Community-based Childhood Obesity Prevention

by

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Community-based Childhood Obesity Prevention
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Publications and conference abstracts arising from this thesis

Journal articles


3 (C). Millar L, Rowland B, Nichols M, Swinburn B, Bennett, C, Allender S. (2012). Effects of sugar sweetened beverage and high fat food consumption and raised BMI z-scores among Australian children from 4 to 10 years of age. Obesity (accepted 22/7/2013) (Refer to Chapter 3)


Invited Keynote presentations

1. **Millar L.** Working together to increase healthy activity & eating, and reduce obesity in our community, forum and workshop. 17 April 2012, Hastings, Victoria, Australia.

Oral conference presentations


challenges in Fiji and Tonga. AEA and PHAA Conference, 9 December, 2011, Melbourne, Australia.


Other publications related to this thesis


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Abstract

Childhood obesity is a serious problem both globally and in Australia and prevention solutions are urgently required. Community-based interventions have shown promising results in preventing obesity in children especially amongst younger children. Understanding successful interventions is essential in determining the appropriate targets to address the obesity epidemic. This thesis investigated a number of targets at an individual level; sugar sweetened beverage (SSB) consumption, high fat food (HFF) consumption, physical activity (PA) and sedentary behaviour, and also the higher order ecological factor of community capacity building, that are aimed at reducing childhood obesity. This thesis aimed to build on existing studies to provide evidence to show the obesogenic behaviours that should be targeted and the most appropriate approaches to childhood obesity prevention.

This thesis comprises a series of 10 manuscripts (labelled A to J) that when taken together, address the research aim and objectives as well as answer the research question. Manuscript A examined the patterns of sweet drink consumption in a sample of Australian children (n=1,604) aged from four to 18 years from the It’s Your Move! and Be Active Eat Well Projects. The data were collected between 2003 and 2008 (mean duration between measures 2.2 years). It was found that children in Australia were frequent consumers of large quantities of sweet drinks with an average of almost 80% of primary and secondary school age children drinking sweet drinks on the surveyed day. The quantities being consumed were also high; the median intake among consumers was 500 ml and almost a third consumed more than 750 ml per day.
Manuscript B used the same data as Manuscript A but examined whether baseline or two-year change in sweet drink intake in children and adolescents was associated with standardised Body Mass Index scores (BMI z-score). Manuscript B found an inconsistent relationship between SSB consumption and weight status in children. No association was observed between time one sweet drink intake and BMI z-score at time two among children or adolescents. Differential effects were observed whereby children from higher SES families reporting an increased intake of sweet drinks at time two compared to time one had higher mean BMI z-score at time two. There was no evidence of a dose-response relationship between sweet drink intake and BMI z-score.

Manuscript C aimed to determine the relationship between frequency of consumption of sugar sweetened beverages (SSBs) and high fat foods (HFFs) and body weight in Australian children aged from 4 to 10 years. Independent associations were found between SSB and HFF and BMI z-scores. With each additional occurrence of SSB intake per day, BMI z-score increased by 0.015 units and with each additional occurrence of HFF consumption per day, BMI z-score increased by 0.014 units. This indicates that SSB and HFF consumption should be targeted in obesity prevention efforts.

Manuscript D examined the relationships between physical activity, sedentary behaviour and body mass index (BMI) among a sample of Australian adolescents. The evidence for targeting physical activity and sedentary behaviour provided in Manuscript D was mixed but in general higher levels of physical activity in males and females was associated with lower BMI z-scores. Analysis of an interaction between levels of physical activity and sedentary behaviour suggested no clear patterns of association.
Manuscript E described the evaluation and reporting of community capacity building within community-based obesity prevention interventions and determined the common strategies used to build capacity. The systematic review of peer reviewed studies between 1970 and 2012 identified nine projects that used a capacity building approach and reported some findings. Only two projects reported formal evaluation of capacity building. The most common strategies to build capacity focused on the allocation of resources, particularly for programs and workforce and community development. It was concluded that evaluation of community capacity should be incorporated into the design of community-based, obesity prevention interventions. Furthermore, ongoing evaluation of community capacity throughout the intervention would support implementation and ensure the project is working to its full potential.

The objective of manuscript F was to describe the common methods used in a series of community-based obesity prevention interventions set among adolescents. The countries that participated in the Pacific Obesity Prevention in Communities project (Australia, Fiji, New Zealand and Tonga) each implemented a community-based intervention programme promoting healthy eating, physical activity and healthy weight in adolescents. Capacity-building was a feature in all countries but the strategies used to deliver the project differed by country. Changes in anthropometric, behavioural and perception outcomes were evaluated at the individual level and school environments and community capacity at the settings level.
Manuscript G reported the outcome results of anthropometric indices and relevant obesity-related behaviours from the It’s Your Move! project (IYM). IYM was a multi-faceted, community-based, obesity prevention project that targeted Australian adolescents (n=2,054; mean age 14.5 years at baseline). It was the Australian arm of the Pacific Obesity Prevention in Communities (OPIC) project (2005-2008). It was found that at follow-up the intervention group recorded relatively lower weight (-0.74 kg, P < 0.04) and BMI z-scores (-0.07, P < 0.03) compared to the comparison group. However, no pattern of positive behavioural change was observed. It was concluded that a capacity building approach can be successful in preventing childhood obesity.

Manuscript H examined changes in community capacity over the course of the year IYM intervention (2005–2008) in schools and asked whether greater increases in capacity were associated with greater decreases in overweight/obesity. It was found that intervention schools increased in capacity over the course of the project and comparison schools did not. The intervention schools that increased the most in capacity also recorded a decrease in the prevalence of overweight/obesity. This analysis showed that capacity building is important to the success of obesity prevention projects.

Manuscript I reported the anthropometric and dietary and physical activity behavioural outcomes of the Ma’alahi Youth Project (MYP). MYP was conducted between 2006-2008 and was the Tongan arm of the Pacific OPIC project. The sample comprised 1,720 adolescents with an average of 14.5 years at baseline. Like IYM, MYP aimed to build the capacity of the community to promote healthy eating and physical activity. The outcomes included a relative decrease in percent fat among the intervention group compared to the
comparison but this was over shadowed by the finding that prevalence of overweight/obesity increased by an average 11% and was almost 60% at follow-up. Stronger efforts were called for if obesity prevention was to be successful amongst this group.

The final manuscript (J) reflected on the strengths and major challenges of the Pacific OPIC project, considered issues affecting these types of research and reported on the developmental direction for future obesity prevention. An important message from this manuscript was the need for long lead times for these types of projects. This would enable a thorough assessment of the needs as well as the collection and analyses of some baseline measures. It is vitally important to identify the areas that require capacity to be built prior to implementation.

The conclusion to this thesis shows that targeting obesogenic behaviours through community based interventions can prevent childhood overweight/obesity. This thesis has demonstrated that increasing community capacity to promote healthy eating and physical activity is one way to prevent childhood obesity. The evidence clearly shows that soft drinks and other sugary drinks should be removed from the diets of children. Other food types which are not essential for healthy growth should also be limited if not eliminated. There is mixed evidence to support the relationship between childhood obesity and physical activity and sedentary behaviour but here is enough evidence to be suggestive of a relationship. When individual level interests are considered within a capacity building approach they are more successful in preventing childhood obesity than they are when targeted singly. This research has added important knowledge to the field of childhood obesity prevention as it has identified alternate population measures of intervention success, and provided directions for future research in the area. These future directions include greater collaboration between leaders in the field to
jointly create standardised measurement tools for evaluating obesogenic behaviours, incorporating longer lead times into projects so that baseline characteristics can be assessed prior to implementation, developing theoretical models to better explain the complexity inherent in community-based prevention projects, developing ways to quantify community capacity in a way that can be used multiple times over the duration of a project, and advancing the science to include a systems approach to prevention.
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Glossary of key terms and abbreviations

BMI  Body mass index, defined as body weight in kilograms divided by square of height in metres (kg/m$^2$)

BMI z-scores Standardised body mass index for age

CDC  Centre for Disease Control and Prevention

CI  95% confidence intervals (unless otherwise specified)

HOYVS Health of Young Victorians Study

IYM  It’s Your Move! the Australian arm of the Pacific OPIC project

kcal  Kilocalories

kj  Kilojoules

LSAC Longitudinal Study of Australian Children

ml  millilitres

MYP  Ma’alahi Youth Project the Tongan arm of the Pacific OPIC project

NCD  Non-communicable disease

Normal weight  -2SD to 1SD (child – WHO standards)

NSCH  National Survey of Children’s Health

Obesity  BMI z greater than 2SD (child – WHO standards)
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<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
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<tr>
<td>Obesogenic</td>
<td>Tending to encourage excessive weight gain</td>
</tr>
<tr>
<td>Overweight</td>
<td>Between BMI z greater than 1SD &amp; less than or equal to 2SD (child – WHO standards)</td>
</tr>
<tr>
<td>oz</td>
<td>Fluid ounce</td>
</tr>
<tr>
<td>PA</td>
<td>Physical activity</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
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<td>SSB</td>
<td>Sugar sweetened beverages</td>
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<tr>
<td>Thinness</td>
<td>Less than -2SD (child – WHO standards)</td>
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<tr>
<td>WHO</td>
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Chapter 1: Introduction

1.1 Chapter overview

Childhood obesity is a serious problem both globally and in Australia and prevention solutions are urgently required. Community-based interventions have shown promising results in preventing obesity in children especially amongst younger children. Understanding successful interventions is essential in determining the appropriate targets to address the obesity epidemic. This thesis investigates a number of targets at an individual level; sugar sweetened beverage (SSB) consumption, high fat food (HFF) consumption, physical activity (PA) and sedentary behaviour (SB), and also higher order ecological factors such as; community capacity building, that are aimed at reducing childhood obesity. This thesis aims to provide evidence to show the obesogenic behaviours that should be targeted and the most appropriate approaches to childhood obesity prevention. The findings may then be used in the development of policy and future interventions.

