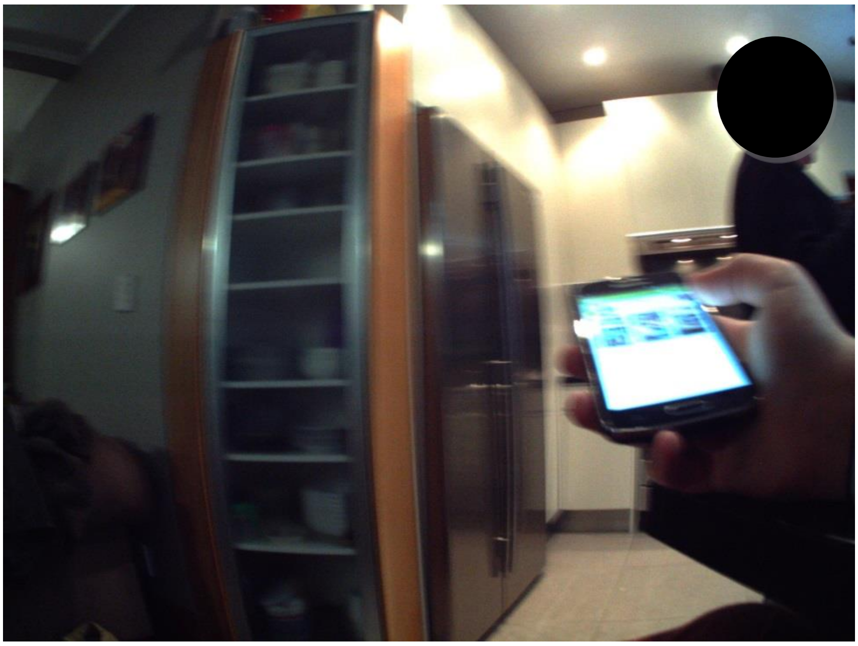


Figure 15 Example of image that would be annotated as 'Home' > 'Mobile Device' > 'Undetermined'

During the scoping study the presence of more than one screen in a single frame was commonly observed, for example, watching television while playing on a tablet. Multiple screens were defined as two or more screens being visible in an image. In the case of multiple screens, images were coded multiple times for each screen type present. Figure 16 shows an example of a child using two screen types simultaneously.

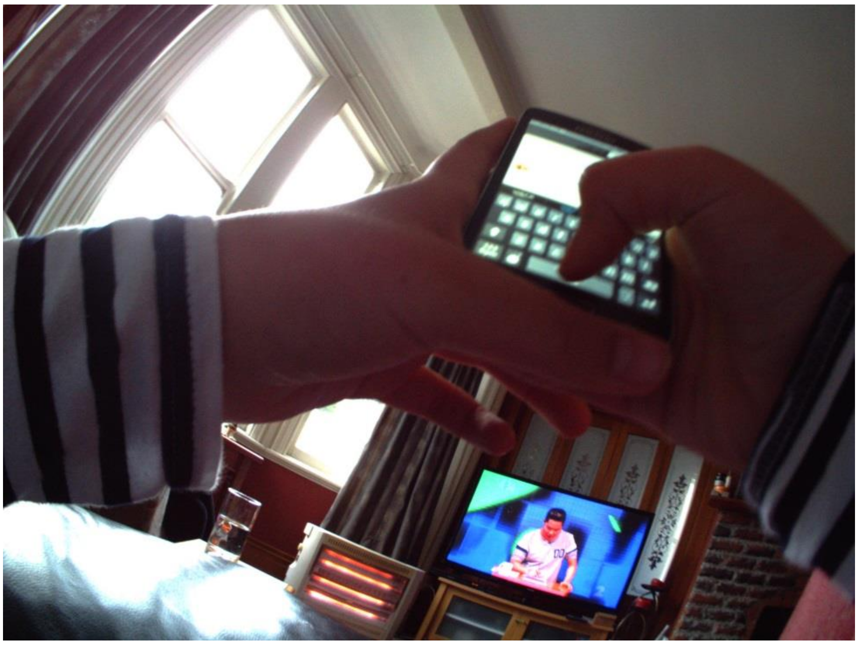


Figure 16 Example of an image that would be annotated as 'Home' > 'Television' > 'Programme' *and* 'Home' > 'Mobile Device' > 'Unknown'

A series of images where the annotator was more than 50% certain that the camera was not being worn – usually identified by a series of identical images – was annotated as 'setting' > 'uncodable' > 'camera not worn'.

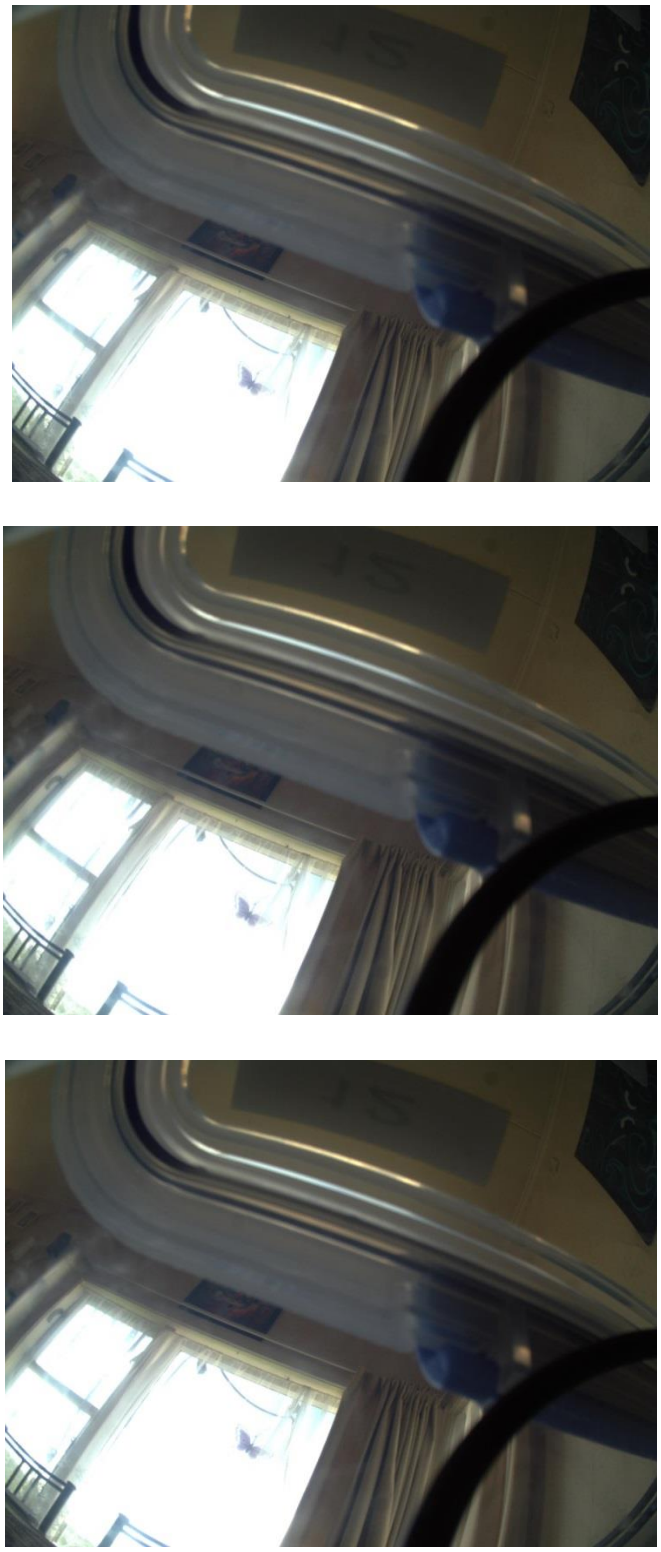


Figure 17 Series of images that would be coded 'setting' > 'uncodable' > 'camera not worn'

Table 6 presents the screen-based activities annotations and corresponding definitions for Kids'Cam Screen Time.

Table 6 Screen-based 'activity' annotations and corresponding definitions for Kids'Cam Screen Time

Activity	Definition
Programme	Watching any form of programme or movie, this activity was most common on a television screen
Games	Content of the screen appeared to present some goal or objective, with rules and restrictions around obtaining it.
Social	Activities that involved interacting with others. Encompassed activities such as Facebook, Instagram, Snapchat, text-messaging etc. and were most often carried out on mobile devices, tablets and computers.
Internet	Using websites other than those used for social or gaming activity, and included online shopping and watching videos on YouTube.
Background	When a screen was present in the child's immediate vicinity, however the child did not appear to be fully engaged with it, but could still be influenced by it.
Other	During the scoping study it was determined that an 'Other' annotation would be required to describe any screen-based activity other than those described above such as listening to music on iTunes, or running offline programmes such as Microsoft Word and Microsoft PowerPoint
Undetermined	Images where it was clear the child was engaging with a screen (see page 80), but the annotator was uncertain what was occurring on the screen, this situation most commonly occurred due to an interference of light.

3.4. Rules used to annotate images in Kids'Cam Screen Time

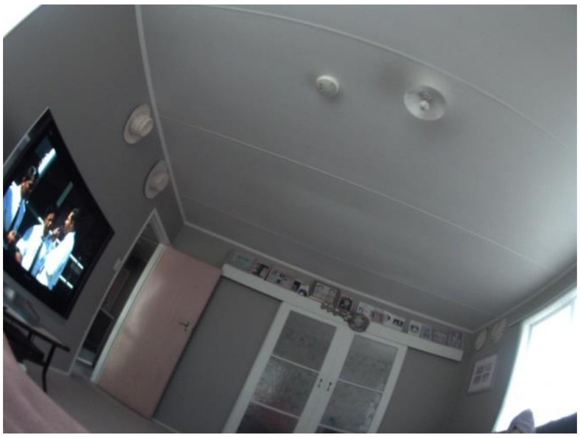
Prior to the commencement of image annotation for Kids'Cam Screen Time, rules were developed on how images should be annotated. The rules were informed by discussions with supervisors, and the relevant literature from researchers who had previously conducted studies using wearable cameras.

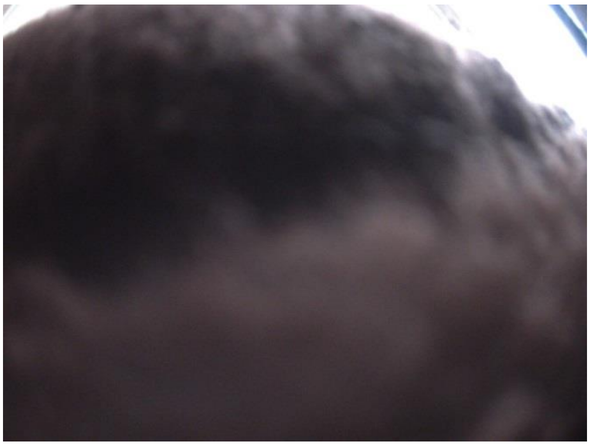
Eighteen image rule

During the scoping study, it was observed that within a sequence of images containing a screen, some images were completely blocked. Such instances occurred when for example the participant was watching television, the camera flipped and images were taken while the camera was lying flat against the child's torso, or the camera fell behind a blanket or sweatshirt. In the event of a completely blocked image, the eighteen image rule was devised to ensure consistency throughout the analysis process.

The eighteen image rule states that a series of fully blocked images can be counted as screen time if the images before and after the blocked image show a screen, and that not more than eighteen images (approximately 2-3 minutes) occur in between. If more than eighteen blocked images occur between two images with screens, the blocked images cannot be included as screen time; they are also removed from total time. The rule, and the choice of eighteen images, was based on previous wearable camera research. The *SenseCam Coding Manual* produced by The University of California, San Diego, USA, used a ten image rule (the equivalent of three minutes, given reduced image-taking frequency of the cameras used in the study) when coding for physical activity and environment. The authors thought three minutes was justified, as a change in context or environment is unlikely in that time period (Doherty et al., 2012).

The images in Figure 18 illustrate how the eighteen image rule was implemented for fully blocked images in Kids'Cam Screen Time. The first image shows that the child is watching television. In the two following images, the camera has fallen behind a blanket, and thus the annotator cannot be certain that the child is still watching the television. However, the subsequent images show the television in plain sight again. In this instance, all four images would be annotated as 'Home' > 'Television' > 'Programme'. If however, nineteen or more images elapsed between the images in which the television is seen, the blocked images would be annotated as 'Uncodable', and also excluded from total time. The argument for the eighteen image rule is that even if the television was obstructed for up to eighteen images (2-3 minutes), if an image showing the screen on appears subsequently, it is unlikely the screen was switched off.





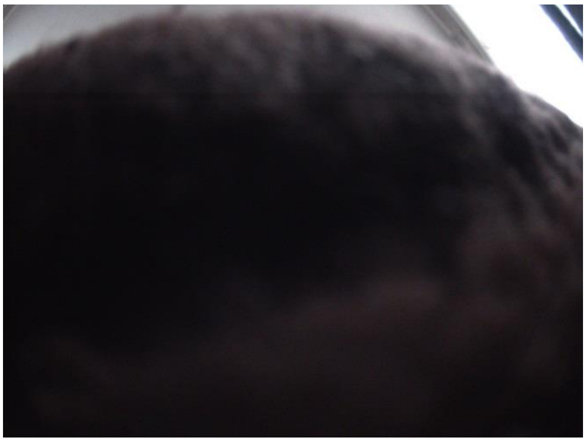
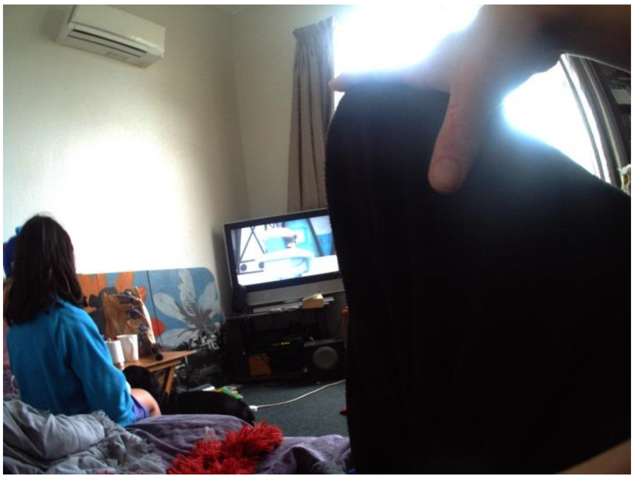


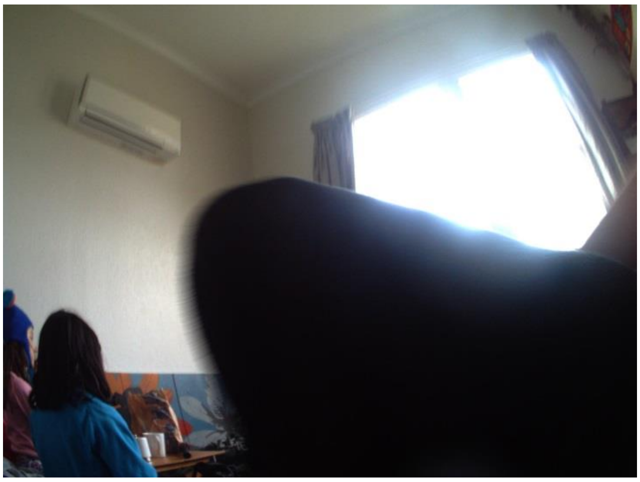
Figure 18 Series of images that would all be annotated 'Home' > 'Television' > 'Programme'

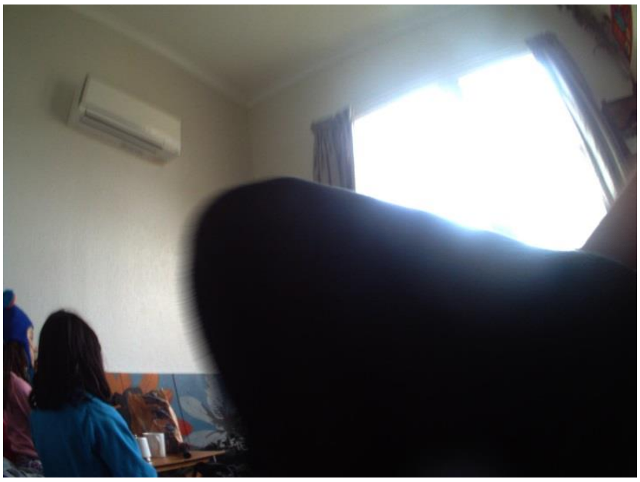
Partially blocked images

The eighteen image rule was also applied when images that were partially blocked, such as by a hand, or when images show a screen and in subsequent images the screen is blocked or not in the view of the camera despite no change in context or environment. If nineteen or more images lapsed between the first and last instance of certain screen time, they could not be included as screen time, however they would be counted as total time to calculate rates. Partially blocked images were included as total time because it was still possible to determine the setting of the image, and whether the child was still wearing the camera. This is in contrast to images that were fully blocked, as in those instances it was possible that the child had removed the camera, and thus the images were not representative of their true surroundings.