This chapter provides an overview of the topic, defines key terms, and reviews the relevant research. Only literature relevant to the overall thesis is included as each manuscript also provides background and review material. The chapter also sets out the aims and objectives of the thesis, and explains the significance of the research, and outlines the thesis structure.

1.2 Research context

The main focus of the thesis is obesity prevention among Australian children (it includes children up to age 18 years except where otherwise specified) but it also includes research
from the Pacific region. In trying to understand the reasons for the success of a community-based intervention in Australia I also examined a similar intervention in another country (Tonga). These findings can be used to understand the possibilities for generalisation of this approach outside Australia especially in developing countries with high levels of obesity. All of the research included in this thesis was conducted between 2005 and 2013.

1.3 The problem of obesity

Over the past forty years the prevalence of overweight and obesity among children has increased at an alarming rate. It remains high today and is expected to rise in the future (1-3). In Australia the prevalence of overweight/obesity in 1969 was approximately 8% among young males and 12% among young females (4). Between 1969-1985 there was no change in overweight/obesity among young females (aged between 10 and 15 years) but there was an increase of 35% among males which meant that the males caught up with the females (4). Starting from a base higher than 1969 the prevalence almost doubled between 1985 and 1995 from 11% to 20% among males (aged 7 to 15 years) and 12% to 22% among females (aged 7 to 15 years) (2). Further rises were recorded in 2007-08 for children aged 5-17 years with proportions of overweight or obesity for males at 26% and females at 24% (5). The overall proportion remained stable in 2011-12 (6) (represented in Figure 1). Interestingly, in the most recent study, the prevalence of overweight/obesity among females was 27% compared with 23% of males (6) but this looks like a reversal to the norm as there was only one time period included in this review where the prevalence of overweight/obesity among males outstripped that of females. Figure 1 highlights the sharp increase in prevalence experienced by Australian children from the 1970s to the 1990s then an apparent plateauing. These data show a similar pattern to the worldwide pattern reported by Wang and Lobstein (1).
In a comprehensive review Wang and Lobstein (1) reported that among school age children prevalence increased from the 1970s to the 2000s in all surveyed countries (n=60) except Russia and Poland and among pre-school children the majority of countries recorded increased prevalence. Indeed, the worldwide prevalence of childhood overweight and obesity among pre-school children increased from 4.2% (CI: 3.2%, 5.2%) in 1990 to 6.7% (CI: 5.6%, 7.7%) in 2010. In 2010, 43 million pre-school children were estimated to be overweight and obese and 92 million were at risk of overweight. Furthermore, it was predicted that this trend was expected to reach 9.1% (95% CI: 7.3%, 10.9%), or 60 million, in 2020 (3).

![Graph](image)

**Figure 1 Change in prevalence of overweight/obesity among Australian children from pre 1969 to 2012**

*Adapted from data reported by Booth et al (4), Magarey et al. (2), Maziak et al. (5) and The Australian Bureau of Statistics (6).
To summarise, the prevalence of overweight or obesity among Australian youth increased from approximately 11% in 1985 to approximately 25% in 2011-12 but this increase has not been uniform. There was a rapid increase until about 1996, which then slowed and may have even plateaued in some age groups (6-8). Celebration of these findings may be somewhat premature as the prevalence of childhood obesity remains high making it a serious public health concern plus recent modelling has predicted further increases. In the next section I describe the elevated health risks associated with increased body mass index (BMI).

### 1.4 Health risks of obesity

Obesity is described as the abnormal or excessive fat accumulation that presents a risk to health (9). It is important to note that obesity is negatively related to health. The link between obesity and poor health outcomes has been demonstrated many times. Health indicators include factors relating to physical, social and psychological outcomes.

In Australia a recent study using population representative data found that compared with children in the normal weight range, children who were overweight/obese were more likely to experience a range of physical and psychological problems. The prevalence of overweight/obesity was lowest in the early primary school years (6-7 years; 19%) and highest among adolescents (13-18 years; 26%). As with overweight/obesity the patterns of associations between the comorbidities and BMI varied with age but overall among the older aged children and adolescents poor physical and psychological outcomes were associated
with overweight/obesity (10). These findings can be generalised as the data analysed was from two large, representative data sets (n > 16,000; aged 2 – 16 years). Data from two studies; the Longitudinal Study of Australian Children (LSAC) and the Health of Young Victorians Study (HOYVS), was used to quantify the physical and psychosocial health of underweight, overweight and obese children compared with their normal-weight peers (10). LSAC is an ongoing nationally representative longitudinal cohort survey study which aims to examine Australian children’s development and wellbeing and how this relates to social, economic, and cultural aspects of their environment (11). There are two cohorts of children; the birth (B) cohort and the kindergarten (K) cohort (approximately 4 years at wave 1), and there have been four waves of biennial data collection with wave one data collected in 2004 (11). HOYVS was also a population based longitudinal cohort study that first collected data from five to eight year old children in 1997 (12). Follow-up data collection occurred in 2000 and 2005.

Further concrete evidence of the link between childhood obesity and physical, social and psychological issues is provided in a recent review of the literature (13). The objective of the review was to identify and report associations between childhood obesity with physical and psychological comorbidities. The review covered the years 2000 - 2012 and 79 articles were included. The studies were mostly cross-sectional and were conducted mainly in the USA, Europe and Australia with children aged between 0 and 18 years. The review found an association between metabolic risk factors such as large waist circumference, hypertension, high triglycerides, hyperglycemia, and low HDL cholesterol and overweight/obesity. Furthermore the authors found some evidence between poor dental health and being overweight/obese. To illustrate, a study by Willershausen and others (14) amongst German school children reported a positive correlation ($p = 0.002; n = 2,071$) between BMI and dental
caries and an Australian cohort study (n = 4,149) found that being overweight/obese at 6 years old increased the odds of dental caries at eight years old (OR = 1.26; p = 0.04). There were many studies that found associations between obesity and increased ADHD diagnoses and sleep problems (13). The conclusion that can be drawn from this review is that obesity is related to poor health outcomes in children and so urgent action is required targeting childhood obesity to maximise health and well-being.

Data from the USA’s 2007 NSCH, a large study of children (n = 91,642) aged up to 18 years, was used to explore the relationship between adverse health outcomes and obesity (15, 16). The survey collected demographic information plus substantive health and well-being data for the child and his or her family, and sampling weights (16). Halfon and colleagues (15) found that the prevalence of overweight/obesity in this sample (n= 43,297; aged 10 to 17 years) was 31% according to the CDC’s growth charts (17). Moreover, children who were overweight/obese were more likely to report poorer health status, lower emotional functioning, and school-related problems. Higher rates of specific comorbid conditions that were related to both overweight and obesity included asthma (base=normal weight; OR 1.30, CI 1.05-1.62 for overweight & OR 1.61, CI 1.28-2.03 for obesity), allergies (base=normal weight; OR 1.20, CI 1.03-1.39 for overweight & OR 1.28, CI 1.09-1.50 for obesity) and headaches (base=normal weight; OR 1.43, CI 1.10-1.97 for overweight & OR 1.56, CI 1.21-2.01 for obesity). For obesity only comorbidities included a higher likelihood of poor general health (OR 2.18, CI 1.76–2.69), restricted activity (OR 1.39, CI 1.01–1.65), repeat grade (OR 1.57, CI 1.24–1.99), ADHD (OR 1.29, CI 1.04–1.93), depression (OR 1.41, CI 1.04–1.93), learning disability (OR 1.57, CI 1.24–1.98) and ear infections (OR 2.22, CI 1.55–3.17) among others (15).
In addition to the immediate health implications, there is a link between childhood obesity and adult onset Type 2 diabetes, coronary heart disease and hypertension (18). Childhood obesity is also linked to adult onset cardiovascular disease (CVD) but the aetiology is not clear (19). It is not known whether adult CVD is caused by childhood obesity persisting into adulthood or whether childhood obesity causes CVD directly (19). Moreover, a relatively large and fairly consistent body of evidence now demonstrates that overweight and obesity in childhood and adolescence have adverse consequences on premature mortality and physical morbidity in adulthood (20). What is known is that behavioural patterns learnt in childhood persist into adulthood so early dietary and physical activity patterns predict later ones (21-24). This makes it essential to promote healthy eating and physical activity in childhood.