Figure 19 illustrates how the eighteen image rule was implemented for partially blocked images. The figure shows a series of images where the child initially is clearly watching television. In the subsequent two images, the child's knee is obstructing the view of the television from the camera, and thus the annotator cannot be certain that the child is still watching. However, the following figure then shows the television in plain sight again. Thus, all four images would be annotated as 'Home' > 'Television' > 'Programme'. The argument for the eighteen image rule is that even if the television was obstructed in the same manner as the second and third images, for up to eighteen images, if an image comparable to the final image appears subsequently, it is unlikely the screen was switched off.







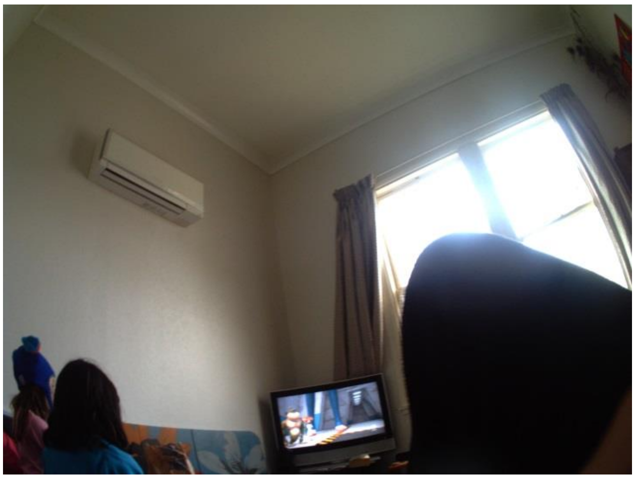


Figure 19 Images annotated 'Home' > 'Television' > 'Programme'

When using the eighteen image rule, a degree of logic was necessary from the annotator in images where the screen was not directly captured by the Autographer. For example, the eighteen image rule is appropriate when applied to television, as a television would rarely be turned off for less than three minutes and turned back on without a change in context. However due to the nature of use of a smart phone it is more likely to be turned off for a shorter period of time than two to three minutes, or eighteen images. To be conservative, mobile devices were predominantly only coded for when the image contained some portion of the screen. The 50% certainty rule (described below) was used in the circumstances where a screen was not fully visible in the image.

50% Certainty Rule

The 50% certainty rule was devised in discussion with supervisors, and informed by a similar rule used in a project from the University of Oxford that investigated physical activity using wearable cameras (Doherty et al., 2012). The 50% certainty rule was used for instances where it was unclear whether a child was watching a screen or not. This situation may occur when the camera did not capture the screen in the image, however from previous and subsequent images it is clear that the screen is still on, and the setting has not changed. If the annotator was more than 50% certain that the screen was still present, and did not breach the eighteen image rule, the image could be annotated as screen time. In any instance where the annotator was 50% or less certain that there was a screen present in the image, the image was annotated as 'not screen time'.

The 50% percent rule was also used when determining whether a screen was on or not, in the instance where the annotator was less than 50% sure that a screen was on, it was not annotated as screen time. This rule was also used when annotating for screen activities. If the annotator was at least 50% sure of what was being carried out on the screen, it could be annotated accordingly. However, if the annotator was less than 50% certain, it would be coded as 'undetermined'. If the annotator took more than ten seconds to decide whether or not an image was screen time, it could not be annotated for screen time.

Background

To account for passive screen viewing, an image was annotated as background when a screen was present in the image, however the child did not appear to be fully engaged with it, for example they were facing away or doing something else. Predominantly television was annotated as background, as the nature of television means it can still be seen and heard and consequently has an influence on the child, even when they are not looking directly at it. In contrast, a mobile device in the background may not have any influence at all and thus was not annotated as background screen time.

An image not containing a television could be annotated as 'background' if previous and subsequent images gave the annotator reason to be more than 50% certain that the screen was still present and on, and the setting had not changed. However, in the interest of being conservative, if more than ten minutes lapsed before the screen was seen on in the background again, it could not be annotated as background. Ten minutes was decided upon after discussions with supervisors, as it seemed a plausible time frame for a television to be left on between frames.

Proportion of screen visible in image

No specific proportion of screen was required to be visible in order to be coded as screen time. This was because the child was likely to be watching or influenced by the screen no matter what portion was captured by the camera. If the annotator had reasonable evidence from previous and subsequent images to be more than 50% certain that the image is showing a screen that is on, it was annotated according to the study protocol.

In summary, the previously described annotations and rules were developed specifically for the Kids'Cam Screen Time study. This section provides a standalone document that could be used by other researchers to code screen time using the same method. The 'Kids'Cam Screen Time cheat sheet', in Appendix A can be used alongside the annotation protocol to guide annotation.

3.5. Reliability testing

To ensure reliability of the study protocol, a sub-set of images was annotated by the author and supervisors in accordance with the study's annotation protocol prior to commencement annotation of the full Kids'Cam Screen Time data set. Annotations were required to achieve 90% agreement between all three annotators before annotation could commence. Any differences in annotations were discussed until consensus was achieved, and the annotation protocol amended accordingly.

3.6. Determining recreational screen time

A concern that arose when interpreting the results of Kids'Cam Screen Time, was whether any of the participant's screen time was spent using computers to complete school homework. As Kids'Cam Screen Time was only interested in recreational screen time, an indication of the amount of children's homework screen time was sought. Principals of each of the participating schools were emailed the following questions:

1. Are the children at your school given homework?
2. If yes
    i. How much time would you expect a student to spend doing homework?
    ii. Would they be expected to use computers to complete their homework?

Principals who did not reply to the initial email were followed up with a phone call to them or office staff and interviewed by phone.

3.7. Analysis

Data was retrieved from the annotation database by the Kids'Cam biostatistician in a form similar to an Excel spreadsheet. Upon review of the data, it was clear that there was wide variation in the amount of total time captured by the participants during the after school period. Therefore, it was decided to exclude from the analysis those participants who had image data of 30 minutes or less. Thirty minutes was based upon the view that this seemed like a reasonable length of time to be somewhat representative of the afternoon period. Excluding participants with less than 30 minutes of image data resulted in 105 participants being included in Kids'Cam Screen Time.

Data was weighted appropriately by the Kids'Cam biostatistician to account for oversampling. Data analysis was treated like a complex survey, due to the sampling design, using Stata's "svy" command functionality. This included accounting for the stratification in the sampling frame (by both ethnicity and school decile group) and clustering of children within schools. Data were also weighted back to the total population size within each stratum, so that total estimates properly accounted for sampling (on the basis of ethnicity and school decile group) that by design did not approximate the spread of children in this age range across these two characteristics.

Statistical analysis was conducted by myself. Using the software programme Stata the mean screen time, and screen types and activities were extracted. Using lines of code generated by the Kids'Cam biostatistician, the mean values of screen time were compared with various demographic variables. The weight status of each child was expressed according to Cole cut-offs as overweight/obese (BMI $\geq$ 25.0) or non-overweight (BMI $\leq$ 24.9). With the assistance of the Kids'Cam biostatistician, I also adapted a code to express screen time as a rate for the total amount of time each child captured, expressed as screen time/hour.

3.8. Timeline for Kids'Cam Screen Time

Work on Kids'Cam Screen Time commenced in April 2015. Prior to the completion of the software required for annotation, I completed my scoping study using Excel spreadsheets and *Windows Photo Viewer*. During the scoping study, I analysed the screen time of 25 children, each of which took approximately 30 minutes, or 12 and a half hours in total. The scoping study helped to inform the annotation protocol, which was developed over approximately 6 weeks of discussion with my supervisors, and by testing the data in *Windows Photo Viewer*. On completion of the annotation protocol in July 2015, the Kids'Cam annotation software was still under development, meaning it was not possible to commence annotation of images for Kids'Cam Screen Time until October 2015. The Thursday afternoon data of all 169 participants totalling 120,780 images was annotated with total image time ranging from 0 minutes, to 3 hours and 47 minutes. Each child's image data took on average 50 minutes to annotate. Annotation of the entire data set took seven weeks to complete, working full time. I attended courses and one-on-one tutorials with the biostatistican to learn how to use Stata, and interpret and present the results.

Summary

This chapter has presented the method used to determine the extent and nature of the Kids'Cam participants' screen time. In 2014-15, data was collected by 169 children from 16 schools in the Wellington region of New Zealand. Participants were asked to wear cameras on lanyards around their neck that automatically took pictures approximately every 7-10 seconds for four days.

The Kids'Cam Screen Time study analysed the image data of the 105 Kids'Cam participants who had thirty-one or more minutes of image data captured during the period from after school to the end of the day on a Thursday.

A scoping study was undertaken to assess the nature of the images, and a Kids'Cam Screen Time-specific annotation protocol and schedule developed. Using bespoke annotation software, each image was annotated according to the schedule for instances of screens, and the setting and screen activity. Data outputs were subsequently analysed statistically using the software programme Stata to determined mean screen time, the screen types used by the participants and the screen-based activities they engaged in. Differences by various demographic variables were also determined.

The results of the analysis of the image data and subsequent outputs are presented in Chapter Four.

Chapter Four: Results

This chapter presents the results of the Kids'Cam Screen Time study. Image data was captured using wearable cameras, and coded using bespoke software according to the annotation protocol presented in Chapter 3. Data was extracted from the annotation software and analysed using the data analysis programme Stata, whereby lines of code were inserted to generate the results to answer the following research questions:

This thesis seeks to address the following research question:

1. What is the nature and extent of children's screen time during the after school period on a typical weekday?

In doing so, it also addresses the following sub-questions:

i. What is the association between children's after school screen time and overweight/obesity?
ii. What is the association between the screen type or screen activity children engage with, and overweight/obesity?
iii. What is the association between screen time, type and activity, and a child's gender, ethnicity, and level of deprivation?

This chapter commences by outlining the characteristics of the dataset, followed by the results of the reliability test. The screen time findings are described according to the variables of interest, namely, gender, BMI, ethnicity, and level of deprivation. The overall mean time for each demographic variable is presented to give an indication of average screen time across the afternoon period. Where appropriate, screen time is also presented as a rate per hour to account for differences in mean total image time across demographics (shown in Table 7). Rates ratios are also presented to directly compare rates between demographic variables. Where rates are too small to be of value they are not given. It should be noted that rate ratios are a comparison of rates of screen time per hour, and not of mean values of mean screen time.

Box plots are used throughout the chapter to illustrate the distribution of mean values. The shaded box of the box plot represents the interquartile range, where the mean screen time values for 50% of the sample lie. The horizontal line through the box indicates the sample's median value. The 'whisker' components of the graph (the two vertical lines at each end of the box) represent the distribution of the upper quartile (highest 25% of mean values) and lower quartile (lowest 25% of mean values). Any plots outside the upper and lower 'whiskers' of the graph represent outliers. Mean times, rates and rates ratios are also presented in tabular format; statistically significant rates ratio values are shaded.

4.1. Dataset characteristics

The dataset consisted of any images taken during the Thursday after school period, defined as being the first image captured after the child leaves school (delineated by when the child appeared to leave school property, usually onto the street, or into a vehicle) until the last image captured by the participant that day. The total time captured by each participant for the analysis period ranged from 30 minutes and 12 seconds (30m 12s), to 3 hours 47 minutes (3hr 47m), with a mean total time of 1hr 51m.

Mean total image time varied between some groups based on demographic variables. Boys collected a mean total image time of 2hr 2m 28s for the analysis period, whereas girls collected a mean total image time of 1hr 49m 48s. 'Non-overweight' children had a mean total image time of 2hr 4m 22s, whereas the 'overweight/obese' group had a mean total image time of 1hr 44m 48s. Mean time captured by ethnicity was: New Zealand European children, 2hr 2m 38s; Māori children, 1hr 40m 48s; and Pacific children, 1hr 43m 48s. Children categorised in NZiDep 1,2,3 had a mean total image time of approximately 2hr, while NZiDep 4 and 5 had a slightly less mean time of approximately 1hr 30m, as shown in Table 7.

Table 7 Mean total image time by demographic variables of interest

Variable (n/105)	Mean total image time
Gender	
Boys (46)	2hr 2m 28s
Girls (59)	1hr 49m 48s
BMI	
Non-overweight (57)	2hr 4m 22s
Overweight (48)	1hr 44m 48s
Ethnicity	
NZ European (45)	2hr 2m 38s
Māori (36)	1hr 40m 48s
Pacific (24)	1hr 43m 48s
Deprivation	
NZiDep 1, 2, 3 (74)	2hr
NZiDep 4, 5 (29)	1hr 30m
NZiDep unknown (2)	1hr 2m 11s

4.2. Reliability test

As described in Chapter Three, five participants were randomly selected for independent annotation by both supervisors to determine external reliability of the Kids'Cam Screen Time annotation protocol. Of the 4,279 images annotated for reliability, there was 90% agreement across all annotators before discussion. Table 8 presents the results of the reliability test for the selected participants.

Table 8 Results of reliability test

Participant number	Number of images annotated	Number of images with agreed annotations	Percentage of images annotated correctly (%)
1001001	826	817	98
1001002	850	817	96
1001003	367	334	91
1001008	1,013	1,011	100
1001009	1,739	1,300	75
Total	4,795	4,279	90

The most commonly disagreed upon annotation category was ‘activity’, whereby several annotations differed by how they perceived what was occurring on the screen. In the majority of instances, this was because one annotator coded for an activity, for example ‘games’ or ‘social’, while another selected ‘undetermined’. Table 8 shows only a 75% agreement in child 1001009, an outlier compared with the rest of the tests. This was due to a series of 376 images where the child had removed the camera but had not switched it off. As it was still capturing images of the surroundings, one annotator annotated this ‘community venue’ > ‘default’ > ‘default’. However, upon review and discussion, it was agreed that this, and similar occurrences, would be annotated as ‘setting’ > ‘uncodable’ > ‘camera not worn’.

4.3. Determining recreational screen time

Of the 16 school principals contacted to determine each school’s homework policy, 10 responded to email, and a further four responded to a phone call follow-up. All principals indicated that children would receive some form of homework, with a wide range of estimated times, from 10 minutes to over an hour per week night. The average time reported by principals was approximately 35 minutes of homework per night. Responses were mixed on whether children were required to use screens to complete homework. Eight principals reported that some element of screen time could be used to complete homework, while six indicated that they would not expect students to require a screen to complete homework. Table 9 shows the results of the homework survey.

Table 9 Expected homework per night, and whether homework requires a digital device for each school

School identification number	Approximate amount of homework per night (minutes)	Does homework require a digital device?
1	Less than 20	Not compulsory
2	60	No
3	60	Some screen time may be necessary
4	Less than 40	Yes
5	30	If available
6	35	No
7	25	No
8	-	Yes
9	30	Yes
10	22.5	Some
11	22.5	No
12	10	No
13	30	No
14	Over an hour	Some
15	Did not respond	-
16	Did not respond	-

4.4. Screen time

The participants had a mean screen time of 44m 52s during the analysis period. Five children had a mean screen time of more than the recommended two hours per day. The distribution of mean screen time for the Kids'Cam Screen Time sample is shown in the box plot in Figure 20.