The reported studies utilised large data sets with representative samples from children in the USA and Australia. It was found that Australian children who were overweight/obese face similar issues to their international peers as poor health outcomes and obesity were related. The findings from individual studies were supported by findings from a recent review of the literature. However, the cross sectional nature of these analyses precludes determining causation and no moderation or mediation analyses were reported so it is not known if the pathways between the outcome and the independent variables were direct or indirect. A second weakness was that many different growth standards were used to report body weight; some used the CDC standards (17), some used the WHO standards (25), some the IOTF (26), some country specific standards while others used adult BMI. The use of different body standards may make it difficult to directly compare findings. Nonetheless there were compelling associations between poor health and overweight/obesity among children.
regardless of the standards used. One explanation for the consistent findings is that different standards (WHO & CDC) provided similar discriminatory functionality for metabolic risk in children (27). Overall, when considering the relationship between weight status and morbidity, longitudinal data are needed to clarify the causal pathways and build the evidence base to better inform policy makers and clinicians.

Despite the limitations, there is strong evidence that childhood obesity is associated with immediate negative physical, social and psychological outcomes and with negative health outcomes in adulthood. Given this evidence and the high levels of childhood obesity there is a clear mandate for intervention to prevent further rises and reduce childhood obesity in Australia. The remainder of the introduction concentrates on the determinants and solutions to childhood obesity.

1.5 Determinants of obesity

Obesity at its most basic level is caused by an energy imbalance within the person; when more kilojoules are consumed than are used, the weight of the person increases. The main contributing factors to the energy imbalance are unhealthy diets, lack of physical exercise and high levels of sedentary behaviour (see Figure 2) (28, 29).
Figure 2 A logic pathway for modelling changes (Δ) in eating, sedentary and physical activity patterns to changes in weight, body mass index (BMI: in kg/m²), and prevalence of overweight and obesity (30).

Different countries have different dietary guidelines that are freely accessible online or in print (31-35). While there are differences in the amounts recommended the overarching principals are similar. Guidelines recommend including higher levels of foods like fruit, vegetables and whole grains, fewer servings of milk (or alternatives) and lean meat (or alternatives), and very little amounts of oil. They also recommend limiting intake of foods high in saturated fat such as many biscuits, cakes, pastries, pies, processed meats, commercial burgers, pizza, fried foods, potato chips, crisps and other savoury snacks (34). Drinking water is encouraged while drinking sugar-sweetened soft drinks and cordials, fruit drinks, vitamin waters, energy and sports drinks are discouraged (34, 36, 37). These recommendations help ensure that children eat sufficient nutritious foods to grow and develop normally (34). These
behaviours need to be promoted to assist children in reaching and maintaining a normal weight.

This thesis will next report the patterns of consumption of SSBs and HFFs, and the relationships between both risk factors and childhood obesity. The section following this determines the amounts of fruit and vegetables being eaten by children and how this relates to childhood obesity. The final section in this part of the thesis describes levels of PA and SB, and how these relate to childhood obesity.

1.5.1 Sugar sweetened beverages and high fat foods

Patterns of consumption

The dietary guidelines are quite specific in their recommendations around limiting the consumption of SSBs but these recommendations are not vigorously followed. The frequency of SSB consumption and the volume consumed has increased or remained high over time and this is likely to contribute to childhood obesity. It is likely to contribute to obesity through the consumption of excess kilojoules as, on average, a 12-oz (~350ml) serving of soda provides 150 kcal (~630kJ) and 40–50 g sugar in the form of high-fructose corn syrup, which is equivalent to 10 teaspoons of table sugar (38). In a recent review by Pan and Hu it was concluded that one reason for the link between SSB consumption and obesity was that liquid carbohydrates was less satiating, and energy compensation at subsequent meals was incomplete and imprecise, which led to increased energy intake (37). This means
that people do not cut back on the food eaten to compensate for the kilojoules ingested through drinking SSBs.

Where once SSBs were reserved for celebrations or treats now it appears it has become the norm in some societies to drink them on a daily basis. For example, analysis of data (n = 3,007) from the Australian National Nutrition Survey, of 1995, found that SSBs were consumed by about a quarter of two to seven year olds, a third of eight to 15 year olds and half of 16 to 18 year olds on the surveyed day (39). The quantity consumed increased with age; 53ml per/day to 364ml for children aged two to three years old and 16 to 18, respectively. When calculated for consumers (rather than the whole sample) the pattern remained similar but the amount was greater, rising from 222ml to 714ml for two to three and 16 to 18 year olds (39), respectively.

A later survey (the 2007 Australian National Children’s Nutrition and Physical Activity Survey) found that the proportion of consumers was lower among the younger age groups compared to the data from 1995: 31% to 12% and 36% to 22% among boys aged two to three years and four to seven years, respectively; and 21% to 13% and 31% to 19% among girls aged two to three years and four to seven years, respectively (40). There were no significant changes among the other age groups (8-11, 12-15, 16-18) or in quantity consumed. The authors did warn that direct comparisons should be treated with caution as the drinks included were slightly different over surveys as were the ages of children.
Differences in reporting are further highlighted by two findings from the same survey. Findings from analyses of the 2007 Australian National Children’s Nutrition and Physical Activity Survey which gathered information on 4,487 Australian children aged 2-16 years were reported in two different articles; one found that 47% of children consumed SSBs on the surveyed day (40) or other authors reported that the proportion was 80% (41). The differences in prevalence can be explained by the criteria used to define SSBs; Clifton et al. (40) included sugar sweetened soft drink, cordial, fruit drink and sports drink whereas Hafekost et al.’s (41) definition was more inclusive and comprised carbonated products (including energy drinks), juices with added sugar, cordial (defined as flavoured drink concentrate), sports drinks, milkshakes/smoothies, and flavoured milk. The rationale proposed for the inclusion of milk drinks was that although they vary in fat content they all contained sugar levels comparable to other SSBs.

Regardless of the differences in outcomes it is still clear that Australian children are consuming SSBs contrary to the recommendations. When compared to children in other developed countries, Australians are placed somewhere in the middle on the table of SSB consumers. The children of America seem to be the largest consumers and children from several European countries the smallest consumers.

Population data from the USA paints a grim picture with almost all children reporting SSB consumption in the middle 2000’s. Cross-sectional data from children aged 2 to 18 years surveyed over three time periods (1977-78, 1989-1991, 1994-96) for the large USA National Health and Nutrition Examination Survey (NHANES) were used to describe SSB consumption (42). It was found that the mean proportion of children consuming SSBs (soft
drinks & fruit drinks combined) on the surveyed day increased from 74% for the first two
time periods to 85% for the final period which is extremely high. In addition concurrent rises
in both the number of serves per day and portions sizes makes consumption levels alarmingly
high. In the earliest survey the average number of serves per day was 2.02 and the average
serving size was 13.1oz (≈387ml) which translates to about 26.5oz (≈782ml) per day. These
amounts increased to 2.2 servings of 15.8oz (≈467ml) or 34.8oz (≈1,030ml) in the second
time period and to 2.55 servings of 18.9oz (≈560ml) or 48.2oz (≈1,425ml) per day for the
final time period (42). The proportion of young people drinking SSBs rose to 90% for the
period 1999-2004 (43). The prevalence of childhood overweight/obesity in 1965 was around
12% (IOTF) (44) and this had risen to 35% in 2003/4 (IOTF) (45). Later reports indicate that
32% of children were overweight/obese in 2009/10 when the CDC growth standards are used
(46). Due to differences in growth standards used it is not possible to comment on the
apparent plateauing of prevalence but this would be in accordance with similar findings from
around the globe (7, 8, 47) but what can be clearly surmised is the large increase in
prevalence from the 1960’s to the mid 2000’s which coincided with increased SSB
consumption.

Children from the USA may not be typical consumers as data from serial cross sectional
surveys of young adolescents in Norway in 2001 and 2008 showed a decrease in the
frequency of consumption per week (p/w) of regular soft drink (2.7 p/w to 1.6 p/w) and
lemonade (4.8 p/w to 2.5 p/w) but an increase in the frequency per week of diet soft drinks
(1.2 to 1.6) (48). The authors speculated that the drop may have been due to concerted efforts
by authorities to reduce the levels of SSB consumed by the population (48). For example
there was a tax increase on SSBs and schools were challenged to decrease SSB consumption
and increase water consumption among the children. In that same time frame the prevalence
of childhood overweight/obesity was approximately 14% (49). Although these figures cannot be directly compared to the figures from the USA, it does appear that children in Norway consume on a weekly basis what the children from the USA consume on a daily basis and there is a smaller proportion of overweight/obese children.

The differences between countries can be seen more sharply when presented together. For example a large analysis involving 114,558 school-pupils aged 11, 13 and 15 from 28 countries participating in the WHO collaborative cross-national study of Health Behaviours among School-aged Children 2001–2002, found that among girls the lower proportions of daily consumers of SSBs were from Finland (5%), Denmark (6%) and Estonia (7%) and the higher from Scotland (42%), Netherlands (38%) and Ireland and Wales (both 35%) (50). Among boys the patterns were similar but the figures differed. The lower proportions of daily consumers were from Finland (10%), Lithuania (12%) and Estonia and Denmark (both 13%) and the higher from the Netherlands (50%), Scotland (49%) and Belgium Flemish (48%) (50). Although there are differences between the European countries, none report prevalence figures for daily consumption of SSBs that approach those reported among children from the USA.

The prevalence of consumers and the quantity consumed may be higher in places like the USA but children in Australia are not far behind and so may benefit from strategies to decrease the level of SSB consumption. To determine if SSB consumption is a suitable target for intervention I will next examine the relationship between SSB consumption and obesity.
Sugar sweetened beverage consumption and childhood obesity

Studies have demonstrated that higher SSB intake is associated with greater BMI (51-54) but there are few among Australian children. In Australia, Tam et al. reported an association between intakes of soft drink/cordial at age 8 years and excess weight gain at age 13 years in both boys and girls (n = 268) from Western Sydney (53). They reported that the average carbohydrate intake from soft drink/cordial was 10 g higher ($p = 0.002$, Mann–Whitney U-test) per day in children who were overweight/obese at follow-up compared to those who had a BMI in the normal range at both baseline and follow-up, and 23 g higher ($p = 0.019$, Mann–Whitney U-test) per day compared to those who reduced their BMI over time; i.e. overweight/obese at baseline and normal at follow-up.

Data from an Australian obesity prevention intervention were used by Sanigorski et al. (55) to determine the pattern of obesogenic risk factors and the association with weight status in children aged 4–12 years. Sanigorski used the baseline data from 2,184 children to describe the cross-sectional relationships between consumption of fruit, vegetables, packaged snacks, fast foods, fruit juice/drink and soft drink with overweight/obesity. Relevant to this section of the thesis, the authors found that two or more servings of fruit juice per day or more than three servings of soft drink was positively related to overweight/obesity (55).

One of these studies used two time points, the other cross-sectional data and both involved young, pre-adolescent children. It remains unknown if the relationships hold among older Australian children or when multiple time points are used. Using representative cohort data with multiple time points allows for robust analysis of changes in behaviours and outcomes,
and in the relationships between factors. Findings from this type of analysis may be
generalised to the wider population and can inform further intervention and policy
development. There have been studies in other countries that have found positive
relationships between SSB consumption and childhood obesity.

Systematic reviews of cross sectional and two-time point studies have identified associations
between consumption of SSBs and increasing body weight in adults and children (38, 56, 57).
Malik et al.’s review comprised 30 studies of which 18 involved children and/or adolescents
but none were from Australian samples (38). There were 13 cross-sectional, six prospective
cohort and two intervention studies (2 of the prospective studies also reported cross-sectional
findings). Of the cross-sectional studies, six found positive associations, three suggested a
positive association and three reported null findings (38). Of the six prospective cohort
studies, four reported positive associations of SSB consumption and childhood
overweight/obesity and two reported non-significant associations. Both the intervention
studies found that reducing SSB consumption was associated with reduced BMI. The largest
of the studies (n=16,679); Growing Up Today, reported both cross-sectional and longitudinal
results (58). They reported only one positive association in the cross-sectional analysis; girls
who drank more sugar-added beverages were heavier (BMI =0.06 kg/m² higher per serving, p
= 0.04). Longitudinal associations were found between consumption of SSB’s and BMI;
boys: + 0.03 BMI units per daily serving, p < 0.05; girls: + 0.02 BMI units, p < 0.10 (58).
Based on all the findings, the authors concluded that there was a relationship between SSB
consumption and body weight but further evidence captured through multi-time point,
longitudinal cohort studies was required to provide more convergence in the data (38).
A large systematic review and meta-analysis reported a positive association between SSB consumption and total energy intake (56). The review comprised 88 studies that investigated the relationship of SSB consumption with total energy intake and/or body weight and/or milk intake. Due to study heterogeneity stratified analysis methods were used. The results pertinent to children were that there was a positive association between consumption of SSB’s and energy intake over 13 studies but the effect was small $r = 0.08$ (0.07, 0.09). Similarly there was a positive association found between SSB’s and body weight (22 studies) with a small but significant effect size 0.03 (0.02, 0.04). There was a negative association between SSB and milk consumption (19 studies): $-0.12$ ($-0.13$, $-0.11$), and the effect size was larger (56). It would appear that as children consume greater amounts of SSB’s their energy intake along with their body weight increases and the drinking of milk is being displaced. These findings provide supporting evidence for the hypothesis of incomplete and imprecise energy compensation (37). There were no studies among Australian children included in the review and meta-analysis.

More research using multi-time point, longitudinal methods is required to establish the relationship between consumption of SSB and body weight in children generally but especially in countries other than the USA. The USA has an extremely high prevalence of SSB consumption amongst children so the findings may not be generalisable to children from countries like Australia. This coupled with the dearth of Australian evidence about frequency and quantity of SSB consumption and its relationship with body weight makes further research an imperative.

1.5.2 High fat food
Patterns of consumption

According to the model above (Figure 2) it is not only SSBs that contribute to obesity but also the type and amount of food that is eaten. Nutritional guidelines can once again be used to identify which foods are best avoided to maintain a healthy body weight. The recent Australian dietary guidelines recommend choosing those foods listed under ‘discretionary choices’ infrequently and in small amounts or not at all (34). These foods are not essential or necessary to healthy diets and are high in kilojoules, saturated fat, added sugars and/or salt (34). For example, among others, most sweet biscuits, cakes, desserts and pastries; processed meats and sausages; ice-cream; confectionary and chocolate; savoury pastries and pies; commercial burgers; commercially fried foods; potato chips, crisps and other fatty and/or salty snack foods; cream, butter and spreads which are high in saturated fats fit into the ‘discretionary’ category. For the sake of parsimony from here on these types of energy dense/nutrient poor foods will be labelled high fat food (HFF).

The guidelines from New Zealand are similar to the Australian guidelines in that they recommend limiting foods high in fat, sugar and/or salt to once a week at the most as these types of foods provide few vitamins and minerals and are not essential to a healthy diet (31). The examples of foods that should be avoided are very like the list from the Australian guidelines. The recommendations from the USA are more specific and include actions around reducing daily salt intake to less than 2,300 mg, consuming less than 10% of calories from saturated fat, consuming less than 300mg of dietary cholesterol, keeping trans fatty acid consumption as low as possible, reducing the intake of calories from solid fats and added sugars, and limiting the consumption of foods that contain refined grains (32). These science-
based guidelines were designed to decrease the risk of obesity and other chronic diseases by limiting the consumption of HFF but whether they are followed or not are yet to be determined (31, 32, 34).

In Australia the changes in consumption of HFFs among Australian children have been tracked. Data from the 1985 National Dietary Survey of Schoolchildren and the 1995 National Nutrition Survey were compared and the findings reported (59). The proportion of children aged from 10 to 15 years consuming confectionary on the day of the survey increased between 1985 and 1995 for both boys and girls. For boys the percentage consuming increased from 34% to 50% and the mean intake increased by 9g per day (59). For girls the proportion consuming increased from 42% to 50% and the mean intake increased by 6g per day (59). The same study found that the proportion of children consuming snack foods had also increased from 27% to 29% among boys and from 33% to 36% among girls but the average intake per day remained at 12g (59).

Another study utilised the 1995 National Nutrition Survey and analysed the data with respect to ‘extra’ foods. “Extra’ food is defined as it is implied; food that is not necessary to maintain good health. In the latest Australian Dietary Guideline ‘extras’ are now termed ‘discretionary foods’ (see above) (34). Analysis of data from the 1995 National Nutrition Survey (n = 3007; aged from 2 to 18 years) found that almost all (99.8%) the children consumed at least one ‘extra’ food in the 24 hours prior to the survey (60). The consumption of ‘extra foods’ contributed an average of 41% to daily energy intake, which is two to four times higher than the recommended limit of 5–20%, as specified in the now superseded Australian Guide for Healthy Eating (AGHE) (61). The ‘extra’ foods contributing most to average energy intakes
were fried potatoes (4.2%), SSBs (3.3%), ice cream/ice confection (3.1%) and sweet biscuits (2.4%) (60).

At a later date the authors, Rangan et al., compared the findings above to findings from the 2007 Australian National Children Nutrition and Physical Activity Survey (n = 4,896, aged from 2 to 16 years) (62). The results from 2007 suggest that similar proportions of children (99.7%) were consuming ‘extra’ foods but the proportions of intakes differed. When comparing the average intakes from 1995 and 2007 of fried potatoes (4.2% in 1995 to 2.9% in 2007), SSBs (3.3% in 1995 to 1.7% in 2007), ice cream/ice confection (3.1% in 1995 to 2.4% in 2007) and sweet biscuits (2.4% in 1995 to 2.5% in 2007) in almost all cases the proportion of daily intake accounted for by the ‘extras’ was lower. Not only were the proportions lower but the average daily kilojoule intake had also decreased from 1995 by approximately 300 kJ in 2007 for boys and 250 kJ for girls (62). These small changes have resulted in a shift in the right direction but the consumption of ‘extra’ foods remains high among Australian children, contributing to 35% of energy intake which is still more than twice the recommended limit of 5—20% of energy intake set by the AGHE and far in excess of the recommended intake in the new guidelines (61). It is now recommended that these types of foods not be eaten especially if you are short, small, above your healthiest weight or not very physically active, or the portion size needs to be quite small (34). Nonetheless, these changes have paralleled the plateauing of childhood obesity in Australia but the consumption of ‘extra’ foods remains high as does the prevalence of overweight/obesity.