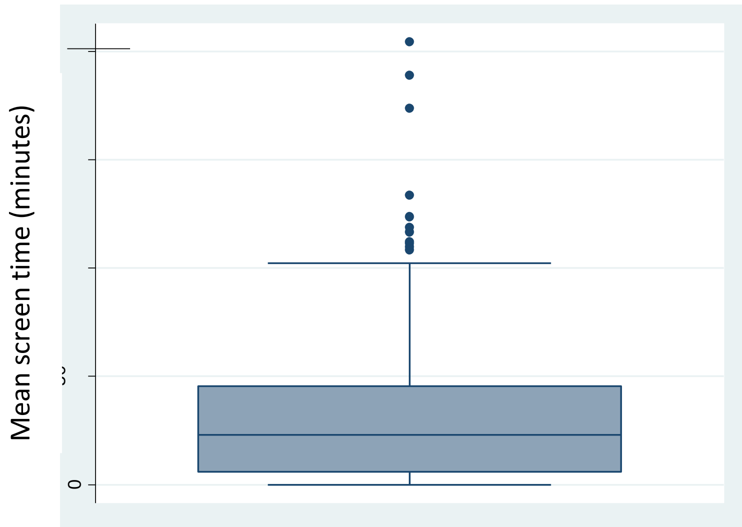


Figure 20 Distribution of children's overall mean screen time

Screen time duration varied according to the three time periods identified in this study. One hundred children captured images during the afternoon period (up to 5.30pm) of whom, 87 (87%) had some screen time. Mean screen time for the afternoon period for those 100 children was 21m 21s. Similarly, during the early evening time period (5.31pm-8.00pm), 82 (77%) of the 105 participants had some screen time. Mean screen time was 19m 54s for all 105 children. During the late evening time period (8.01pm onwards), 33 of the 105 (31%) participants had some screen time. Mean screen time for all children in the late evening time period was 9m 54s.

When screen time is expressed as a rate of total image time, results differ slightly. Over the time analysed, the rate of screen time was 22m 48s per hour. Children had the greatest rate of screen time during the late evening period (after 8pm), followed by the early evening period (5.30pm-8pm), and the afternoon period (3pm-5.30pm). For the afternoon period, children watched screens at a mean rate of 20m 24s per hour, equating to a mean duration of 51 minutes over the two and a half hour time period. The early evening period showed that children used screens at a rate of 24m 36s per hour, the equivalent of 1hr 1m 30s over the two and a half hour time period. During the late evening period children watched screens at the highest rate of 36m 36s per hour.

4.4.1. Screen time by gender

On average, boys watched screens for twice as long as girls during the Thursday after school period. Mean screen time for girls was 29m 16s, and 59m 57s for boys. The maximum time girls spent watching screens was 2hr 53m, while for boys the maximum was 3hr 25m. Figure 21 compares the distribution of mean screen time for boys and girls. It shows that the lower quartile is similar for boys and girls, however the mid quartiles stretch across a far greater range in boys. The median of mean screen time is substantially greater for boys than for girls, and mean screen time in the upper quartile is greater in boys.

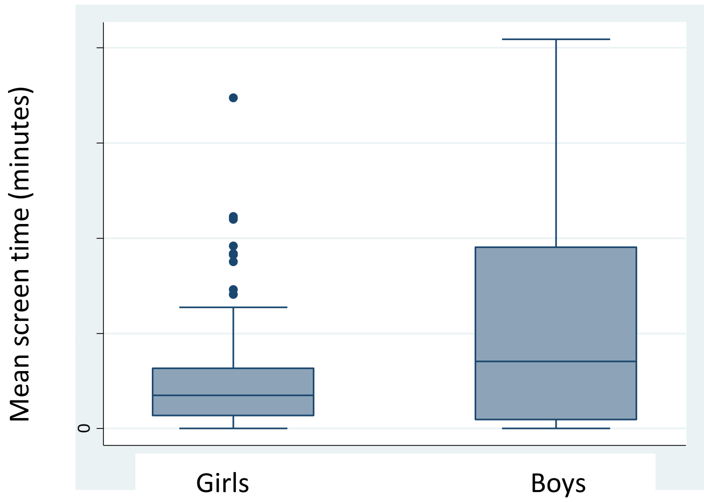


Figure 21 Distribution of mean screen time by gender

The rate of screen time was also significantly greater in boys than girls. The rate of screen time per hour for boys was almost twice that of girls, being 29m 24s per hour, and 14m 24s per hour respectively (RR: 1.85, 95% CI 1.11-3.07) times greater in boys than in girls. Table 10 shows differences in mean screen time, rates, and rates ratios by gender.

Table 10 Screen time by gender

	Mean time	Rate of screen time (per hour)	Rates ratio (95% CI)
Girls	29m 16s	14m 24s	1.00
Boys	59m 57s	29m 24s	1.85 (1.11-3.07)

*Shaded boxes indicate statistical significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.4.2. Screen time by BMI

Mean screen time was greater in non-overweight children than in overweight/obese children, with non-overweight children's mean screen time being 52m 7s, whereas for 'overweight/obese' children it was 35m 54s. When considered by BMI category, underweight children had a mean screen time of 59m 1s. For normal weight children, mean screen time was 51m 37s, in overweight children, 35m 24s, and in obese children, 37m 8s. Figure 22 shows the distribution of mean screen time by aggregated BMI categories. It shows how distribution is spread over a greater range in non-overweight children, indicating less certainty of the true mean value and the possibility that other factors may be influencing the mean value for non-overweight children.

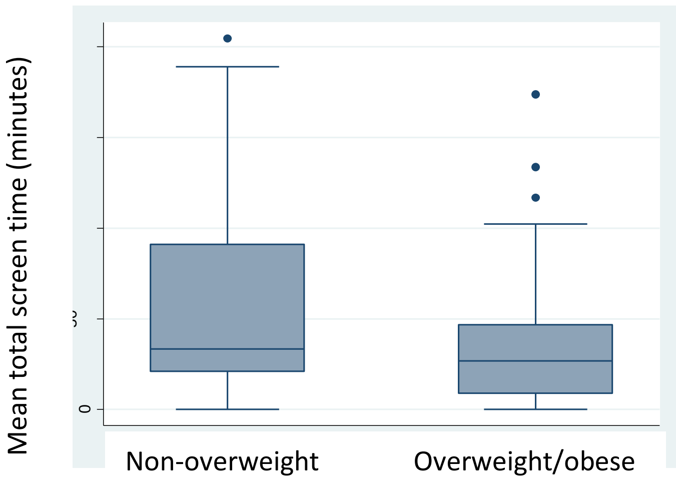


Figure 22 Distribution of mean screen time by BMI

Overweight/obese children also experienced less screen time per hour than their non-overweight counterparts. The rate of screen time in non-overweight children was 25m 12s per hour, whereas for overweight/obese children, was 20m 14s per hour. Rates ratios showed that screen time in overweight/obese children was 0.82 (95% CI 0.49-1.37) times that of non-overweight children. Table 11 shows differences in mean screen time, rates and rates ratios by BMI.

Table 11 Screen time by BMI

	Mean time	Rate of screen time (per hour)	Rates ratio (95% CI)
Non-overweight	52m 7s	25m 12s	1.00
Overweight	37m 8s	20m 14s	0.82 (0.49-1.37)

* Rates ratios are a comparison of screen time per hour and not of mean values

4.4.3. Screen time by ethnicity

Only small differences in mean screen time by ethnicity were found, with New Zealand European children experiencing the most screen time, and Māori children the least. New Zealand European children had a mean screen time of 45m 54s for the Thursday after school period, while Māori children were found to have a mean time of 40m 38s over the same period, and Pacific children a mean time of 44m 53s. Figure 23 shows the distribution of mean screen time by ethnicity. It shows that there is little difference in distribution between the three ethnic groups, indicating that mean screen time is likely similar for New Zealand European, Māori and Pacific children.

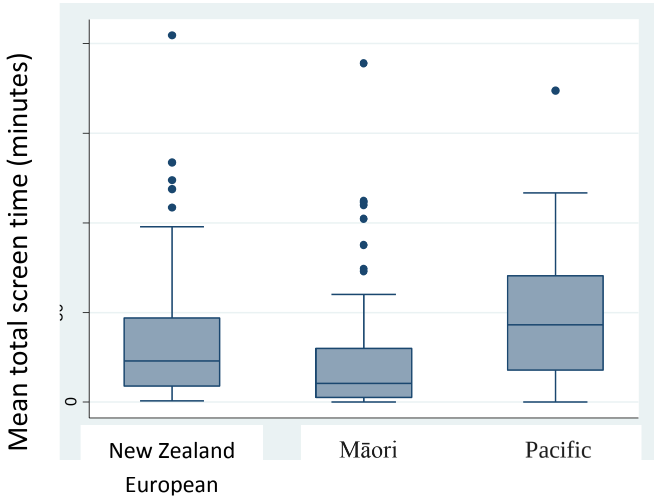


Figure 23 Mean screen time by ethnicity

Converse to trends in mean screen time, when expressed as rates, screen time is greatest in Pacific children, followed by Māori, and New Zealand European. The rate of screen time for New Zealand European children was 22m 12s per hour, for Māori children was 24m 0s per hour, and for Pacific children was 25m 35s per hour. Rate ratios show that screen time in Māori and Pacific children is 1.07 (95% CI 0.73-1.57) and 1.14 (95% CI 0.67-1.96) times that of in New Zealand European children, respectively. However, these results were not statistically significant. Table 12 shows differences in mean screen time, rates and rates ratio by ethnicity.

Table 12 Screen time by ethnicity

	Mean time	Rate of screen time (per hour)	Rates ratio (95% CI)
NZ European	45m 54s	22m 12s	1.00
Māori	40m 38s	24m 0s	1.07 (0.73-1.57)
Pacific	44m 53s	25m 35s	1.14 (0.67-1.96)

*Rates ratios are a comparison of screen time per hour and not of mean values

4.4.4. Screen time by deprivation

Mean screen time decreased with increasing deprivation. The least deprived children in the sample (NZiDep 1) had a mean screen time of 53m 36s, whereas the most deprived (NZiDep5) had a mean screen time of 24m 0s. Mean screen time for children in the NZiDep categories 2-4 decreased with increasing deprivation (50m 12s, 34m 33s and 30m 17s, respectively). Figure 24 shows the distribution of mean screen time relative to deprivation. Mean screen times spread across the greatest range for the least deprived children (NZiDep 1), and the median was greatest in NZiDep 2. Distribution of the interquartile range was also greatest for NZiDep 1 and 2, which may be accounted for by fewer participants in these groups. Fewer participants would result in outliers having greater influence on the inter-quartile range than for larger groups.

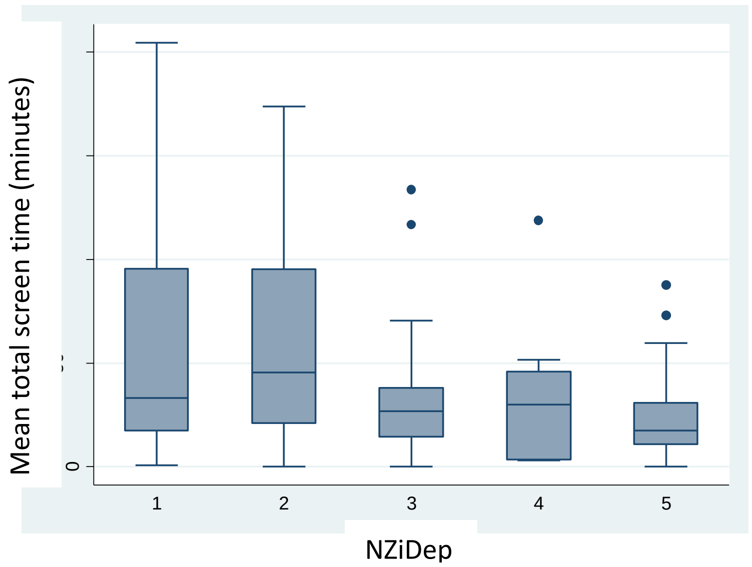


Figure 24 Distribution of mean screen time by NZiDep

The rate of screen time was greatest in children of NZiDep 1 and, although statistically non-significant, again decreased with increasing deprivation. The most deprived children (NZiDep 1) had a rate of 25m 48s per hour of screen time, NZiDep 2 had a rate of 24m 0s per hour, NZiDep 3 had a rate of 17m 24s per hour, NZiDep 4 had a rate of 19m 12s per hour, and NZiDep 5 had a rate of 16m 12s per hour. Results showed that screen time rates in NZiDep 2 were 0.92 (95% CI 0.48-1.76) times as much as NZiDep 1; in NZiDep 3 rates were 0.67 (95% CI 0.33-1.31) times as much; in NZiDep 4 were

0.74 (95% CI 0.27-1.99) times as much, and in NZiDep 5 were 0.61 (95% CI 0.32-1.18) times as much. Table 13 shows differences in mean screen time, rates and rates ratio by deprivation.

Table 13 Screen time by deprivation

	Mean time	Rate of screen time (per hour)	Rates ratio (95% CI)
NZiDep 1	53m 36s	25m 48s	1.00
NZiDep 2	50m 12s	24m 0s	0.92 (0.48-1.76)
NZiDep 3	34m 33s	17m 24s	0.67 (0.33-1.31)
NZiDep 4	30m 17s	19m 12s	0.74 (0.27-1.99)
NZiDep 5	24m 0s	16m 12s	0.61 (0.32-1.18)

* Rates ratios are a comparison of screen time per hour and not of mean values

4.5. Screen types

Of all the screen types considered in this study, children used television the most, followed by computers, then mobile devices and tablets. A mean time of 18m 48s was observed for television viewing, followed in popularity by computers/laptops with a mean time of 14m 27s, mobile devices with mean time of 5m 57s, and tablets with 5m 39s.

Television only was analysed by time period. Of all the study participants, most used television during the early evening period (5.31pm-8pm); sixty-three children spent some time watching television during this time. For the 100 children who captured any time during this period, the mean time for television was 9m 10s. The afternoon was the next most common period for children to be watching television, with a total of fifty-four children watching some television. For the 100 children who captured any image time over this period, mean time for television was 7m 21s. After 8pm, the number of children who watched some television dropped to twenty-seven. For the forty children who had any image time after 8pm, the mean time for television was 7m 46s. Table 14 shows the proportion of children watching television and their mean time of watching, by time periods.

Table 14 Television viewing by time periods

Time period	Number of children watching television/children with any image data for this time period (n/N)	Rate of television time (per hour)
Afternoon (after school-5.30pm)	54/100	6m 36s
Early-evening (5.31-8pm)	63/100	11m 24s
Late-evening (8.01pm-camera off)	27/40	25m 48s

4.5.1. Screen type by gender

Mean time spent using screens was greater in boys than girls across all screen types. Girls spent 17m 44s viewing television, whereas boys spent 19m 50s using television, on average. Girls spent a mean time of 4m 15s using computers while boys used computers for a a mean time of 24m 19s. Mobile use was also less for girls than boys, with them using mobiles for a mean time of 2m 59s, whereas boys used them for a mean time of 8m 50s. Finally, girls used tablets for a mean time of 4m 18s, while boys spent 6m 58s using tablets.

Expressed as rates, there was no difference in time spent watching television between boys and girls (RR: 1.01, 95% CI 0.58-1.75). However, there were differences for other screen types. Boys used computers just over five times as long as girls (RR: 5.16, 95% CI 1.18-22.59). Similarly, they also used mobile devices (RR: 2.67, 95% CI 0.75-9.47) and tablets (RR: 1.46, 95% CI 0.38-5.54) at a greater rate than girls, though not significantly. Table 15 shows differences in mean time and rates ratio for screen types by gender.

Table 15 Screen type by gender

Screen type		Mean time	Rates ratio (95% CI)
Television			
	Girls	17m 44s	1.00
	Boys	19m 50s	1.01 (0.58-1.75)
Computer			
	Girls	4m 15s	1.00
	Boys	24m 19s	5.16 (1.18-22.59)
Mobile device			
	Girls	2m 59s	1.00
	Boys	8m 50s	2.67 (0.75-9.47)
Tablet			
	Girls	4m 18s	1.00
	Boys	6m 58s	1.46 (0.38-5.54)

*Shaded box indicates statistical significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.5.2. Screen type by BMI

As previously presented, non-overweight children in this study had a greater mean screen time than overweight/obese children. Differences were also found in screen type by weight status. Non-overweight children spent considerably more time using computers, Non-overweight children had a mean screen time for computer usage of 20m 17s, whereas overweight/obese children were observed to have a mean computer-based screen time of 6m 55s. By contrast, differences in television, mobile and tablet usage were minor. Non-overweight children spent a mean time of 21m 0s in front of televisions, while overweight/obese children spent a mean time of 19m 43s. These values are substantially closer to each other than those for overall screen time of 52m 7s and 35m 54s for the two BMI categories, respectively. Differences in mobile and tablet use between non-overweight and overweight/obese children were also less marked. Non-overweight children were found to use mobile devices for a mean time of 5m 53s, while it was 6m 36s for overweight/obese children. For tablets, mean time for non-overweight children was 6m 12s, and for overweight/obese children it was 5m 12s.