The surveys used in the preceding are representative of Australian children generally but there are sub-sections of the community where a less healthy diet is more likely to be
consumed. For example, a cross-sectional study involving 259 children (n = 102 of Aboriginal and Torres Strait Islander children & n = 157 of non-Indigenous children) aged 10 to 12 years from a rural area in Australia aimed to describe the food and nutrient intake in 2005/6 using three 24 hour food recalls (63). The study found that energy dense/nutrient poor foods accounted for almost half of the daily energy intake (63). Stronger intervention strategies generally but especially among vulnerable groups are needed to bring Australian children’s daily diet in line with the recommended guidelines as they are still consuming too much energy dense/nutrient poor foods and this may be contributing to the high levels of childhood overweight/obesity.

In the USA surveys over the past 20 years highlight the changes in dietary patterns among children (64). Data from 10,647 children aged 2 to 6 years who participated in the Continuing Survey of Food Intake in Individuals 1989-1991 and 1994-1998 or the What We Eat In America, National Health and Nutrition Examination Surveys 2003-2004, 2005-2006, and 2007-2008 were analysed and the types and quantities of food consumption over time reported. There was increased consumption of savoury snacks (51 kcal; p<0.01), pizza/calzones (32 kcal; p<0.01), sweet snacks and candy (25 kcal; p<0.01), fruit (24 kcal; p<0.01), mixed Mexican dishes (22 kcal; p<0.01), cheese (21 kcal; p<0.01), and fruit juice (18 kcal; p<0.01) and decreased consumption for ready to eat (RTE) cereals (25 kcal; p<0.01), starchy vegetable dishes (22 kcal; p<0.01), and nuts and seeds (19 kcal; p<0.01) (64).

Cross-sectional data also highlight the contribution of energy dense/nutrient poor foods to high levels of kilocalories (kcal) consumed daily by children from the USA. For example, a study using data from the US Department of Agriculture’s Continuing Survey of Food
Intakes by Individuals (CSFII) 1994 to 1996 found that about one third of children (N = 6,212) aged 4 to 19 years on a typical day (n = 1720; 30.3% of the total) ate fast food. This consumption was significantly and positively associated with total energy, total fat, saturated fat, total carbohydrate, added sugars, sugar-sweetened beverages, and non-beverage energy density (65). Conversely, fast food consumption was significantly and inversely associated with consumption of fibre, milk, fruits, and non-starchy vegetables (65). The authors calculated that because 30.3% of study participants ate fast food on any given day, these foods seem to contribute an additional 57 kcal (187 kcal x 30.3%) to the daily diet of the average child in the United States which could, theoretically, result in an additional 6 pounds of weight gain per child per year, assuming 3500 kcal/pound of body weight, if energy expenditure were unchanged (65). It appears that a more healthy diet was being replaced by a more unhealthy diet and this was contributing to excess weight gain.

A later study reported a higher proportion of children consuming energy dense/low nutrient foods. Analysis of 24 hour recall dietary data from 2,314 children from grades 1 through to 12 participating in the 2004/5 3rd School Nutrition Dietary Assessment Study showed that 68% of children consumed SSB’s averaging 159 kcal and 88% consumed energy dense/low nutrient foods averaging 368 kcal throughout the day (66). This translates to children having consumed 527 “empty calories” during a 24-hour period (66). Together, these studies suggest that the increase in the quantity of energy dense/nutrient poor foods consumed was accompanied by an increase in the proportion of children eating those foods. In the main the consumption of energy dense food by children in the USA increased and this may have been a factor in the increased levels of obesity.
In the UK the story was slightly different with mixed results for changes in consumption of selected foods. Data from the National Diet and Nutrition Surveys (NDNS) of 1997 and 2008/9 were examined to identify and describe changes in food consumption and nutrient intakes in the UK (67). The representative sample included young people aged 4–18 years (n = 462 in 2008 & n = 1,701 in 1997). The study found that consumption of ‘pasta, rice and other cereals’ (including pizza) increased from 1997 to 2008–09 in boys and girls aged 4–10 years, and boys aged 11–18 years (all \( p < 0.0001 \)) (67). However, consumption of ‘chocolate confectionery’ decreased significantly among all children (\( p < 0.001 \)) and consumption of ‘savoury snacks’ decreased significantly among the younger age groups (both sexes \( p < 0.0001 \)). In the older age groups, consumption of ‘sugar, preserves and sweet spreads’ (including table sugar) decreased (both sexes \( p < 0.0001 \)) and in boys aged 4–10 years, consumption of biscuits (\( p < 0.0001 \)) and sugar confectionery (\( p < 0.0001 \)) also decreased over time (67). Soft drink consumption decreased (both sexes \( p < 0.0001 \)) but fruit juice consumption increased among boys of both age groups (\( p < 0.0001 \)) while water consumption increased for all groups of children (\( p < 0.0001 \)) (67). Similar to the Australian findings, the changes were mostly healthful and if these trends continue there may be subsequent changes in population prevalence of childhood overweight/obesity. Changes in prevalence depend on there being a relationship between consumption of energy dense/nutrient poor foods and weight change.

**High Fat Food consumption and childhood obesity**

There are few Australian studies that examine the association between the consumption of energy dense/nutrient poor foods and childhood obesity and none that use representative data. One state based study has shown mixed results. MacFarlane and colleagues examined
whether aspects of the family food environment were associated with BMI z-scores in a survey of Australian children (68). Cohort data were drawn from the baseline and first follow-up phases of the HEAPS study, conducted in 2002/03 and 2006. Included in the analyses were 161 children in the younger cohort (aged 5 to 6 years at baseline) who had follow-up measures and 132 in the older cohort (aged 10-12 years at baseline). Cross-sectional and longitudinal (2 time points) analyses were reported. The study reported very few statistically significant relationships either cross-sectionally or longitudinally between breakfast eating patterns, food consumption while watching TV, parental provision and child consumption of energy dense/nutrient poor food away from home, and parental provision and child consumption of energy dense/nutrient poor food at home with BMI z-scores. The only significant associations were the longitudinal relationship between infrequent breakfast consumption (compared to daily breakfast consumption) in older children with weight status (OR = 2.2; 95% CI 1.1, 4.7) and the cross-sectional relationship between eating fast food at home one or more times per week (compared to less than once per week) in older children at baseline with weight status (OR = 3.1; 95% CI 1.4, 7.0) (68); children who were infrequent breakfast eaters or ate fast food once a week or more at home were more likely to be overweight/obese. There appears to be little relationship between the factors tested above but more studies from countries other than Australia may provide more compelling evidence.

Studies from countries where there is a culture of research around fast and convenience foods, like the USA, can provide the necessary evidence of the strength of associations between consumption of energy dense/nutrient poor foods and childhood obesity. An example of this is provided by analysis of a cohort study from the USA that found a link between fast food consumption at an earlier time and body weight at a later time (69). As part of the National Longitudinal Study of Adolescent Health in the USA data were collected
from 9,919 children in Waves II (age range 11–21 years) and III (age range 18–27 years) in the years 1996 and 2001/2, respectively (69). The frequency of consumption of fast food increased from 2.15 ± 0.05 serves per week to 2.48 ± 0.05 (t = 5.50, p < .0001) from wave II to III. In addition the frequency of fast food consumption at Wave II predicted BMI z-scores at Wave III; for each additional day of fast food consumption at Wave II, BMI z-scores were predicted to increase by 0.02 by Wave III (β = .02, p < .05) (69).

Still further evidence of a link between fast food consumption and adiposity was reported by Taveras et al. (70). The authors used data from the ongoing Growing Up Today Study to investigate the cross-sectional and longitudinal associations (yearly intervals 1996 to 1999) between consumption of fried foods away from home and BMI. The sample comprised a cohort of 7,745 girls and 6,610 boys, aged 9 to 14 years at baseline (1996) who self-reported heights and weights, and food intake (70). At baseline 60% of respondents were eating fast food away from home one or more times per week and BMI was found to be linearly related to increasing categories of fast food away from home (p = 0.02 for trend) among boys (70). The longitudinal analysis using data from 1996, 1997, 1998, and 1999 found that children who increased consumption of fast food away from home from “never or <1/week” to “4 to 7/week” gained approximately 0.21 BMI units (95% CI 0.03, 0.39). The reference group in the longitudinal analyses were children who consumed fast food away from home “never or <1/week” at baseline and 1 year later (70). Another study that utilised the same dataset but from years 1996, 1997 and 1998 tested the relationship between snack food consumption and BMI z-scores (71). The study which included only snack foods (n = 25) such as potato chips, popcorn, cookies, pie, jello etc. found that changes in intake were unrelated to changes in BMI z-scores over time. However, at baseline (1996) the average number of serves of snack foods per day was three and these accounted for approximately 18% of caloric intake per day.
(71). One reason for the difference in findings may be that in the Taveras et al. study the comparison groups were extreme; i.e. the group that changed from low to high consumers against those who remained low, whereas in the second study a continuous measure was used. Perhaps there is a cut point where the association between consumption of energy dense/nutrient poor foods becomes positive. Regardless of the disparity in findings it remains that in this sample at baseline, a large proportion of children were regularly eating fast food away from home and were, on average, eating three snack foods per day which together makes for an unhealthy diet.

Results from the UK were concordant with those from the USA. The association between eating fast foods at age 13 and body measurements at 15 was tested using data from the Avon Longitudinal Study of Parents and Children (ALSPAC) (UK). The participants included 4,827 children from birth cohort who were recruited in 1990’s (72). The study found that food consumption at age 13 was significantly related to standardised BMI at 15 years ($\beta = 0.08; 95\% \text{ CI } 0.03, 0.14$), as was percent fat ($\beta = 2.06; 95\% \text{ CI } 1.33, 2.79$) and the odds of being obese also were elevated (OR 1.23; 95\% CI 1.02, 1.49) (72).

Within Australia the evidence is scant but there is strong evidence from the large longitudinal studies outside of Australia of the positive relationship between the consumption of energy dense/nutrient poor foods and childhood obesity. However most of the evidence originates from the USA where the prevalence of consumption of energy dense/nutrient poor foods is high and so the results may not be applicable to Australian children. More evidence is required if these types of foods are to be an intervention target.
The evidence from cross-sectional studies has not been as strong as that from the longitudinal studies above. For example, analysis of the Survey of Sugar Intake among Children in Scotland used to identify associations between dietary patterns and obesity (73). The survey found that there was no consistent association between unhealthy dietary patterns and obesity with only one significant relationship between lower snack food consumption with higher BMI in boys aged 5-11 years \( (p \text{ for trend}=0.047) \) (73). Another found a null relationship; analysis of a self-reported food frequency questionnaire that was completed by 513 randomly selected high school students from Greece showed that snack consumption (eating sandwiches, cheese pies, croissants, and other snacks between breakfast and lunch) was not associated with BMI \( (p>0.05) \) (74). Still in Greece it was found that eating sweets and snacks (per 1 serving/week) was not associated with overweight/obesity in boys or girls compared with not eating sweets or snacks (75). A Swedish study investigated eating habits and body fatness in children \( (n = 476; \text{ age range } 16-17 \text{ years}) \) (76). It was reported that fast food intake was not correlated with percentage of body fat in boys or girls. In contrast, in Bogota in 2006 a study found a positive relationship between high adherence to a snacking pattern that contained foods like candy, ice-cream, packed fried snacks and SSBs and overweight/obesity \( (PR 1.95; 95\% CI 0.99-3.84) \) compared low adherence using data from 3,075 children aged between 5 and 12 years (77).

In contrast to the longitudinal findings, the cross-sectional data presented above provides little evidence for a positive association between high levels of fast food intake and body weight in children. Caution needs to be applied when interpreting cross-sectional studies because without temporal data, causal pathways cannot be established and the possibility of
reverse causality cannot be ruled out (that is being overweight causing a reduction in consumption) (78). The preceding studies that have investigated the dietary determinants of obesity have included each of the determinants separately so it is unknown if one accounts for the other when included together. It may be that the variance in BMI attributable to SSB consumption is attenuated by addition to the equation of HFFs.

**Combined studies of sugar sweetened beverages and high fat foods and childhood obesity**

Data from an Australian obesity prevention intervention were used by Sanigorski et al. (55) and later by Johnson and colleagues (79) to determine the pattern of obesogenic risk factors and the association with weight status in children aged 4–12 years. Sanigorski used the baseline data from 2,184 children to describe the cross-sectional relationships between consumption of fruit, vegetables, packaged snacks, fast foods, fruit juice/drink and soft drink with overweight/obesity. The authors found that the high consumption of fruit (> 3 serves per day) was positively related to overweight/obesity as were 2 or more servings of fruit juice or more than 3 servings of soft drink (55). Consumption of packaged snacks and fast foods were not related to weight status. It may be that children who consumed greater amounts of fruit and/or vegetables generally consumed more kilojoules and so were more likely to be overweight/obese.

More recently Johnson et al. reported a multi-level analyses of the pre/post intervention data that examined changes in obesogenic risk factors and changes in BMI z-scores (79). The authors used moderation analysis to check for intervention effects. Using similar individual
level independent variables as Sanigorski et al. (55) and with the inclusion of household and school level variables, the study found that there was an overall effect on BMI z-scores with the intervention group recording a score 0.085 units ($p = 0.03$) lower than the comparison group. In relation to behaviours the study found that with each extra glass of sweet drink consumption BMI z-scores increased 0.015 units ($p = 0.02$) and with each extra hour of screen time BMI z-scores increased by 0.017 units ($p = 0.02$). There were no other significant relationships. This suggests that an increasing intake of fruit or vegetables is not related to increasing BMI z-scores and provides supporting evidence for the baseline hypothesis above.

Both these analysis provide support for a relationship between SSB consumption and childhood obesity but not for HFF consumption and childhood obesity. The findings are from an intervention study in younger children with a pre/post design. A multiple time-point, longitudinal, cohort study may provide power enough to detect independent relationships between SSB and HFF consumption and childhood obesity. Furthermore, additional studies among older Australian children are needed to add to the evidence base.

The findings from the Australian data are similar to those from around the globe. These studies have found weak relationships between consumption of HFF and increased body weight but more robust findings between SSB consumption and increased body weight. For example, longitudinal analysis of data from the Massachusetts Institute of Technology Growth and Development Study, USA, tested the relationship between energy dense food and beverage intake with relative weight status and percentage body fat (80). The sample comprised 196 non-obese premenarcheal girls 8 to 12 years old were enrolled between 1990 and 1993 and followed annually until 4 years after menarche. The study reported no
association between consumption of candy, chips, baked goods and ice-cream with BMI z-scores or percentage body fat. However, there was a significant positive association between consumption of soda and BMI z-scores where BMI z-scores were 0.17 units higher in the 3rd and 4th quartiles of percentage calories from soda compared to the first quartile ($p < 0.001$ for trend) but not with body fat (80).

More recently, inconsistent findings between unhealthy diets and body weight were reported by Laska et al. (81). The objective of the study was to examine the extent to which changes in adolescent sugar-sweetened beverage (SSB), diet soda, breakfast, and fast-food consumption were associated with changes in BMI and percent body fat (81). The sample comprised two cohorts of adolescents (N = 693; mean age at baseline 14.6 years) from Minneapolis-St Paul, Minnesota, with data collected at baseline (2006/7 or 2007/8) and follow-up 24 months later (2008/9 or 2009/10) (81). Data were analysed cross-sectionally and longitudinally. After adjusting for total physical activity, total energy intake, puberty, race, socioeconomic status, and age, the statistically significant cross-sectional relationships included breakfast consumption being inversely associated with BMI and percent body fat in males (BMI: $-5.08 \text{ kg/m}^2$, $p = 0.001$; % body fat: $-8.82\%$, $p = 0.002$) and in females (BMI: $-4.33 \text{ kg/m}^2$, $p = 0.008$; % body fat: $-7.30\%$, $p = 0.001$) and diet soda intake was positively associated with BMI and percent body fat among females (BMI: $2.45 \text{ kg/m}^2$, $p = 0.001$; % body fat: $3.64\%$, $p < 0.001$) (81). In longitudinal analyses there was only one significant relationship; among males there found was an association between SSB consumption and percent body fat with an increase of one serving of SSB per day being associated with an increase of 0.7 units of PBF ($p = 0.001$) (81). The findings are mixed from studies among adolescents from the USA but the first study included only females and the second was pre/post data from one city in the USA.
Limitations of measuring consumption of sugar sweetened beverages and high fat food

The mixed findings may be due to the differences in foods included in studies and the limitations of dietary assessment methods (82). Measurement and interpretation of SSB consumption is less complex than measurement of HFFs as the kilojoule content of SSBs is quite uniform and the beverages are usually presented in standard sizes so measurement can be more precise. Conversely HFF includes a range of diverse food items, and studies have variously defined HFFs according to frequency of consumption, calculated energy density or number of convenience foods (not fast foods) (69, 72, 81, 83).

The sections above provided an overview on foods that potentially lead to increased prevalence of childhood overweight/obesity. It was shown the SSB consumption does have a consistent positive relationship with childhood obesity but the relationship with HFF was not as clear. This overview also highlighted the dearth of information on these relationships among Australian children and adolescents in particular. The following section provides evidence on the pattern of consumption of foods that can potentially prevent childhood obesity; fruit and vegetables.
1.5.3 Fruit and vegetables

In relation to fruit and vegetables, many countries have their own recommendations for the optimal daily consumption required to promote good health (31-34) and other countries use the WHO guidelines which recommend a minimum of five servings (400g) of combined fruit and vegetables per day (35) but the majority of populations eat at levels below guidelines (84-92). Examples of dietary guidelines include: the latest Australian guidelines suggest that children aged two to three years eat a minimum of two and a half serves of vegetables and one serve of fruit per day and this increases through the age groups to five and a half serves of vegetables and two serves of fruit for 14 to 18 year old boys; New Zealand guidelines specify two or more servings of fruit and three of vegetables daily for all children (31); Canada recommends a combined total of five serves for four to eight year old children, six servings for the nine to 13 age group, seven for females aged 14 to 18 and eight for males the same age (33); and, in the USA the number depends on the sex, age and activity of the child (32).