Although mean time for the use of most screen types is greater in non-overweight than overweight/obese children, the same observation is not evident when the relationships are expressed as rates. Overweight/obese children used television, mobiles and tablets at the same or greater rate as non-overweight children, whereas they used computers at a lesser rate. The rate of television watching in obese/overweight children was 1.04 (95% CI 0.72-1.5) times that as in non-overweight children. Conversely, the rate of overweight/obese children's computer time was less than half that for non-overweight children (RR: 0.41, 95% CI 0.14-1.15). Overweight/obese children used mobile devices a third more (RR: 1.33, 95% CI 0.41-4.27) than non-overweight children, and tablets equally as much (RR: 1.00, 95% CI 0.26-3.80). Table 16 shows differences in mean time and rates ratios for screen types by BMI.

Table 16 Screen type by BMI

Screen type	Mean time	Rates ratio (95% CI)
Television		
Non-overweight	21m 0s	1.00
Overweight	19m 43s	1.04 (0.72-1.50)
Computer		
Non-overweight	20m 17s	1.00
Overweight	6m 55s	0.41 (0.14-1.15)
Mobile device		
Non-overweight	5m 53s	1.00
Overweight	6m 36s	1.33 (0.41-4.27)
Tablet		
Non-overweight	6m 12s	1.00
Overweight	5m 12s	1.00 (0.26-3.80)

** Rates ratios are a comparison of screen time per hour and not of mean values

4.5.3. Screen type by ethnicity

Of the three ethnic groups of interest in Kids'Cam Screen Time, New Zealand European participants spent the greatest mean time using almost all screens. The exception was television, which they used the least. New Zealand European children had a mean television use time of 16m 18s; Māori and Pacific children had a mean time of 31m 44 and 19m 18s, respectively. New Zealand European children used computers for a mean time of 16m 40s. By contrast, Māori and Pacific children used computers for a mean time of 6m 25s and 11m 36s, respectively. Mean time for mobile use was 6m 38s in New Zealand European children, while Māori and Pacific children had a mean time of 2m 36s and 5m 45s, respectively. Lastly, New Zealand European children used tablets for a mean time of 6m 19s, whereas Māori and Pacific had a mean time of 4m 10s and 4m 2s.

When expressed as rates, New Zealand European children used computers, and tablets the most, and television the least. Pacific children used television at a significantly greater rate per hour than New Zealand European children. New Zealand European used computers and tablets at the greatest rate, and Māori children used mobiles slightly more. Māori and Pacific children watched almost one and a half times (RR: 1.43, 95% CI 0.98-2.08) and over twice (RR: 2.28, 95% CI 1.18-4.44) as much television as New Zealand European children respectively. Māori and Pacific children used computers at a rate 0.84 (95% CI 0.23-3.08) times that of New Zealand European children respectively. The rate for mobile use in Māori children was the same as for New Zealand European children (RR: 1.04, 95% CI 0.62-1.76), whereas for Pacific children was just under half that of New Zealand European children (RR: 0.46, 95% CI 0.16-1.30). Māori and Pacific children both used tablets less than New Zealand European children (RR: 0.77, 95% CIs 0.23-2.56, 0.32-1.86 respectively). Table 17 shows differences in mean time and rates ratios for screen type by ethnicity.

Table 17 Screen type by ethnicity

Screen type	Mean time	Rates ratio (95% CI)
Television		
NZ European	16m 18s	1.00
Māori	31m 44s	1.43 (0.98-2.08)
Pacific	19m 18s	2.28 (1.18-4.44)
Computer		
NZ European	16m 40s	1.00
Māori	6m 25s	0.84 (0.23-3.08)
Pacific	11m 36s	0.45 (0.10-1.97)
Mobile device		
NZ European	6m 38s	1.00
Māori	2m 36s	1.04 (0.62-1.76)
Pacific	5m 45s	0.46 (0.16-1.30)
Tablet		
NZ European	6m 19s	1.00
Māori	4m 10s	0.77 (0.23-2.65)
Pacific	4m 2s	0.77 (0.32-1.86)

*Shaded boxes indicate statistical significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.5.4. Screen type by deprivation

Television use by deprivation

For the most part, mean time spent using television decreased with increasing deprivation. The exception was in the least deprived group (NZiDep 1), which had the lowest mean time for television watching of 14m 5s. Children categorised as NZiDep 2 had the highest observed mean screen time with 31m 40s, with mean time for television watching for children categorised as NZiDep 3, 4 and 5 being 20m 33s, 19m 17s, and 14m 44s, respectively.

When expressed as rates, the relationship between television and deprivation differs only slightly from the means. Children categorised as NZiDep 2 used television at a rate 2.21 (95% CI 1.00-4.9) times that of the least deprived (NZiDep 1). Children categorised as NZiDep 3 used television at a rate 1.51 (95% CI 0.89-2.79) times that of NZiDep 1, and those categorised as NZiDep 4 and 5 used at a rate 1.79 (95% CI 0.92-3.74) and 1.38 (95% CI 0.83-2.27) times that of NZiDep 1.

Computer use by deprivation

Mean computer usage was greatest in the least deprived children, and tended to decrease with increasing deprivation. The most deprived children in the sample (NZiDep 1) spent a mean time of 24m 31s using computers. This is in contrast to children categorised as NZiDep 2 whose mean computer usage time was 6m 59s. For children categorised as NZiDep 3, mean computer usage time was 8m 26s; for NZiDep 4 it was 1m 1s, and for NZiDep 5 it was 3m 34s.

Despite significant differences between NZiDep 1, and NZiDep 4 and 5 in computer use, no clear trend was found for this association when screen time was expressed as a rate per hour. Children categorised as NZiDep 2 used computers at a rate 0.28 (95% CI 0.04-1.90) times as much as those categorised as NZiDep 1. Children categorised as NZiDep 3 used computers at a rate 0.36 (95% CI 0.09-1.32) times as much, NZiDep 4 used at a rate 0.09 (95% CI 0.01-0.49) times as much, and NZiDep 5 used at a rate 0.19 (95% CI 0.06-0.65) times as much as NZiDep 1.

Mobile use by deprivation

Mobile phone usage tended to decrease with increasing deprivation. The least deprived children (NZiDep 1) had a mean usage of 8m 43s. The mean dropped to 5m 31s for children categorised as NZiDep 2, 3m 37s for NZiDep 3, 1m 43s for NZiDep 4, and 1m 51s for NZiDep 5. Expressed as rates, children of NZiDep 2 used mobile devices at a rate 0.62 (95% CI 0.29-1.35) times that of children categorised as NZiDep 1. Children of NZiDep 3 at a rate 0.42 (95% CI 0.10-1.76) times that of NZiDep 1, NZiDep 4 used at a rate 0.26 (95% CI 0.07-.95) times that of NZiDep1, and NZiDep 5 used at a rate 0.28 (95% CI 0.06-1.30) times that of NZiDep1.

Tablet use by deprivation

Varying values were observed for mean tablet use by deprivation. For NZiDep 1 mean tablet use was found to be 6m 16s, for NZiDep 2 was 6m 0s, for NZiDep 3 was 1m 57s, for NZiDep 4 was 8m 16s and for NZiDep 5 was 4m 45s. Expressed as rates, children of NZiDep 2 used tablets at a rate 0.94 (95% CI 0.27-3.26) times that of NZiDep 1. For NZiDep 3, children used tablets at a rate 0.32 (95% CI 0.13-0.78) times that of NZiDep 1, NZiDep 4 at a rate 1.76 (95% CI 0.15-6.52) times as long, and NZiDep 5 equally as long as NZiDep 1 (RR: 1.00, 95% CI 0.15-6.5). Table 18 shows differences in mean time and rates ratios for screen type by deprivation.

Table 18 Screen type by deprivation

Screen type	Mean time	Rates ratio (95% CI)
Television		
NZiDep 1	14m 5s	1.00
NZiDep 2	31m 40s	2.21 (1.00-4.90)
NZiDep 3	20m 33s	1.51 (0.89-2.79)
NZiDep 4	19m 17s	1.79 (0.92-3.74)
NZiDep 5	14m 44s	1.38 (0.83-2.27)
Computer		
NZiDep 1	24m 31s	1.00
NZiDep 2	6m 59s	0.28 (0.04-1.90)
NZiDep 3	8m 26s	0.36 (0.09-1.32)
NZiDep 4	1m 1s	0.09 (0.01-0.49)
NZiDep 5	3m 34s	0.19 (0.06-0.65)
Mobile device		
NZiDep 1	8m 43s	1.00
NZiDep 2	5m 31s	0.62 (0.29-1.35)
NZiDep 3	3m 37s	0.42 (0.10-1.76)
NZiDep 4	1m 43s	0.26 (0.07-0.95)
NZiDep 5	1m 51s	0.28 (0.06-1.30)
Tablet		
NZiDep 1	6m 16s	1.00
NZiDep 2	6m 0s	0.94 (0.27-3.26)
NZiDep 3	1m 57s	0.32 (0.13-0.78)
NZiDep 4	8m 16s	1.76 (0.15-6.52)
NZiDep 5	4m 45s	1.00 (0.15-6.5)

*Shaded boxes indicate statistical significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.6. Screen activity

Of the activity categories included in the study, the highest mean screen time was observed for watching ‘programmes’, followed by ‘games’, ‘social activities’ and ‘background’. Mean screen time across the sample for watching ‘programmes’ was 12m 28s. This was followed by ‘games’, with a mean of 10m 55s. The ‘other’ category, which comprised of activities such as listening to music through iTunes or offline activities such as Microsoft Word, had a mean time of 10m 7s. Children spent a mean time of 5m 55s with screens classified as ‘background’, 3m 38s participating in ‘social’ activities, and 3m 05s using the ‘internet’. The screen was too blurry for activity to be determined for a mean time of 1m 30s.

4.6.1. Screen activity by gender

Mean screen time was greater in boys than girls for almost all screen activities observed. The exception was watching programmes. Girls spent a mean time of 14m 19s using screens to watch programmes, whereas boys spent a mean time of 10m 41s doing so. Conversely, boys spent a mean time of 19m 47s playing games on screens, as opposed to girls who spent a mean time of just 1m 45 playing games. In terms of social puposes, girls spent a mean time of 1m 55s using screens, whereas boys spent a mean time of 5m 19s. Girls had a mean time of 2m 7s for internet, compared with boys who had a mean time of 4m 13s. Girls spent a mean time of 3m 46s with a screen on in the background while boys spent a mean time of 8m 0s with a screen on in the background.

With the exception of watching programmes, the patterns of screen activity and gender were similar as those for mean screen time when expressed as rates. Boys used screens to watch programmes for 0.67 (95% CI 0.42-1.06) times as long as girls. Boys spent significantly more time playing games on screens than girls (RR: 10.22, 95% CI 3.34-31.25). Boys used screens for social purposes at a rate two and a half times that of girls (RR: 2.51, 95% CI 0.21-28.96), and internet at a rate nearly twice that of girls (RR: 1.81, 95% CI 0.42-7.84). Boys also spent almost twice as long as girls (RR: 1.91, 95% CI 0.73-4.99) with screens on in the background. Table 19 shows differences in mean time and rates ratios of screen activities by gender.

Table 19 Screen activity by gender

Screen activity		Mean time	Rates ratio (95% CI)
Programmes			
	Girls	14m 19s	1.00
	Boys	10m 41s	0.67 (0.42-1.06)
Games			
	Girls	1m 45s	1.00
	Boys	19m 47s	10.22 (3.34-31.25)
Social			
	Girls	1m 55s	1.00
	Boys	5m 19s	2.51 (0.21-28.96)
Internet			
	Girls	2m 7s	1.00
	Boys	4m 13s	1.81 (0.42-7.84)
Background			
	Girls	3m 46s	1.00
	Boys	8m 0s	1.91 (0.73-4.99)

*Shaded box indicates statistical significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.6.2. Screen activity by BMI

Screen activities varied somewhat by BMI. Mean time was slightly greater in non-overweight children than overweight/obese children across all activities, and considerably greater for playing games in non-overweight children. Mean time spent watching programmes was 12m 52s for non-overweight children, whereas for overweight/obese children it was 11m 8s. Non-overweight children spent a mean time of 15m 32s playing games, whereas overweight/obese children played games for 4m 53s, on average. Mean time was greater for social activities in overweight/obese children than non-overweight children, at 6m 46s and 1m 49s, respectively. Non-overweight children had a mean internet time of 4m 4s, whereas overweight/obese children spent 2m 2s doing so. Non-overweight children spent a mean time of 6m 34s with screens on in the background; for overweight/obese children time spent with screens on in the background was 5m 26s, on average.

Rates of watching programmes and background exposure were virtually identical between overweight/obese and non-overweight participants. However, non-overweight children spent significantly more time playing games on screens than overweight/obese children. By contrast, overweight/obese children had a greater rate than their non-overweight counterparts for using screens for social activities. Overweight/obese children watched programmes on screens at much the same rate (RR, 1.03 (95% CI 0.74-1.42), and played gamed just over a third less (RR, 0.38 (95% CI 0.19-0.71) as non-overweight children. Overweight/obese children used screen for social activities at a rate 4.46 (95% CI 0.85-23.34) times as much as non-overweight children, and 0.59 (95% CI 0.16-2.27) times as much for internet. The rate at which children had screens on in the background was the same for overweight/obese and non-overweight children (RR: 0.99, 95% CI 0.28-3.42). Table 20 shows differences in mean time and rates ratios of screen activities by BMI.

Table 20 Screen activity by BMI

Screen activity	Mean time	Rates ratio (95% CI)
Programmes		
Non-overweight	12m 52s	1.00
Overweight/obese	11m 8s	1.03 (0.74-1.42)
Games		
Non-overweight	15m 32s	1.00
Overweight/obese	4m 53s	0.38 (0.19-0.71)
Social		
Non-overweight	6m 46s	1.00
Overweight/obese	1m 49s	4.46 (0.85-23.34)
Internet		
Non-overweight	4m 4s	1.00
Overweight/obese	2m 2s	0.59 (0.16-2.27)
Background		
Non-overweight	6m 34s	1.00
Overweight/obese	5m 26s	0.99 (0.28-3.42)

*Shaded box indicates significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.6.3. Screen activity by ethnicity

Mean time spent by participants on each screen activity varied by ethnicity. Māori children had the greatest mean time for programmes and background television, whereas New Zealand European children had the greatest mean time for games, social activities and internet. New Zealand European children had the lowest mean time watching programmes of 11m 4s. By contrast, Māori and Pacific children had mean times of 16m 10s and 15m 23s, respectively. Of the three ethnicities, New Zealand European children played games the most, with a mean time of 12m 22s, while Māori and Pacific children had a mean time of 6m 4s and 8m 40s, respectively. New Zealand European children also had the greatest mean time of social activity of 4m 5s, while

Māori and Pacific had mean times of 1m 20s and 3m 34s, respectively. New Zealand European children had a mean time for internet of 3m 22s, while Māori and Pacific children had mean times of 2m 18s and 3m 6s, respectively. New Zealand European children had a mean time of 5m 34s of background screen time, whereas Māori children had the greatest mean time (11m 24s) and Pacific children had the least (3m 10s).

Expressed as rates, New Zealand European children had the lowest rate per hour of watching programmes, while Pacific children had the greatest rate for programmes and background screen time, and the lowest rate for playing games and social activities. Māori and Pacific children watched programmes 1.68 (95% CI 0.93-3.03) and 1.71 (95% CI 0.79-3.71) times as much per hour, respectively, as New Zealand European children. New Zealand European children played games at the greatest rate per hour, Māori and Pacific children played games 0.84 (95% CI 0.22-3.20) and 0.57 (95% CI 0.19-1.69) times as much as New Zealand European children. Māori children had a rate for social activity 1.06 times that of New Zealand European children, while Pacific children had a 0.38 (95% CI 0.07-2.23) times that of New Zealand European children. Māori children had the greatest rate of internet at 1.11 (95% CI 0.31-3.98) times as much as New Zealand European children, while Pacific children had a rate 0.80 (95% CI 0.10-6.18) times as much as New Zealand European. Pacific children had the greatest rate of background screen time with 2.40 (0.64-9.05) times as much as New Zealand European children, while Māori children had the least with 0.69 (0.18-2.57) times as much as New Zealand European. Table 21 shows differences in mean time and rates ratios of screen activities by ethnicity.

Table 21 Screen activity by ethnicity

Screen activity	Mean time	Rates ratio (95% CI)
Programmes		
NZ European	11m 4s	1.00
Māori	16m 10s	1.68 (0.93-3.03)
Pacific	15m 23s	1.71 (0.79-3.71)
Games		
NZ European	12m 22s	1.00
Māori	6m 4s	0.84 (0.22-3.20)
Pacific	8m 40s	0.57 (0.19-1.69)
Social		
NZ European	4m 5s	1.00
Māori	1m 20s	1.06 (0.24-2.23)
Pacific	3m 34s	0.38 (0.07-2.23)
Internet		
NZ European	3m 22s	1.00
Māori	2m 18s	1.11 (0.31-3.98)
Pacific	3m 6s	0.80 (0.10-6.18)
Background		
NZ European	5m 34s	1.00
Māori	11m 24s	0.69 (0.18-2.57)
Pacific	3m 10s	2.40 (0.64-9.05)

* Rates ratios are a comparison of screen time per hour and not of mean values

4.6.4. Screen activity by deprivation

Programmes by deprivation

Mean time watching programmes increased somewhat with increasing deprivation, with the exception of children categorised as NZiDep 5. Mean time spent watching programmes was lowest for the least deprived children (NZiDep 1), at 11m 1s. This typically increased with increasing deprivation categories (NZiDep2, 12m 53s; NZiDep3, 14m 23s; NZiDep 4, 14m 44s; and NZiDep5, 12m 5s). Rates of programme watching also increased somewhat with increasing deprivation. Children categorised as NZiDep 2 watched programmes for 1.15 (95% CI 0.51-2.57) times as long as NZiDep 1, NZiDep 3 watched programmes for 1.35 (95% CI 0.86-2.11) times as long, NZiDep 4 watched for 1.75 (95% CI 0.81-3.75) times as long, and NZiDep 5 watched for 1.44 (95% CI 0.95-2.18) times as long as NZiDep 1.

Games by deprivation

Mean time spent playing games on screens decreased with increasing deprivation. Children categorised as NZiDep 1 spent a mean time of 14m 8s playing games. NZiDep 2 spent a mean time of 14m 44s playing games, NZiDep 3 spent 7m 22s, NZiDep 4 spent 4m 37s, and NZiDep 5 spent 1m 36s playing games. This relationship remained relatively consistent when expressed as rates. NZiDep 2 spent 1.03 (95% CI 0.11-9.39) times as long playing games as NZiDep 1, NZiDep 3 spent 0.54 (95% CI 0.22-1.31) times as long, NZiDep 4 spent 0.43 (95% CI 0.08-2.29) times as long and NZiDep 5 spent 0.11 (95% CI 0.03-0.76) times as long playing games as NZiDep 1.

Social activity by deprivation

The relationship between deprivation and mean time using screens for social activity was somewhat inconsistent. Children categorised as NZiDep 1 had a mean time spent engaging in social activity on screens of 4m 57s. NZiDep 2 had a mean time of 2m 16s, NZiDep 3 had a mean time of 37s, NZiDep 4 had a mean time of 6m 11s, and NZiDep 5 had a mean time of 1m 52s. When expressed as rates, almost all deprivation groups had a lower rate of social screen time than the least deprived children (NZiDep 1), with the exception of NZiDep 4. Children categorised as NZiDep 2 used screens for social activity at a rate 0.45 (95% CI 0.07-2.79) times that of the least deprived children (NZiDep 1). Children categorised as NZiDep 3 had a rate 0.13 (95% CI 0.01-2.03) times NZiDep 1, NZiDep 4 had a rate 1.64 (95% CI 0.56-4.75) times NZiDep 1, and NZiDep 5 had a rate 0.50 (95% CI 0.03-7.52) times NZiDep 1.

Internet by deprivation

No clear trend was observed for the association between mean time spent using the internet, and deprivation. The least deprived children (NZiDep 1) was found to have a mean time for internet of 3m 59s, while NZiDep 2 had a mean time of 2m 14s, NZiDep 3 had a mean time 0m 10s, NZiDep 4 had a mean time of 1m 53s and NZiDep 5 had a mean time of 4m 19s. Similarly, expressed as rates, no clear association can be determined between rate of internet time and deprivation. Children categorised as NZiDep 2 had a rate of internet 1.07 (95% CI 0.31-3.62) times that of NZiDep 1, compared with NZiDep 3 with a rate 0.49 (95% CI 0.08-2.93) times as much. Children categorised as NZiDep 4 had a rate significantly less than NZiDep 1 (RR: 0.06, 95% CI 0.01-0.29), and NZiDep 5 have a rate 0.74 (95% CI 0.14-3.92) times as much.

Background screen time by deprivation

Mean background screen time was greatest in children of NZiDep 1, and decreased somewhat with increasing deprivation. Mean background screen time for NZiDep 1, was 6m 44s, 6m 39s for NZiDep 2, 5m 47s for NZiDep 3, 3m 19s for NZiDep 4, and 4m 5s for NZiDep 5. Trends remained similar when background screen time was expressed as a rate per hour. NZiDep 2 spent 0.97 (95% CI 0.25-3.70) times as long with screens on in the background as NZiDep 1. NZiDep 3 spent 0.89 (95% CI 0.20-3.86) times as long with screens in the background, NZiDep 4 spent 0.64 (95% CI 0.10-4.16) times as long, and NZiDep 5 spent 0.80 (95% CI 0.17-3.80) times as long. Table 22 shows differences in mean time and rates ratios of screen activities by deprivation.

Table 22 Screen activity by deprivation

Screen activity	Mean time	Rates ratio (95% CI)
Programme		
NZiDep 1	11m 1s	1.00
NZiDep 2	12m 53s	1.15 (0.51-2.57)
NZiDep 3	14m 23s	1.35 (0.86-2.11)
NZiDep 4	14m 44s	1.75 (0.81-3.75)
NZiDep 5	12m 5s	1.44 (0.95-2.18)
Games		
NZiDep 1	14m 8s	1.00
NZiDep 2	14m 44s	1.03 (0.11-9.39)
NZiDep 3	7m 22s	0.54 (0.22-1.31)
NZiDep 4	4m 37s	0.43 (0.08-2.29)
NZiDep 5	1m 36s	0.11 (0.03-0.76)
Social		
NZiDep 1	4m 57s	1.00
NZiDep 2	2m 16s	0.45 (0.07-2.79)
NZiDep 3	3m 37s	0.13 (0.01-2.03)
NZiDep 4	6m 11s	1.64 (0.56-4.75)
NZiDep 5	1m 52s	0.50 (0.03-7.52)
Internet		
NZiDep 1	3m 59s	1.00
NZiDep 2	2m 14s	1.07 (0.31-3.62)
NZiDep 3	0m 10s	0.49 (0.08-2.93)
NZiDep 4	1m 53s	0.06 (0.01-0.29)
NZiDep 5	4m 19s	0.74 (0.14-3.92)
Background		
NZiDep 1	6m 44s	1.00
NZiDep 2	6m 39s	0.97 (0.25-3.70)
NZiDep 3	5m 47s	0.89 (0.20-3.86)
NZiDep 4	3m 19s	0.64 (0.10-4.16)
NZiDep 5	4m 5s	0.80 (0.17-3.80)

*Shaded boxes indicate statistical significance

** Rates ratios are a comparison of screen time per hour and not of mean values

4.7. Summary of results

Screen time

In this study, children used screens for a mean time of 44m 52s over the analysis period. Five children had a mean screen time greater than the recommended daily limit of two hours, and the early evening period (5.31pm-8.00pm) was the most common time for children to have some screen time. Boys were used screens more than girls, and non-overweight children used screens more than overweight/obese children. Only small differences were observed in mean screen time by ethnicity, with New Zealand European children having the greatest mean screen time and Māori children the least. Mean screen time was greatest for the least deprived children (NZiDep 1), and decreased somewhat with increasing deprivation.

When expressed as rates, trends in mean screen time are generally consistent with mean screen time, with the exception of ethnicity. The rate of screen time was significantly greater in boys than in girls, and overweight/obese children experienced less screen time per hour than their non-overweight counterparts. Converse to trends in mean screen time, when expressed as rates, screen time was greatest in Pacific children, followed by Māori, and New Zealand European children. Although statistically non-significant, relative rates indicate that the rate of screen time was greatest in the least deprived children (NZiDep 1), and showed a decrease with increasing deprivation.

Screen type

Of all the screen types considered in this study, children used television the most, followed by computers, mobile devices, and tablets. Mean time spent using screens was greater in boys than girls across all screen types. Non-overweight children spent considerably more time using computers than overweight/obese children. Differences in television, mobile and tablet usage were relatively minor. In contrast to Māori and Pacific children, New Zealand European children spent the greatest mean time using all screens, with the exception of television, which they used the least.

For the most part, mean time spent using television decreased with increasing deprivation, although the least deprived children (NZiDep 1) had the lowest mean time for television watching. Mean computer and mobile usage was also greatest in the least deprived children, and tended to decrease with increasing deprivation. Conversely, no clear trend was observed for tablet use by deprivation.

Trends for screen type differed somewhat when expressed as rates. No difference in the rate of time spent watching television was found between boys and girls. Also converse to findings of mean times, overweight/obese children used television, mobiles and tablets at the same or greater rate as non-overweight children, however were still found to use computers less. Pacific children used television at a significantly greater rate per hour than New Zealand European children, whereas New Zealand European used computers and tablets at the greatest rate, and Māori children used mobiles slightly more. Television use appears to decrease with increasing deprivation, with the exception of the least deprived who have the lowest rate of television. Similarly, mobile phone usage tended to decrease with increasing deprivation however no clear trend was observed for tablet use and deprivation.

Screen activity

Of the activity categories included in the study, the highest mean screen time was observed in watching programmes, followed by games, social activities and background. Screen activities varied somewhat by demographic factors. Mean screen time was greater in boys than girls for all screen activities observed, with the exception of watching programmes. Mean time was also slightly greater in non-overweight children than overweight/obese children across all activities, and considerably greater in non-overweight children. Māori children had the greatest mean time for programmes and background television, whereas New Zealand European children spent the greatest mean time on games, social activities and internet. Mean time watching programmes somewhat increased with increasing deprivation. Conversely, mean time spent playing games and for background television on screens decreased with increasing deprivation, while the relationship between deprivation and mean time for social activity was somewhat inconsistent.

The rate of screen time was greater in boys than girls for all activities, with the exception of watching programmes. Rates of watching programmes and background exposure were virtually identical between overweight and non-overweight. However, non-overweight children spent significantly more time playing games on screens, while overweight/obese children spent more time using screens for social activities. New Zealand European children had the lowest rate of watching programmes, while Pacific children had the greatest rate for programmes and background screen time, and the lowest rate for playing games and social activities. Rate of programme watching and background television increased somewhat with increasing deprivation, by comparison computer use decreased with increasing derivation, and no clear trend was observed for rate of social activities and deprivation.

The following chapter discusses the findings of this study in the context of the previous research reviewed in Chapters 2 and 3. Strengths and limitations of the study are then discussed, followed by an exploration of the implications for policy and practise, and further research.

Chapter Five: Discussion

This chapter concludes this thesis. First, results of the Kids'Cam Screen Time study are summarised and discussed in the context of previous research of a similar nature, to answer the primary research question:

1. What is the nature and extent of children's screen time during the after school period on a typical weekday?

And the sub-questions:

i. What is the association between children's after school screen time and overweight/obesity?
ii. What is the association between the screen type and screen activity children engage with, and overweight/obesity?
iii. What is the association between screen time, type and activity, and a child's gender, ethnicity, and level of deprivation?

A discussion on the strengths and limitations of the Kids'Cam Screen Time study follow, and the implications of the study findings for policy and practise, and further research, are presented.

5.1. Children's screen time after school on a typical weekday

This study found that children's after school screen time on a regular weekday is, on average, likely to be around 45 minutes. This estimate likely allows children to meet the New Zealand Ministry of Health's guidelines, and those internationally, which recommend children engage in no more than two hours of recreational screen time per day (Ministry of Health, 2012). Four of the 105 children (4%) in this study used any screen type for longer than two hours. These findings are in contrast to the previous research reviewed in Chapter Two, and contrary to the expectations of Sigman, who stated that "there is little reason to assume New Zealand will be impervious to global trends" (Sigman, 2015, p. 6). For example, a report by the UK Government's Office of Communications (Ofcom), found that UK children aged 8-11 years and 12-15 years used screens for 4.5 and 6.5 hours per day, respectively (Ofcom, 2014). In New

Zealand, the National Institute of Health (NIHI) found that 66% of 10-14 year olds watched more than two hours of television per day. Similarly, the Ministry of Health's 2014/15 Health Survey reported that almost 50% of 10-14 year olds were watching more than two hours per day of television (Ministry of Health, 2015; NIHI, 2014).

Differing results between this study, and the Ministry of Health and NIHI estimates, for duration of children's screen time could be due to methodological differences. In both New Zealand reports, children's mean screen time was estimated using self-report data. Self-report data for this type of variable, and other variables for which restrictive guidelines exist, would typically be assumed to produce an under-representation of the true value of children's screen time (Adams, Soumerai, Lomas, & Ross-Degnan, 1999; Otten, Littenberg, & Harvey-Berino, 2010). A reason for this is social desirability bias, whereby people report a level of screen watching they deem to be socially appropriate as opposed to the true value. It is also likely that when self-reporting on a variable such as screen time, people are likely to forget how long they spend using screens, or are unaware. Given Kids'Cam's objective means of collecting data, it would be reasonable to assume that screen time estimates derived from this study would be higher than previously reported, not less.

Another likely reason for a lesser amount of screen time observed in this study than in other studies may be due to only analysing a proportion of the day. Much of the previous research reported on children's screen time for a whole day. Although the after school period is intuitively the time of day that children would be most likely to be watching screens, self-report and proxy-report figures are likely to include screen time for the before and during school period. It is also important to note that in this study, only Thursday image data was analysed. It is probable that children engage in considerably less screen time during the week than weekend days due to them having more recreational time on weekend days. The findings reported by the Ministry of Health and NIHI are an aggregate of television use on weekdays and weekend days[5]. Thus, aggregated means calculated in those studies will likely overestimate screen time (mostly television viewing) on a typical weekday.

[5] Awaiting segregated data from the Ministry of Health.

A less conservative estimate of children's screen time during the after school period is given by presenting screen time as a rate of total image time. As such, children's screen time was higher at 22m 48s per hour. Extrapolating this rate across the after school period, for example 3pm-9pm (6 hours) results in children using screens for up to 2hr 16m. This estimate is considerably greater than that predicted by children's mean screen time during the after school period in this study (45 minutes). However, it is only just over the recommended daily limit of two hours. Even when accounting for morning and lunchtime recreational use, total recreational screen time does not align with previous self-reported estimates, which are much higher, or excessively exceed recommendations.

5.1.1. Screen type

In this study, television was the screen type used most by participants (mean duration, 21m 11s), followed in popularity by computers/laptops (12m 8s). These findings are consistent with the 2015 New Zealand Children's Media Use Study, which also identified television as the most commonly used form of media, followed by computers/laptops (Colmar Brunton, 2015). Although the New Zealand Children's Media Use Study reports on availability of devices while Kids'Cam Screen Time reports mean time and rate per hour, it would be reasonable to assume that availability and usage are related. Of all screen types included in the Kids'Cam Screen Time study (television, computers, tablets and smartphones), children have the greatest access to television in the home. Authors of the New Zealand Children's Media Use Study found that almost all (98%) children aged 6-14 years had access to a television in their homes, while nine out of ten children watched television every day. Children were also found to spend more time watching television than any other form of media. The New Zealand Children's Media Use Study also found that computers are the second most commonly used device by New Zealand children and that they are also common in the homes of New Zealand children, with almost nine out of ten 6-14 year olds having access to a computer or laptop at home (Colmar Brunton, 2015).