Over the past 15 years the evidence from Australian national studies shows that fruit and vegetable consumption among Australian children and adolescents has declined over time (93). In 1995 three quarters of surveyed children and adolescents ate some fruit that day and one fifth ate vegetables (93). Nonetheless, only one third of those children and adolescents met the recommended minimum daily fruit and vegetable intake (93). Findings from a 2007 Australian survey found that 61% of four to eight year olds consumed adequate fruit but only 1% of 14 to 16 year olds met the recommended guidelines (94). Similarly, with vegetable consumption 22% of the younger aged children met the dietary guidelines for vegetable intake and 5% of the older group (94). The news is slightly better in 2011-12 when 95% of
five to 11 year old Australian children met the recommended daily intake of one serving of fruit per day and 20% of children aged 12-17 years met the recommended daily intake of three servings (6). Similarly, a higher proportion of the younger age group (5-7 years) met the recommended intake of vegetables per day compared to the middle age group (8-11 years) and the older age group (12-17 years) (56%, 31% & 15%, respectively). The proportion of children meeting the guidelines would diminish if the new dietary guidelines of 2013 were the comparators as these guidelines recommend greater consumption of fruit and vegetables (34). At the same time that low levels of fruit and vegetable consumption were recorded, the prevalence of obesity continued to increase or, in the later years, plateau. Given the low levels of fruit and vegetable consumption it is unlikely that these foods contribute to the excess kilojoules required to cause an energy imbalance.

The following examples from international studies illustrate childhood dietary patterns in relation to the consumption of fruit and vegetables. Analysis of the 2003–2004 National Health and Nutrition Examination Survey (NHANES) found that American adolescents less than 1% consumed the recommended daily servings of fruit and vegetables (88). In Canada, a large survey conducted in 2003 involving 18,524 adolescents found that over 50% ate fewer than 5 serves of combined fruit/vegetables per day (91) and in Scotland, adolescents (n = 6,410) reported eating fruit and vegetables on fewer than 5 days per week in 2010 (89). Data from almost 27,000 Italian children showed that only 8% of three year olds consumed five portions of a combination of fruit/vegetables daily but 41% consumed SSBs on a daily basis. Older children reported a similar pattern with 10% of five to six year old children met the WHO guidelines for daily fruit and vegetable consumption but 51% consumed sugar-sweetened beverages (86). Furthermore, in the year 2000, over half of all surveyed adolescents (n=443) from the Kingdom of Tonga in the Pacific Islands reported eating no
fruit or vegetables at least once per day (92). In a later study it was found that two-thirds of Tongan adolescents (n=2,084) reported a low frequency of fruit consumption (85). The consumption pattern of fruit and vegetables among Australian children and adolescents mirrors international findings. Regardless of methodology or country of origin the evidence points to low levels of fruit and vegetable consumption by children and adolescents the world over.

To conclude the section on the dietary determinants of childhood obesity, it was shown that in some countries many children are consuming large amounts of SSBs and HFFs and low amounts of fruit and vegetables. SSB consumption in particular was related to childhood obesity but the findings were mixed in respect to the relationship between the consumption of HFF and childhood obesity. The longitudinal studies from the USA suggested a relationship but the findings from cross-sectional studies were mixed. When both SSBs and HFFs were included in the one analysis only SSB consumption was related to childhood obesity but there were limitations to the studies. What was apparent was the lack of studies using large representative samples of children over multiple time points to provide robust evidence of the relationship between changes in SSB and HFF consumption and changes in BMI. One other gap highlighted was the lack of evidence emanating from Australia.

1.5.4 Physical activity and sedentary behaviour

Physical activity and sedentary behaviour guidelines

Moving to the energy output side of the equation, the changes in the pattern of food consumption have also been accompanied by changes in physical activity and sedentary
behaviours. The WHO defines physical activity (PA) for children as including play, games, sports, transportation, chores, recreation, physical education, or planned exercise, in the context of family, school, and community activities and recommends that children aged 5 to 17 years should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily (95). Sedentary behaviour (SB) has been defined as time when children are doing very little physical movement and includes sitting for long periods, using motorized transportation, watching television, playing passive video games and playing on the computer (96).

Around the globe most countries have adopted similar guidelines. For example, in Australia, it is recommended that children aged 5–18 years accumulate at least 60 minutes, and up to several hours, of moderate to vigorous PA every day and no more than two hours of screen time a day for entertainment (i.e. excluding educational purposes) (94). The USA guidelines propose that children and adolescents should do 60 minutes (1 hour) or more of physical activity daily (97) as do the ones from the UK and Canada where it is recommended that in addition to the PA they should also minimise the amount of time spent being sedentary (sitting) for extended periods (96, 98). This is similar to the European guidelines which state that school-aged youth should participate in 60 minutes or more of moderate to vigorous PA daily, in forms that are developmentally appropriate, enjoyable, and involve a variety of activities (99). In general it is recommended that children should participate in at least one hour of moderate to vigorous PA and limit screen time to no more than two hours per day. The majority of children do not adhere simultaneously to both these guidelines.
Patterns of prevalence

Approximately two-thirds of young people (aged 9 to 16 years) in Australia met the recommended amounts of moderate to vigorous physical activity and pedometer steps but only one-third met the recommendations for screen time according to findings from the 2007 National Children’s Nutrition and Physical Activity Survey (94). These findings were similar to a 2010 state-based survey that reported 63% of students in Years 6, 8 and 10 met the PA guideline during summer school terms, but fewer met the guideline during winter school terms (51%) (100). When the percentages are averaged it appears that the proportion of children meeting the recommendations is decreasing. Indeed there is evidence to support this finding. Between 2004 and 2010 the prevalence of children meeting the PA guideline decreased at an annual rate of approximately 2.2% for boys and 1.2% for girls (100). At the same time, the amount of time in sedentary behaviour and screen time increased over time among boys, 5.7 hours per day to 6.0 hours and 2.9 hours to 3.0 hours, respectively but for girls the time remained the same; was 5.3 hours per day for sedentary behaviour and 2.3 hours for screen time. These figures indicate that Australian children are becoming more inactive and increasingly sedentary over time and this may be the same in other countries.

The children from the USA exhibit similar behavioural patterns. Data from the 2009-2010 National Health and Nutrition Examination Survey, a representative sample of the US population, show that among children aged 6 to 11 years (n=1,218), 70% met physical activity recommendations and 54% met screen-time viewing recommendations but only 38% met both recommendations concurrently (101). These results are cause for concern as levels of physical activity generally decrease with age. For example, the 2011 Youth Risk Behavior
Surveillance (USA) showed that the proportion of children doing no exercise increased with age; from 11.2% (95% CI 9.9, 12.8) in year 9 to 13.8% (95% CI 12.8, 14.8) in year 12 (102).

It appears that children in Canada are less active and more sedentary than their Australian peers. Active Healthy Kids Canada recently reported that the percentage of 10 to 16 year olds accumulating 60 minutes of moderate to vigorous physical activity on a daily basis remained low but stable between the 2002 (18%), 2006 (19%) and 2010 (18%) (103). They also report that in 2009/10 only 19% of children aged 10-16 reported meeting the Canadian sedentary Behaviour Guidelines (≤ 2 hours of recreational screen time per day) and that the average screen time per day was 6 hours and 37 minutes (103).

![Figure 3 Trends in daily moderate-to-vigorous physical activity, 21 EU countries, 2005-06 to 2009-10 (104)](image)

Source: Currie, C. et al. (2008), Inequalities in Young People's Health; Currie, C. et al. (2012), Social Determinants of Health and Well-being Among Young People.
In Europe, the proportion of children meeting the recommended guidelines for moderate to vigorous PA decreased as children age and they have also decreased over time (Figure 3).

In addition, the average amount of screen time reported by children across a number of European countries exceeded the recommended 2 hour maximum (Figure 1.5.3) (105). These European data show that young people in Europe are failing to meet the recommended guidelines for both moderate to vigorous physical activity and for screen time.

Figure 1.5.3 Screen time in minutes for combined TV and computer use among European children aged 10 to 12 years in 2010

Adapted from data reported by Brug et al. (105)
Overall only a small proportion of children the world over meet the quite generic recommended guidelines for physical activity and screen times. How this impacts on the levels of obesity needs to be determined so that targeted strategies aimed at improving the health of children can be implemented.

A study from the USA sought to examine the combined influence of physical activity and screen time (television and video games) on the weight status of children in order that the utility of the current guidelines could be evaluated (106). Participants included 709 children (318 boys and 391 girls) aged approximately 10 years (106). It was found that the independent association of physical activity and overweight indicated that boys who were not meeting the PA guidelines were 2.74 times more likely to be overweight than those that met the recommendation, and for girls the odds were 2.37 times more likely to be overweight than those who met the recommendation. In terms of screen time, boys exceeding the recommended 2 hours of total screen time were 1.69 times more likely to be overweight than boys who met the recommendation, and girls were 1.22 times more likely to be overweight than those who met the recommendation. When physical activity and screen time were combined, the boys and girls who did not meet either recommendation were approximately 4.5 and 3.0 times more likely to be overweight than those meeting both recommendations, respectively (106). Thus, meeting the recommended guidelines for both screen time and physical activity was strongly related to weight status in children from the USA which suggests the guidelines are effective in their current form. The generalisability of these findings can be tested through examination of studies from children in countries other than the USA.
The relative strength of physical activity and screen time with weight status was determined in a recently published study by Maher et al. (107). Randomly selected nine to 16 year old Australian children were studied (n=2,200) and about 20% of youth met the screen time recommendations, whereas about 80% met the recommendations for physical activity. The authors found that as levels of vigorous physical activity increased screen time decreased in males ($r = -0.39, p < 0.0001$) and in females ($r = -0.31, p < 0.0001$) (107). After many different forms of analyses they concluded that compliance with screen time guidelines was a stronger indicator of weight status than physical activity guideline compliance; increased weight status was associated with increased screen time (107). The path between screen time and weight status may be influenced by factors such as diet or other extraneous variables, which were not controlled for in these analyses. These findings were slightly different than the findings from the preceding study but more clarity can be provided through examination of current literature.