The participants of Kids'Cam Screen Time spent similar times using tablets and mobile devices (mean time of 4m 56s and 4m 58s, respectively). This is in contrast to the 2015 New Zealand Children's Media Use Study that found substantially more children have access to a tablet (almost three-quarters) in the home than smart phones (just under half) (Colmar Brunton, 2015). Differences between the latter study and Kids'Cam Screen Time may be explained by the different study designs and methods used. The participant sample in the New Zealand Children's Media Use Study included children younger (6-14 years) than those in the Kids'Cam Screen Time sample (11-13 years). This is salient, as younger children may use smart phones less than older children. Differences in the findings may also be explained by differences in study objectives. Kids'Cam Screen Time investigated the time children spent using screens, while the New Zealand Children's Media Use Study aimed to determine children's access to screens. Although it is reasonable to assume that greater access infers greater usage, this may not always be the case. In addition, it is possible that although children have greater access to tablets, they use them for shorter time periods than smart phones. Another explanation may be the differences in the definition of a 'mobile'. The Kids'Cam Screen Time 'mobile' category included smart phones and the iPod touch, whereas the New Zealand Children's Media Use Study included smart phones only. iPod touch use may have made up a considerable proportion of time spent on mobile devices found in Kids'Cam Screen Time. Discerning between smart phones and iPod touches was problematic, as it is difficult to differentiate them in the images.

5.1.2. Screen activities

The most common screen-based activity observed in Kids'Cam Screen Time was watching programmes, followed, in order, by playing games, 'other' activities, background, and social activities. Children spent, on average, 12m 28s using screens to watch programmes. This finding is consistent with the New Zealand Children's Media Use Study, which found watching television programmes to be the most common form of children's media consumption, with 74% of children aged 6-14 years reporting they watched programmes on television daily (Colmar Brunton, 2015).

Kids'Cam Screen Time participants played games for 10m 55s, on average. This finding is also supported by the New Zealand Children's Media Use Study, which found that games were the most common form of internet use, with just over three-quarters (76%) of internet users reporting they used the internet to play games. All 'other' activities, including playing music, engaged Kids'Cam Screen Time participants for just over 10 minutes. While this finding is not directly comparable to those of the New Zealand Children's Media Use Study, 10% and 15% of New Zealand children in that study used the internet to listen to music on sites such as Spotify and Soundcloud, and stream music for free from the internet, respectively.

Facebook, Instagram, Snapchat and texting were classified as 'social' activities in this study, and were found to account for a mean time of 3m 38s of children's overall screen time. According to the New Zealand Children's Media Use Study, Facebook is the fourth most common activity New Zealand children accessed the internet for, with a fifth (21%) of those who had access to the internet reporting to use Facebook. Similarly, 78% of 9-16 year old European children with internet access were found to access social media sites in the Net Children Go Mobile Project (Mascheroni & Ólafsson, 2014).

In this study, children were observed with screens playing in the background for an average of 5m 55s. The 'background' category was only used where the annotator thought it plausible that the child could be influenced by the media through sound. For example, a television that another family member was watching while the child was in the same room would be coded as 'background', whereas a computer would not. Background television has the potential to influence children's food behaviours through passive food marketing. However there is little previous literature on the relationship between background television, and overweight and obesity.

5.2. Differences by gender

5.2.1. Screen time by gender

In this study, boys' screen time exceeded that of girls' (59m 57s and 29m 16s, respectively). Furthermore, boys' rate of screen time per hour (29m 24s) was significantly greater than that of girls' (14, 24s) (RR: 1.85, 95% CI 1.11-3.07). This finding is in contrast to those of the Ministry of Health's 2014/15 New Zealand Health Survey in which there was no difference found between boys and girls use of screens. However, when the 2014/15 New Zealand Health Survey data is considered by age group, a slightly greater proportion of 10-14 year old boys reported watching more than two hours per day of screen time than girls of the same age group (47.8% and 44.3%, respectively).

International research demonstrates differences in screen time between boys and girls. For example, a cross-sectional study of 4-12 year old US children assessed screen time in relation to sociodemographic and weight status, and found that a greater percentage of boys reported high screen time (more than two hours per day of television and computers) than girls (68% vs. 62%) (Anderson et al., 2008). These findings are also supported by results from Jago et al. (2011), who investigated the proportion of 5-6 year old boys who exceeded the daily guidelines of more than two hours of screen time per day (which included television, computers, game consoles, and smart phones) than girls.

5.2.2. Screen type by gender

To date, previous New Zealand findings for differences in screen time by gender are based on data for television watching only. It is possible that gender differences found in Kids'Cam Screen Time may be accounted for by the inclusion of other screens and gender differences in the use of those screens. For each of the screen types accounted for in Kids'Cam Screen Time the mean screen time for each was greater for boys than girls. The most distinct difference was in boys' time spent using computers. On average, boys spent 24m 19s using computers whereas girls spent only 4m 15s, a significantly greater proportion of time (RR: 5.16, 95% CI1.18-22.59). By contrast, although boys had a greater mean time for television than girls (17m 44s and 19m 50s, respectively), when considered as a rate, virtually no difference between boys and girls was found (RR: 1.01 95%, CI 0.58-1.75).

International research also demonstrates differences between screen types by gender. Anderson et al., (2008) found that 12% of boys and 8% of girls watched television for more than the recommended two hours per day on a regular weekday. The authors also found that girls used computers as much as boys on weekdays, however there was a significant difference in weekday game console use, whereby 53.1% of boys reported "some use", compared with 33.8% of girls. Results from Kids'Cam Screen Time are also partly supported by de Jong et al. (2013), who found that boys spent more time using computers than girls but found no difference in time spent watching television (de Jong et al., 2013). Conversely, authors of a US cross-sectional study investigating the impact of computer use on children's development found that while boys reported spending more time using computers during school time than girls, they found no gender difference in computer use outside of school time (Subrahmanyam et al., 2001).

Several explanations for the observation that boys are greater users of computers have been suggested. Vekiri and Chronaki (2008) determined attitudes toward computers, and perceived parental and peer support as important factors for computer use. They found that while both boys and girls expressed positive self-efficacy and beliefs about the value of computers, boys' views were somewhat more positive than girls. Boys were also reported to receive more parental support to use computers than girls, and were more likely to talk about and use computers with their peers. The authors recognised gender inequality in computer literacy as an issue for concern due to growing reliance on computers in the work place, and the potential that girls may be limiting their future academic and career options (Vekiri & Chronaki, 2008).

Another possible explanation for gender differences in computer use is that computer games continue to be considerably more popular among boys (Subrahmanyam et al., 2001). Game producers have admitted their products are designed and marketed almost exclusively to boys. Consequently, it is unclear whether variance in computer use between boys and girls is a cause or effect of such marketing (Subrahmanyam et al., 2001). It has also been suggested that boys enjoy computer games more than girls because they tend to prefer 'pretend' play, based on fantasy, which is the basis for the majority of computer games, compared with girls who prefer more reality-based play (Tizard et al., 1976). Taking into account the observation by Subrahmanyam et al. (2001) that boys spend more time using computers during, but not out of, school hours than girls, it is possible that boys perceive computers as a more valuable learning tool than girls. However, as the same observation was not made in the current study, this explanation would only be plausible if the extra time boys spent using computers was made up primarily of homework time, which, upon review of the footage, is unlikely.

The differences observed in this study for the use of mobile devices and tablets by gender are considerably less marked and less significant than those observed for television and computers. The 2015 New Zealand Children's Media Use Study found that girls aged 12-14 years used mobile devices more than boys, with 72% found to have access to mobile devices compared with 55% of boys. The Net Children Go

Mobile project found that preferences in device with which to access the internet varied by gender (Mascheroni & Ólafsson, 2014). The authors of the latter study observed that boys of all ages were more likely than girls to use desktop computers, however girls were more likely to use smartphones, laptop computers, and tablets. It is possible that differences in mobile and tablet use by gender do exist, but were not observed in this study due to methodological limitations, which are discussed in a following section.

5.2.3. Screen activity by gender

On average, boys spent more time in almost all screen activities observed in Kids'Cam Screen Time than girls. The exception was programmes, which girls watched at a rate 1.33 times that of boys. This finding is in contrast to the New Zealand Children's Media Use Study that found that boys aged 12-14 years watched television shows on television screens more than girls. However, the report's authors also found that a greater proportion of girls used the internet to watch television shows and movies (38%) than boys (24%). As Kids'Cam Screen Time included watching programmes both on television and on the internet under the 'programme' category, it is possible that programmes watched on the internet make up for a substantial amount of girls' programme watching activity.

Boys in this study spent significantly more time (mean and per hour) playing games on the computer than girls (mean time, 19m 47s and 1m 45s; and RR: 10.22, 95% CI 3.34-31.25). These findings are supported by a Slovakian cross-sectional study of 8,042 children aged 11-15 years that investigated gender differences in screen-based behaviour (Husárová, Veselská, Sigmundová, & Gecková, 2015). The authors found that while there is no difference in the time girls and boys spend watching television, boys use computers for games significantly more than girls. An attempt to explain why males play games more than females was made by a group of researchers at the University of Stanford, who conducted an observational study of 22 students aged 19-23 years using functional magnetic resonance imaging to monitor brain activity while playing computer games (Hoeft, Watson, Kesler, Bettinger, & Reiss, 2008). The authors found that the reward centre in the brain is more activated in men than in women during video game playing. Although participants in the University of Stanford study were considerably older than those in the Kids'Cam Screen Time project, it is possible that such an explanation may be applicable to younger participants.

5.3. Differences by BMI

5.3.1. Screen time by BMI

A sub-question in this study was:

- Is there a relationship between children's exposure to after school screen time and overweight/obesity?

Conclusions drawn from previous literature reviewed in Chapter Two indicated that greater screen time would be associated with increased likelihood of overweight/obesity. However, not only was there no association between increased screen use and increased BMI in the children in this study, but an inverse relationship was found, with non-overweight children having a greater mean screen time (52m 7s) during the observed period than overweight/obese children (35m 54s). Even when expressed as a rate, overweight/obese children used screens less (RR: 0.82, 95% CI 0.49-1.37) than non-overweight children. This finding is in contrast with the vast majority of the current literature on the association between screen time and overweight, reviewed in Chapter Two. Overall, a positive association between screen time and overweight/obesity has been established in the current literature (Dietz & Gortmaker, 1985; Maher, Olds, Eisenmann, & Dollman, 2012; Proctor et al., 2003; Rey-López et al., 2012).

There are several possibilities, largely methodological, for the differences in findings between this study and those in the previous literature. The majority of the latter have focused primarily on television watching and, occasionally they include computer use, whereas in this study all screen types were included. If screen types other than television are shown to have no association with overweight/obesity, or even a negative association, it is possible that the association between overall screen time and overweight/obesity seen in those studies reporting only television time is weaker than the actual value. Hence, the negative relationship between screen time and overweight/obesity observed in this study may be partially explained by the inclusion of other screen types as contributors to screen time.

Differences in data collection methods are another possible explanation for variations in findings. The majority of previous studies have used self and proxy-report to determine screen time. Self and proxy-report typically underestimate behaviours (Lioret et al., 2011; Olafsdottir, Thorsdottir, Gunnarsdottir, Thorgeirsdottir, & Steingrimsdottir, 2006) but it is possible that screen time is more prone to overestimation by this method. Parental report may be prone to exaggeration, as parents may perceive their child spends an excessive amount of time on screens, provoking an estimate greater than accurate. Another possibility is that screen time may not be as fundamental to overweight and obesity prevalence in children as commonly perceived. It is possible that modern screen time does not have the same affect on weight gain as traditional television, which was the focus of many previous studies. Finally, it may be that some screen types are associated with overweight, while others are not, a possibility explored further in the following section.

5.3.2. Screen type by BMI

When screen types are considered separately, their associations with overweight and obesity vary somewhat from that with overall screen time in this study. Non-overweight children used computers for a longer period, on average, (20m 17s), than overweight/obese children (6m 55s). Overweight/obese children used computers at a rate approximately 60% less than non-overweight children (RR: 0.41, 95% CI 0.14-1.15). By contrast, the difference in mean television use between non-overweight and overweight/obese children was considerably reduced, with mean times of 21m 0s and 19m 43s respectively. Overweight/obese children used television at a similar rate (RR: 1.04, 95% CI 0.72-1.5) as that of non-overweight children. These findings suggest that overall screen time is not sufficient in determining the association between screen time and overweight, and that screen type is likely an important factor in a child’s tendency to gain weight.

A potential inference that can be made from this study is that computer usage may be somewhat protective in the development of overweight and obesity in New Zealand children. This finding is supported by Marsh et al. (2014) who observed higher energy intake in children while watching television than in children using computers and videogames, despite equal access to food under each condition. They also found that energy intake from soft drink was significantly greater while children were watching television than when using computers for recreation. Although this finding does not provide evidence for a protective influence of computer usage, it supports the idea that all screen types are not equal in their potential for causing weight gain. It is important to consider that Marsh et al.'s study included boys only and thus such a conclusion is not necessarily applicable for girls (Marsh et al., 2014). Additionally, Kautiainen et al. (2005) found, when investigating media use of 14, 16 and 18 year olds, a statistically significant positive trend between television viewing and overweight; the only other positive relationship the authors found was between computer usage and overweight for 16 year old girls. These findings further support the conclusion that for the majority of children no association between computer use and overweight exists (Kautiainen et al., 2005). It is important to note that the participants in Kautianinen et al.'s study were older (age 14-18 years) than the Kids'Cam Screen Time participants. It is possible that the relationship between screen time and overweight varies also with age.

A number of potential mechanisms for the apparent association between television viewing and overweight, which are not evident for that between computer use and overweight, have been proposed. The mechanisms, discussed in Chapter Two, include decreased energy expenditure by displacing physical activity and increased energy intake while watching television (Marsh et al., 2014). It has been suggested that watching television distracts attention away from the physiological cues of satiation leading to passive overconsumption (Bellissimo et al., 2007; Temple et al., 2007). Another theory is that television may increase energy intake to a greater extent than computer usage because television users have been shown to become more fully immersed in the story, which has been shown to be associated with increased energy intake (Lyons et al., 2013). Associative learning has also been proposed as a possible mechanism for this observation, whereby screen time becomes a conditioned cue to eat (Chapman et al., 2012; Marsh et al., 2013). Marsh et al. (2014) acknowledged that television watching during meal times is common in adolescents whereas video games and computer use may be less common, this may be due to video games and computers requiring the use of one or both hands for a mouse/keyboard or controller (Marsh et al., 2014). They also proposed food advertising on television as a contributing factor in establishing the relationship between watching television and eating, as well as parents enforcing stricter rules around eating while using 'hands on' screens, than with television. While food consumption during screen time was not analysed in Kids'Cam Screen Time, observations made during image annotation support the theory that television watching is more associated with eating than other screen types. It was evident during the annotation phase that children ate more often while watching television than while using other screens, most likely for the reasons previously discussed.

Kids'Cam Screen Time found no significant difference in mean tablet or mobile use between overweight and non-overweight children, with mean time for both being approximately 6 minutes. This finding is in agreement with Jackson et al. (2011), who investigated whether BMI could be predicted from IT use. After adjusting for socio-demographic variables the authors found no association with any form of IT. Interestingly, Lajunen et al. (2007) found a weak correlation between cell phone use and BMI. The average age of the sample was 17 years, rather than 12 years as in the US study described previously (Jackson et al., 2011), and the current study. However, the findings of Lajunen et al. suggest that a weak association between cell phone use and overweight is possibly established during later teen years. There appear to be no other studies examining the association between tablet use and overweight.

5.3.3. Screen activity by BMI

Playing games was the only significant association found between activities and BMI. Expressed as rates, overweight/obese children were found to spend just over a third of the time (RR: 0.38, 95% CI 0.19-0.71) using screens to play games compared with non-overweight children. Mean time for games was also substantially greater in non-overweight than overweight/obese children (15m 32s and 4m 35s, respectively). This finding supports the theory discussed previously, put forth by Marsh and colleagues, that screen activity requiring the use of one or both hands is less conducive, and potentially even protective against, passive overeating and consequent weight gain (Marsh et al., 2014). Interestingly, an observational study of 25 US children aged 8-12 years found no difference in energy expenditure between children watching television and playing video games (Lanningham-Foster et al., 2006), a finding that supports Marsh et al.'s theory. This finding implies that increased energy intake while watching television compared with video games is a contributor to weight gain, as opposed to a difference in energy expenditure.

Counter to the majority of the findings in the previous literature reviewed in Chapter Two, overweight/obese children in this study were not found to spend significantly more time watching programmes than non-overweight children. A possible reason for this could be what appears to be a changing culture of programme watching, whereby a considerable proportion of television programmes are now accessed through the internet through Ondemand sites[6], and by live-pause style television viewing such as MySky[7]. Such applications provide fewer advertisements, by giving the viewer the ability to fast-forward and skip television advertisements, respectively. As such, watching programmes in this fashion potentially results in less exposure to food advertising that has been shown to be associated with overeating in childhood (Borzekowski & Robinson, 2001; Wilson et al., 2006). This study found that overweight/obese children accessed social media sites more than non-overweight children, however the difference was non-significant. Limited prior research was found on this relationship, but social media has been identified as a potential tool for weight loss. The American Heart Association issued a statement:

> *Some research shows that even in virtual social networks, people tend to associate with others like themselves, so if you develop a network of kids who are overweight, you can have an impact on all of them — in the real world and online — because if one starts making healthy changes, the others will be influenced to do so as well.* (American Heart Association, 2012)

If the observation that overweight children use social media more than non-overweight children is correct, social media sites such as Facebook could be an effective intervention method for weight loss in children. No difference in the amount of time non-overweight and overweight/obese children spent with a screen on in the background was found in this study. This implies that children are exposed to little food

[6] Internet site where programmes are available to watch on demand
[7] Live television that can be paused, fast forwarded and rewound

marketing through background media, or are not influenced by food marketing through background media. A more likely explanation is that methodological limitations of this study, such as inconsistencies in the identification of 'background' screen time, may be responsible for the lack of association found between background media and overweight/obesity.

5.4. Differences by ethnicity

In this study, differences were found in screen time by ethnicity. New Zealand European children had a greater mean screen time during the observed period (45m 54s) than Pacific (44m 53s) and Māori children (40m 38s). These findings are counter to those of the 2014/15 New Zealand Health Survey, which found a greater proportion of Māori children (55%) exceeded two hours of television per day, than Pacific children (51%) and European children (42%). Differences in findings may indicate that a greater proportion of New Zealand European children's screen time may be made up by screen types other than television, than Māori and Pacific children. Kids'Cam Screen Time found that New Zealand European children had the greatest mean time for almost all screen types, except for television. The latter findings may explain the differences between this study and the findings of the 2014/15 New Zealand Health Survey.

Patterns in screen time vary slightly when use by ethnicity was expressed as a rate. Relative to New Zealand European children, Māori and Pacific children had a slightly higher (albeit non-significant) rate of screen time (1.07 and 1.14, respectively). The 2014/15 New Zealand Health Survey found differences in television viewing by ethnicity. Māori and Pacific children were significantly more likely to exceed two hours of television viewing per day than non-Māori children and non-Pacific children (1.32 and 1.15 times as likely, respectively). Kids'Cam Screen Time found the rate of television use to be greater for Māori children, and significantly greater for Pacific children, than New Zealand European.

5.5. Differences by deprivation

5.5.1. Screen time by deprivation

The most deprived children (NZiDep5) in the Kids'Cam Screen Time sample used screens less than the least deprived children (NZiDep1) (24m 54s and 53m 35s, respectively). Similarly, the trend for rate of screen time per hour decreased with increasing deprivation, where children categorised as NZiDep 4 and 5 used screens at a rate approximately a quarter (RR, 0.74) and a third (RR, 0.61) less than children categorised as NZiDep 1, respectively, differences which are non-significant.

The relationship between lower physical activity levels with increased deprivation has been well established. However, the association between screen use as a sedentary behaviour and deprivation remains largely undefined (Shishehbor et al., 2006; Stamatakis et al., 2009). Whereas this study demonstrated a slight negative correlation between screen use and increased deprivation, Ogunleye et al. found a small, non-significant increase in screen time with increased deprivation (Ogunleye et al., 2012). Furthermore, Tandon et al. (2012) concluded from a cross-sectional study that a greater proportion of children from highly deprived households had a television, DVD or game console in their bedrooms than children from less deprived households. The authors also found that for every unit increase in household income, there was a decrease in daily screen time.

Kids'Cam Screen Time findings indicate that sedentary behaviour may be greater in less deprived children (NZiDep1). As discussed in Chapter Two, deprived children are more likely to be overweight or obese than less deprived children (Ministry of Health, 2015), thus findings could be considered as further evidence that some screen time may be protective against weight gain. It is also possible that methodological issues (discussed in a later section) or the inclusion of different screen types is responsible for the inconsistencies between this and previous research.

5.5.2. Screen type by deprivation

When screen time was considered by different screen types in this study, patterns by deprivation varied. For television, mean screen time appeared to increase somewhat with increased deprivation. When expressed as rates, the least deprived children also spent the smallest proportion of captured time using television. Although the relationship between deprivation and television in this study is non-significant, the trend is consistent with the 2014/15 New Zealand Health Survey which found that the most deprived children watched television almost 50% more (RR, 1.47) as the least deprived children (Ministry of Health, 2015). Similarly, the New Zealand Children's Media Use Study reported that children from high income households were less likely to watch television (Colmar Brunton, 2015). An explanation proposed by some researchers for such patterns of television viewing by deprivation is that poorer children watch more television than less deprived children as they stay indoors due to a greater likelihood of living in unsafe neighbourhoods (Pagani & Huot, 2007). Parents may perceive television viewing as a safe and acceptable alternative to playing outside, resulting in decreased physical activity, shown in Chapter One to be associated with weight gain (Ebbeling et al., 2002; Rowlands et al., 2000). The study by Pagani and Huot (2007) was carried out in Canada, where it is possible that (perceived or otherwise) neighbourhood safety plays a different role in determining children's likelihood of playing outside than in New Zealand.

The relationship between computer use and deprivation is much clearer than with television. In this study, the most deprived children used computers much less than their less deprived counterparts (RR: 0.19, 95% CI 0.06-0.65). Greater access to computers in more affluent households is a possible reason for this observation. This explanation is supported by the New Zealand Children's Media Use Study, which found that children in homes with household income greater than $80,000 were more likely to have access to a computer at home (Colmar Brunton, 2015). Further, New Zealand trends appear to be consistent with findings from the European study Net Children Go Mobile Project in which a greater proportion of children from high socioeconomic backgrounds used laptops daily (46%) than children from low socioeconomic backgrounds (36%) (Mascheroni & Ólafsson, 2014).

Mobile phone usage in this study also differed by deprivation, with the least deprived children (NZiDep 1) using such devices at a rate almost four times that of the most deprived children (NZiDep5). There is no New Zealand data with which to compare this finding. However, a similar pattern of mobile phone usage was found in the European Net Children Go Mobile Project. In that study, almost half (46%) of children of high socioeconomic position had access to a smart phone, in contrast to just over a third (36%) of children of low socioeconomic position (Mascheroni & Ólafsson, 2014). The authors of Net Children Go Mobile discussed financial constraints as the primary reason for the differences in mobile phone usage by deprivation. Interviews and focus groups with parents revealed that the cost of devices and mobile plans influenced when and whether a parent would buy their child a smart phone. It is likely that this explanation would also apply to the Kids'Cam Screen Time participants. Children from less affluent families may be less likely to have smart phones, resulting in less time spent on these devices, explaining the trends observed in this study.

No trend for deprivation was observed for tablet use by deprivation in this study, with all children using tablets equally. If use of tablets can be implied by availability, this finding is somewhat surprising given that the New Zealand Children's Media Use Study reported that seven in ten children (72%) aged 6-14 years had a tablet available in their home, whereas nine in ten (89%) in high income households (>$120k) could access a tablet. Similarly, the Net Children Go Mobile Project found that children from more affluent households had greater access to tablets (Mascheroni & Ólafsson, 2014). That no difference in tablet use by deprivation was observed in this study could be attributed to the likelihood that tablets are more likely than mobile devices to be a 'sharing' device. In contrast to smart phones, which are commonly personal devices, parents may be more likely to allow children to use a tablet at home. Tablets may also be easier for a parent to monitor usage and activities as screens are larger and search histories easier to obtain. If there is no difference in ownership of tablets between deprivation groups, this could, in part, explain the difference in trends between mobile and tablet use.

5.5.3. Screen activity by deprivation

In this study, activities undertaken by children on screens differed by deprivation. As a proportion of total time, the least deprived children watched the least amount of programmes, although they played the most games, and accessed the internet and social media the most. Children in the two most deprived categories (NZiDep 4 and 5) watched programmes on screens 1.75 (95% CI 0.81-3.75) and 1.44 (95% CI 0.95-2.18) times that of the least deprived children (NZiDep 1), respectively. This finding is supported by findings from the 2014 New Zealand Health Survey, in which the most deprived New Zealand children were significantly more likely to watch television for more than two hours per day than the least deprived children (RR, 1.47) (Ministry of Health, 2015).

For game playing, the most deprived children (NZiDep 5) used screens significantly less than the least deprived (NZiDep 1) (RR, 0.11). This finding is consistent with the New Zealand Children's Media Use Study, in which children living in low income households (less than $50,000 per year) reported playing fewer games on the internet than children from more affluent households (Colmar Brunton, 2015). Differences in game playing by deprivation could be explained by the need for specialty gaming equipment such as controllers and game consoles. However, a Belgian study of 1,001 children aged 10-11 years, aiming to identify the specific characteristics of heavy computer game users, found that children from low socioeconomic backgrounds played games on computers more than those from higher socioeconomic backgrounds (Roe & Muijs, 1998). The Belgian study was concerned with computer games exclusively, whereas Kids'Cam Screen Time included games on any screen. Taking the findings of Roe et al. (1998) into consideration may indicate that for less deprived children a substantial amount of screen based gaming is carried out on tablets or game consoles, such as Playstation and X-Box.

Internet usage by the Kids'Cam Screen Time children decreased somewhat with increasing deprivation. The least deprived children (NZiDep1) had significantly greater use of the internet per hour than the more deprived children (NZiDep 4) (RR, 0.06). Although internet use was also found to be greater for children categorised as NZiDep 1 than NZiDep 5, this relationship was not significant. This finding is consistent with the New Zealand Children's Media Use Study, which identified that children from more affluent households were more likely to access the internet (Colmar Brunton, 2015). Although no significant relationships were established, the Kids'Cam Screen Time study found that the least deprived children (NZiDep 1) were the greatest users of social media sites. However, conversely, in the Net Children Go Mobile Project no difference was found in the likelihood of children having a Social Media Profile between the most and least deprived. A potential reason for why the least deprived children were found to engage in social activity more commonly than others, is that social media websites are commonly accessed via smart phones, which, as discussed previously, are used more among children of lower deprivation. Findings by the Net Children Go Mobile Project may be due to differences in the nature of data collection.

5.6. Strengths and limitations of Kids'Cam Screen Time

Kids'Cam Screen Time is one of the first studies to use wearable cameras to investigate the nature and extent of children's after school screen time. As described in Chapter Two, the vast majority of current literature on children's screen time has relied on proxy-report by parents or child self-report. These methods have a number of advantages, including the ability to collect data from a vast number of people at relatively low cost, the ability to assess all aspects of screen time and that study conditions do not alter behaviour under study. Still, numerous limitations of proxy and self-report have also been identified. Social desirability bias can lead to an under-estimation of screen watching, as people may not perceive screen watching to be a valuable use of time and thus report less than the true value. Self-report also relies on participants' memory. Recalling exact time periods spent in front of screens can be a complex cognitive task, especially for young children, and when reported by a proxy (Sallis & Saelens, 2000). Using an objective method to determine children's screen time, such as wearable cameras, removes the need for participants to recall how long they spent using screens, and reduces the opportunity for social desirability bias and the possibility of error. An objective measure of screen time also allows the researcher to better estimate a more exact amount of time each child spent using a screen. In this study it was possible to identify when, and for how long, a child spent using multiple forms of media throughout the afternoon. As such, the use of wearable cameras has the potential to overcome the limitations of previously used methods. The ability to accurately determine the type of screen being used is another strength of the study.

Wearable cameras also have advantages over researcher observation whereby a researcher observes a participant's behaviour in person. Traditionally, researcher observation has been considered to be a more objective means of collecting children's screen time and use than self-report. Wearable cameras are likely to be less invasive than if a researcher were to be present. Accordingly, the risk of a change in participant behaviour due to the presence of a researcher (the Hawthorne effect) is substantially reduced. Kids'Cam participants were advised that the objective of the study and the use of wearable cameras were to assess their day-to-day surroundings and the impact on their health. Thus, it is unlikely that screen watching behaviour was altered by the presence of the camera. Review of the images in this study, combined with communication with annotators of other Kids'Cam projects, indicates that the behaviour of most participants was not influenced. This view is based on the personal nature of some images, despite the participants being given the opportunity to delete such images prior to researcher review and analysis.

Some strengths of Kids'Cam Screen Time are derived from the design of the Kids'Cam study. The latter used a comprehensive method to oversample for schools and participants. As such, the sample included a range of participants, based on deprivation levels, and the three major ethnic groups in New Zealand, namely New Zealand European, Māori and Pacific, a pattern reflected in the Kids'Cam Screen Time sample. The age of the children (11-13 years) was considered an advantage, as they were young enough to not be self-conscious about wearing a camera, but old enough to cope with the demands and responsibilities of the project. Additionally, there is no need for a researcher to be present at the time of data collection, reducing related costs (Raento, Oulasvirta, & Eagle, 2009).

In Kids'Cam Screen Time, one annotator was responsible for analysing each photograph for the instance of a screen. This is an advantage of the study as it reduces the chances of misclassification bias being introduced.

However, a single annotator could also be perceived as a study limitation, for reasons of external reliability. If the annotator misclassified some aspect of the annotation schedule, it is likely that this error would persist throughout the whole of annotation. For example, if the annotator consistently annotated a laptop as 'tablet' when it should be annotated as 'computer', the true association between tablet usage and various demographics may be attenuated by the misclassification bias. To assess the extent of this limitation, and in an effort to minimise its effects, inter-coder reliability tests were conducted early in the annotation phase. This involved a set of images being independently annotated by two other researchers and results compared with the primary annotator's coding, for which agreement of 90% was reached. This indicates that Kids'Cam Screen Time had a high degree of external reliability.

This study has limitations that may have impacted the study findings and should be taken into consideration when interpreting them. After excluding children who had less than 30 minutes of footage for the Thursday after school period, only 62% of the original Kids'Cam participants (105/169) were eligible to participate in Kids'Cam Screen Time. Subsequently, despite similar baseline demographics, the study power was most likely reduced. However, despite wide confidence intervals, general trends were able to be observed.

As the study was primarily interested in recreational screen time, the inclusion of homework-related screen time could contribute to an inaccurate estimate. However, communication with school principals indicated that the amount of time study participants were expected to spend doing homework each night varied between schools. On average, Year 8 students were expected to do approximately 30-45 minutes per night of homework. Of that time, six principals said that no screen time was expected from students to complete their homework and eight indicated that some screen time may be required, however most implied that screen based homework did not make up a substantial proportion of overall homework time. Combined with the activities undertaken on screens observed in the participants' images during annotation, this information suggests that homework played a minor role in the overall screen time recorded in Kids'Cam Screen Time and that the majority of children's after school screen time was recreational.

Of the four days of footage captured in the Kids'Cam project, Kids'Cam Screen Time analysed only the Thursday after school period. Although unlikely, it is possible that Thursdays may differ systematically from other days of the week (for example children may be more likely to have a sports practice on a Thursday than any other weeknight), in which case the results could not be generalised for the rest of the school week. Further, Kids'Cam Screen Time participants captured a mean total image time of 1h 50mins of the approximate five to six potential hours of after school time (3pm-8/9pm), suggesting that a considerable proportion of the after school period was not accounted for in the analysis. Thus, 45 minutes is a conservative estimate of the true value of children's after school screen time. Before school and lunchtime screen time were also not analysed in this study, further contributing to a potential underestimate of the total amount of screen time recorded during the day. Also, weekend screen time cannot be extrapolated from the Kids'Cam Screen Time results as weekend days follow a different structure to school days, including more recreational time. This study was also limited to urban Wellington and results may differ for children living in other urban centres, or in rural settings. The cross-sectional nature of Kids'Cam Screen Time meant that causality could not be inferenced by the results of this study, which was a limitation. Additionally, adjusting for confounding factors such as energy intake and various modes of expenditure was outside the scope of this study.

To remain conservative, some assumptions were made while annotating images. Despite being a direct measure of screen time, the nature of the data meant it was not always clear to the annotator what screen activity was being engaged in. Additionally, at times it was evident from previous and subsequent images that a child had been watching a screen, but due to the eighteen image rule described in Chapter Three, some series of screen watching were unable to be classified as such. This may have led to an underestimation of total screen time.

Another limitation of the Kids'Cam Screen Time project was that the total number of images captured by each child varied somewhat by demographic variables. For example, boys on average captured forty minutes more footage than girls, normal weight children captured twenty minutes more than overweight or obese children, and less deprived children captured thirty minutes more than the most deprived. If it is assumed that children are just as likely to be watching a screen when they are wearing their cameras as they are when they are not, differences in total footage between demographic groups is not an issue. However, if children are less (or more) likely to be engaging in screen media when they are not wearing their camera (for example they take their cameras off for a sports practice), then differences in total number of images captured will confound the results.

Kids'Cam Screen Time was also originally interested in the presence of food marketing on screens, however on review of the images it was found that wearable cameras do not provide the most accurate estimate of children's exposure to screen-based food marketing. The camera is required to capture an image at the exact time that the advertisement appears on the screen, which is unlikely due to the brevity of many advertisements, especially internet ads that are generally scrolled past. Furthermore, interference of light and the position of the camera at the time of the advertisement can make it difficult to identify food marketing.

5.7. Implications for public health policy and practice

Recommendations for children's screen time were developed by the American Academy of Pediatrics (AAP) in the 1990s. The Australian Department of Health (2010) adopted them soon after, stating that children older than two should not spend more than two hours per day using screens (children younger than two should have no screen time). The New Zealand Ministry of Health also recognises the two hour recommendation (Ministry of Health, 2012). These guidelines were originally developed to limit exposure to violent content on television, and to promote physical activity and other more rewarding pastimes such as reading and interactive play. They were developed when screen time essentially comprised of watching television only, or playing old-style computer games. As such, the AAP has acknowledged the recommendations are out-of-date. In a press release in October 2015, the AAP announced that:

> *In a world where "screen time" is becoming simply "time," our policies must evolve or become obsolete. The public needs to know that the Academy's advice is science-driven, not based merely on the precautionary principle.* (Brown et al., 2015)

The Academy is currently in the process of reviewing their current stance on screen time, and is expected to extend the two hour limit in new guidelines that are scheduled to be released in late 2016.

Such an amendment is supported by the findings from Kids'Cam Screen Time, which suggest there may be differences in the health impacts of screen time by screen type. This finding suggests that a blanket ban on screen time is counter-productive, and recommendations on screen time should be made by screen type. To address the impact of screen-based food marketing on childhood overweight and obesity, limits should be applied to time children spend watching television, despite a shift in viewing habits. Content rather than duration of other screen types such as computers, tablets and mobile devices should be regulated.

Kids'Cam Screen Time provides evidence that the range of screen types which children use differ by demographic variables. Although non-significant, Kids'Cam Screen Time observed that the least deprived children watched television the least, and used computers the most. It was also observed that overweight/obese children had a slightly greater rate of television viewing, and lesser rate for computer use. This may be a contributing factor to why a greater proportion of deprived children are overweight or obese than less deprived children. Results from the current study suggest that efforts to encourage positive screen activities, such as Skyping family and accessing websites that promote learning, as opposed to limiting all screen time, may be a more valuable approach to regulating screen time. Additionally, as mentioned previously, screens may also be a potentially useful method of communicating positive nutrition and other health promotion messages (American Heart Association, 2012).

As discussed in Chapter Two, overweight and obesity is not the only adverse health effect of screen time. Psychological stress, attention deficit disorder, and psychosocial issues are all implicated with screen time, as well as internet-related issues such as cyber bullying and privacy issues. Therefore, although Kids'Cam Screen Time found no association with overweight and obesity, it is important that any screen recommendations do not completely dismiss the harmful aspects of screen time. Screen time is largely an individual behaviour, which presents challenges for population-level interventions. Health promotion programmes, including social marketing, could be implemented to ensure children and parents are aware of the negative aspects of excessive screen time, and are knowledgeable about healthy screen behaviours, such as taking frequent breaks and setting protective features on digital media. This is particularly important given screen-based learning is becoming increasingly more common in New Zealand schools. Healthy screen-based behaviours should be incorporated into the school curriculum as part of the day-to-day use of screens in the classroom. Such action would keep children safe, assist in developing life-long healthy screen behaviours and potentially impact screen behaviours in the home. At a population level, consistent and constant messaging through social marketing campaigns and other health promotion initiatives would support individual's behaviours.

While the majority of children's screen time in Kids'Cam Screen Time appeared to be within or close to current recommendations, over a quarter of children used screens after 8pm. Research indicates that screen use so close to bedtime is potentially harmful to children's health (Higuchi et al., 2003). Programmes developed to address children's screen time should include interventions that identify such children and programmes specifically targeted at such children to ensure they develop healthy screen-based behaviours.

Obesity is primarily the result of an imbalance between energy expenditure (physical activity and sedentary behaviours) and energy intake (dietary behaviours). Interventions to reduce child obesity and improve health outcomes focus on increasing physical activity levels and reducing sedentary behaviour, and reducing dietary energy intake. Despite evidence presented in Chapter Two showing a clear association between screen time, and overweight and obesity in children, results from the Kids'Cam Screen Time study indicated that overall, screen time was not strongly associated with overweight and obesity. This finding suggests that screen time may not be a substantial contributor to child overweight and obesity. This conclusion is in keeping with experts' views that although encouraging greater physical activity is an essential element of obesity prevention initiatives (and a key preventive factor in other health conditions such as hypertension), the greatest gains in improving obesity-related health outcomes are from improving the food environment and in turn children's dietary patterns (Ho, Garnett, Baur, & et al., 2013).

Two recent reports provide guidance for public health action to improve food environments. The report of the recent WHO Commission on Ending Childhood Obesity (the Commission) recommended a number of strategies including updating current dietary guidelines and information to include information on the consequences of childhood overweight and obesity, implementing a tax on sugar-sweetened foods and beverages, front-of-pack labelling, and stricter regulations to reduce the marketing of unhealthy foods and beverages to children (World Health Organization, 2016). The

Commission also recommended updating physical activity guidelines for children, and providing children with safe facilities for children to be physically active. Swinburn et al. (2013) identified seven similar priority areas for action to specifically address New Zealand's childhood obesity concerns.

Screen time has been shown to influence food choices and habits through food marketing and associative learning (Cairns et al., 2009; Chapman et al., 2012; Marsh et al., 2013). In New Zealand, food advertising during school age children's (aged 5-13) programming times, defined by two free-to-air broadcasters in New Zealand as between 3pm (TV2) or 3.30pm (FOUR) and 5pm (TV2 and FOUR), must be screened for nutrient content and approved in accordance with a children's food classification system before being broadcast. However, three in five children (n=63 (60%)) in Kids'Cam Screen Time watched television after 5.30pm, and a quarter (n=27 (26%)) were watching television after 8pm. These findings are supported by previous New Zealand research by the Broadcasting Standards Authority, which found that after dinner was a popular television viewing time with children (Colmar Brunton, 2008). Screening food advertisements for nutrition content prior to broadcasting during children's television programming time is likely to protect those children watching television during the current defined times from harmful food promotions. However, given children's viewing patterns reported in this and other studies, the screening period should be extended to a time when children are unlikely to be watching television. The watershed for broadcasting adult content programming on television in New Zealand is 8.30pm (Colmar Brunton, 2008). Based on the findings of this study, even extending restrictions on unhealthy food advertising to the watershed would likely be ineffective in protecting a substantial proportion of children.

Television viewing habits have changed in recent years, with people having a greater ability to record and watch television programmes at a later time. As such, children may now be exposed to unhealthy food advertising at any time when viewing television in this way. On the other hand, such television viewing practises may have a protective effect given that the advertisements can be skipped. The latter situation is also likely to further widen the inequalities in child obesity prevalence, given the cost of the recording equipment. Thus, a total ban on unhealthy food advertising on television would ensure that all children are always protected from its harm. Such a move would likely also benefit the health of the wider population.

While screen-based food marketing was not recorded in this study, other research indicates that food marketing on new media, such as smart phones, tablets and the internet, is a rapidly emerging contributor to childhood obesity (Harris, Heard, & Kunkel, 2015; Kelly et al., 2015). To address such marketing, experts have called for the development of cross-border regulations (World Health Organization, 2016). However, the constantly changing and personalised nature of food marketing on new media, and its international reach, presents challenges for its control (Kelly et al., 2015). Further, given the AAP's prediction that children's screen time is likely to increase, ensuring that children are protected from harmful marketing of any kind should be a priority for governments (Brown et al., 2015).

5.8. Implications for further research

Kids' Cam Screen Time has provided further insight into the situation of children's screen time in New Zealand. As illustrated by the international uptake of the current AAP recommendations of less than two hours per day, screen time is recognised as comparable across the world. Further research on screen time would be useful for informing policy and the upcoming AAP recommendations. The research conducted for this thesis relied on photographs captured on a Thursday as an indication of children's overall screen viewing on a typical weekday afternoon and evening. Extending this timeframe and analysing data from multiple school days would improve the reliability of the findings. Further insight into a child's habitual screen time could also be achieved by using wearable cameras to investigate school days in different weeks and times of the year. Furthermore, Kids'Cam Screen Time focused exclusively on weekday screen time. Further research could also explore the before-school and lunchtime periods, and how screen time on Saturdays and Sundays differs from the rest of the week, and potentially the school holidays.

The Net Children Go Mobile project found that laptops were the most common device on which children were found to access the internet, followed by smart phones, desktop computers and tablets (Mascheroni & Ólafsson, 2014). This finding poses an interesting further research question for the current study with regard to the difference in use of desktop computers and laptop computers, which were aggregated for the purpose of this study. Additionally, Kids'Cam Screen Time did not provide any significant results for the association between tablet use and overweight. As little research is available regarding this association, and given that tablet use is likely to increase, further research may be valuable in targeting weight gain.

Due to the relatively small number of participants in this study, several results lacked statistical significance and most had wide confidence intervals. To increase the study power and better determine the relationships between screen time and overweight, and other demographic variables, further research should include a greater number of participants.

Another further research question may be how screen time and activities vary across New Zealand geographically, and whether children living in rural settings use screens as much and for the same purposes as children who live in cities. Seasonal differences could also be explored to determine whether any difference in screen viewing exists between summer and winter months.

As established in Chapter Two, food marketing appears to play a role in the association between children's screen time, and overweight and obesity. An objective measure of screen-based food marketing would thus be valuable in understanding this relationship more fully. As discussed previously, the method used for the Kids'Cam Screen Time was not conducive to capturing children's exposure to food advertisements. Further research may employ shorter periods in between photographs or video cameras to investigate food marketing more thoroughly. A review of the images indicated that children ate a range of foods while using screens, which may have varied with screen type. Investigating the relationship between food intake and screen types would be an interesting further research question to better understand the relationship between screens and overweight and could be done using Kids'Cam Screen Time data.

Kids'Cam Screen Time demonstrated that wearable cameras are an effective tool for assessing children's screen time. However, as discussed previously, when devoid of context, it was occasionally difficult to discern whether a child was fully engaging with a screen. Reliability could therefore be enhanced by adding a self-report aspect to the method, whereby the child annotates images alongside the researcher using images to elicit further information (photo-elicitation). Combining wearable cameras with a self-report aspect to the study would also make it possible to more accurately and specifically determine activities children are carrying out on screens, which may lead to a more defined relationship between screen activity and various demographic variables. Gemming et al. (2013) found using image data alongside a 24-hour diet recall valuable in determining actual intake, as the strengths of each method were complementary.

5.9. Conclusion

Childhood obesity is a critical public health issue in New Zealand, the impacts of which are vast and varied. Childhood obesity is also a strong indicator for obesity in adulthood, which is associated with numerous co-morbidities, such as stroke, cardiovascular disease, type 2 diabetes and some cancers. Recreational screen time has been identified as a contributing factor to the obesity epidemic, by promoting sedentary behaviour, displacing physical activity, and increasing food intake. This was one of the first studies to investigate children's screen time using wearable cameras, which provided a more objective means of estimating the amount of time children spent engaged with screens and the types of screens they use than in previous research.

Results from this study suggest that the positive association between screen time and overweight and obesity reported in previous literature may be limited to television only. The small negative relationship between the use of new media, such as tablets and smart phones, and overweight and obesity, suggests that new media use may be somewhat protective against overweight and obesity. As discussed previously, this may be an effect of requiring both hands to use new media, for example in the case of smart phones and tablets, which could reduce the propensity to snack. Furthermore, the association observed between television use, and overweight and obesity, was substantially smaller than that reported in the literature, possibly the result of the changing nature of television viewing.

Given the increasing reliance on screen-based learning in New Zealand schools, it is important that schools incorporate healthy screen behaviours into their day-to-day teaching. Similarly parents must be made more aware of such behaviours so they can also be incorporated into home life. Population-based health promotion initiatives would support such programmes. However, evidence from Kids'Cam Screen Time suggests that policy action to address overweight and obesity in children may be better directed at creating healthy food environments, rather than increasing children's physical activity levels and reducing sedentary behaviour. Given the global extent of screen use among children and international acceptance of recommendations for children's screen time, the findings of this study are likely to be of interest in other jurisdictions.

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Appendix A

Kids'Cam Screen Time Cheat Sheet

Definitions

Setting	Definition
Home	Includes all spaces within the home gates and boundaries i.e. indoor and outdoor spaces; or someone else's home
Community venue	Library Recreation centre/community hall - a public space where meetings are held Marae - includes the meeting house, dining hall, education and associated facilities and residential accommodation associated with the Marae. Church
Street	On the street, outside private property or a community venue or retail
Food Retail	A retail store that sells food. Includes supermarkets, cafes, bakeries etc.
Other retail	General product retailers including K-Mart, The Warehouse, Mitre 10, Bunnings; also Whitcoulls, and game and video stores. Primary purpose is something other than food retail
Outdoor recreation space	Parks - characterized by the presence of large open grassed spaces possibly with some equipment such as climbing frames or playgrounds (not primarily used for organised sport). Walking track - characterized by in-bush or off-road areas such as the town belt. Beach River

Private transport	Inside a car, van or truck
Public transport - facility	Associated with public transport facilities – e.g. bus shelters, train stations, airports etc.
Public transport - vehicle	Inside a bus, train, airplane, ferry
Sport	Swimming pool - council facility/publically accessible swimming pool Indoor sports stadium - sports stadiums that are used for recreational sporting games e.g. ASB stadium Outdoor sports stadium - large regional stadiums where professional matches are held e.g. Westpac Stadium Sports clubrooms - club emblems and colours are on display Sports ground - outdoor area designed primarily for the purpose of playing sport (buildings and other associated structures)

Medium	**Definition**
TV	Television screen
Computer	Includes desktop computer and laptops
Tablet	An electronic screen that does not require a keyboard or mouse, most commonly used for surfing the internet and running applications. E.g. iPads or Samsung Galaxy tabs
Mobile Device	A handheld device, most commonly used for surfing the internet and running applications. Includes smart phones and iPods

Category	**Definition**
Programme	When the screen is showing a programme or movie
Games	When child is engaging in playing a game, or watching the screen that another individual is engaging in a game on
Internet	Includes all internet based activity including YouTube and Google
Social	All forms of social activity observed on the screen, includes Facebook, Instagram, Snapchat, Whatsapp, text messaging etc.
Homework	When a child appears to be doing homework, usually characterised by Powerpoint and Word processing programmes. Also used to annotate internet activity that appears to be homework based
Other	Every other screen based activity observed
Undetermined	If the content of the screen is not visible or discernible from the image captured by the autograph
Second screen	Second screen of the same type engaging in the same activity
Background	When a screen is visible in the frame however the child does not appear to be actively watching it, they may be engaged in another activity while another individual is watching/using the screen. Images were also coded as background if it is known that a screen is present and on, but is not in the frame of the photo
Not in frame	Used to describe the situation where the coder is more than 50% certain that the child is still watching a screen despite it not being visible in the image. To classify as "not in frame" it is required that the screen be visible and on in previous and subsequent images and that the child does not move to another room.

Setting	**Medium**	**Category**
Home	TV	Social
Street	Computer	Games
Community Venue	Tablet	Internet
Food Retail	Mobile Device	Programme
Private Transport	Uncodable	Other
Public Transport		Undetermined
Outdoor Retail		Not in Frame
Outdoor Rec Space		Second Screen
Sport		Background
		Blurry/Blocked