There have been several recent reviews of the literature that examined the association between physical activity and/or sedentary behaviour with children’s body weight (108-110). One reported the associations of physical activity and sedentary behaviour to childhood overweight/obesity in cross-sectional studies from 2000 to 2010 (108). The search included studies of children aged 2 to 19 years with physical activity or sedentary behaviour as a primary independent variable and child weight or body composition as the primary outcome variable (108). Of the 17 studies that were included in the review seven were from the USA and the other 10 from other developed countries; two from Portugal and one each from Greece, Sweden, Germany, New Zealand, Ireland, Canada, Taiwan and Australia. Physical activity was measured using a variety of methods such as the more subjective self-report and the more objective measures such as accelerometers, pedometers, doubly labelled water, heart
rate monitoring and direct observation whereas, sedentary behaviour was gauged mostly through self-report surveys (108). The majority of the studies included measure of both physical activity and sedentary behaviour (n = 11) and the remainder included physical activity only (n = 6) (108). Body composition was measured by researchers and reported using BMI in most instances. The authors concluded that there were mixed results for the association between physical activity with childhood obesity as nine of the studies found evidence of a negative relationship, and three of the studies found no relationship but these found a positive association between sedentary behaviour and childhood obesity. Contrary to expectations, the other study reported a positive relationship between the parent’s report of the child’s access to PE class and prevalence of obesity; greater access was associated with higher levels of obesity. The main difference in methods between these studies was that this was the only study to use an indirect measure for PA as all the others used either direct objective measures (n=9) or direct subjective measures (n=3). For sedentary behaviour most of the studies found a relationship between high levels of sedentary behaviour and high levels of obesity (n = 7) (108). Thus cross-sectional associations were stronger between sedentary behaviour and weight status compared with PA and weight status.

Besides obesity alone, sedentary behaviour has also been linked with a range of negative health and social outcomes. In a recent systematic review of physical, behavioural, and psychosocial health indicators associated with screen-based sedentary behaviour among adolescent girls (aged 12 to 18 years), the authors identified 33 relevant studies (1 from Australia) (109). They found positive associations between weight status, sleep problems, musculoskeletal pain and depression with screen-based sedentary behaviour. The authors identified negative associations between screen time and physical activity/fitness, screen time
and psychological well-being, and screen time and social support but the relationship between screen based sedentary behaviour and diet quality was inconclusive (109).

These reviews together are suggestive of a positive relationship between sedentary behaviour with obesity and provide some support for the negative association between physical activity and childhood obesity. However, as few of the studies included both sedentary behaviour and PA in the same analysis further exploration is required of the synergistic relationship between levels of physical activity and levels of sedentary behaviours on childhood obesity.

In summary, the evidence suggests that children have are consuming high levels of HHFs and SSBs while their consumption of fruit and vegetables has declined, there are mixed findings into activity levels, and time spent in sedentary behaviours has increased. The relationships between obesogenic risk factors and weight status are mixed but SSB consumption, physical activity and television viewing are the more common factors associated with obesity in children. Further longitudinal research using multiple time points could provide clarity and strengthen the evidence base but clearly there is a need for multi-faceted interventions that take into account a range of obesogenic behaviours while still appealing to the targeted group. Obesity prevention at an individual level is one prong and environments are another.

1.6 Environments

The prevalence of overweight and obesity has increased at the same time as environmental changes have occurred: diets have changed to include more HFFs and less fruit and vegetables; there are more places from where to source HFFs (65, 111, 112); food and drink
advertising has increased (113); transport and work life have become more mechanised; people have become time poor, and; housing estates have taken over green spaces and are less walkable. As well as these more tangible changes there is also a perception that it is more dangerous to be out on the street and, in general children are sent mixed messages about health whereby sport is promoted as a healthy behaviour but the food available at sporting venues and community swimming pools include chocolate and confectionery, soft drink and sports drinks, and ice cream (114).

Since the 1960’s there have been increased supply of cereals, rice, maize and wheat which has led to a relative decrease in the cost of food (especially high calorie food), increased accessibility of food and increased marketing aimed at lifting consumption of food (113). More food is being prepared away from home and more fast food is being eaten at home. Between the late 1970s and the mid-1990s, the proportion of food eaten away from home increased from 16 to 27% in the United States (115). Increased energy intake (179 kcal/day) by children from 1977-2006 was associated with a major increase in energy eaten away from home (255 kcal/day) and, over the same period, portion sizes for fast foods and SSBs increased (116). For example, fast-food restaurant consumption was associated with an increase in total daily energy intake of 126 kcal for children and 309 kcal for adolescents and dining at a full-service restaurant also was associated with higher energy intake of 160 kcal for children and 267 kcal for adolescents.

The high demand for fast food has resulted in an increased number of those types of establishments. In the USA the number of fast food restaurants more than doubled from 1972 to 1995 for a total of an estimated 247,115 nationwide (65). The numbers continue to
increase as figures from 2012 predicted that the USA foodservice industry is expected to post its fourth consecutive year of sales growth in 2013, with an estimated 3.8% increase in sales to US$660.5 billion from over 980,000 restaurants (117) at a time when most industries are experiencing contraction due to the global financial crisis. Moreover, fast food pervades virtually all segments of society including local communities, public schools, and hospitals (111, 112) and this may be having a detrimental effect on eating behaviours and on rates of obesity. Fast food and SSBs are often paired in meal deals and so the frequency and quantity of consumption may change together. At the same time that there has been a proliferation of fast food restaurants there has also been a change in consumption and packaging of SSBs.

Interestingly, prior to the 1950’s SSBs were sold in 6.5 oz (≈190ml) bottles but larger servings including 10 oz (≈290ml), 12 oz (≈350ml) and 26 oz (≈760ml) have been introduced since that time (118). Today, contour-shaped plastic bottles are available in even larger sizes, such as the 42 oz (1.25 l) bottle introduced in 2011 that sold for US$1 (119). This bottle is approximately six times as large as the earlier packaging. These factors facilitate the over-consumption of kilojoules which leads to an energy imbalance and weight gain. Consumption of the more traditional diet that was reliant on unprocessed foods like fruits and vegetables seems to have diminished over time. This can be changed if most of the food on offer in the home is mainly healthy (120).

In addition to what is consumed, where one lives may also influence weight status. It has been proposed that the density of food establishments in a neighbourhood can impact on weight status. A recent study examined the relationship between neighbourhood food environment and youth BMI in the USA (121). The longitudinal analysis used data from two
time points of the Early Childhood Longitudinal Study-Kindergarten Class; fifth (2004) and eighth (2007) grade. The relationship between food environment and BMI was examined with two individual outcomes (BMI percentile in eighth grade and change in BMI percentile from fifth to eighth grade) and three alternative measures of food environment (per-capita counts of a particular outlet type, food environment indices, and indicators for specific combinations of outlet types) (121). The hypothesis that improved access to large supermarkets results in lower youth BMI was not supported nor was that greater exposure to fast food restaurants, convenience stores and small food stores increases BMI. The only association reported was that the existence of more types of food outlets in an area, including supermarkets, was associated with higher BMI (121). From these results it appears that the greater availability of food generally is related to high BMI.

In contrast, a Canadian study did find a link between a close proximity to convenience stores from an adolescent’s home and low diet quality (122). One study investigated cross-sectional relationships between actual dietary intake and the local food related built environment among adolescents aged 11-14 years (n = 810) (122). The study utilised a geographic information system (GIS) to assess characteristics of the neighbourhood food environment. The authors found that a close proximity to convenience stores from an adolescent’s home was associated with a low diet quality. Similarly, a close proximity to convenience stores and fast-food outlets and a high density of fast-food outlets in the neighbourhood surrounding a school were also associated with poor nutritional intake (122). This study did not provide information on the impact of the environment on child weight status.
The push from the environment towards over consumption of HFFs and SSBs is one component of the obesity driver. The environment also affects levels of PA. For example, the proportion of children being driven to school has increased dramatically since the 1970’s and at the same time the number of children walking to school has decreased (123-125) but this is not true in all cases. For example an Australian study found that the proportion who walked has not changed but the proportion of children cycling to school had decreased from 21% in 1985 to 5% in 2004 (126). Taken together, this translates to a decline in active transport. Some of the reasons put forward for this change from active to passive transport include an increase in car ownership (124), smaller schools being amalgamated into larger units and so may be further away from homes, and more children attending private schools which may also be further away from the home of the child (123, 125, 127). Other reasons include traffic danger, stranger danger and convenience as the school is on the work route (123, 125, 127). This is particularly relevant as more women are participating in paid employment (123) and so the family may be time poor which makes driving children to school an efficient use of time (125). When they get to school, children are spending their recess and lunch times sitting around talking rather than running around (126). There is less active play during school time and less free play outside school hours.

Fear of stranger danger may inhibit the amount of time young children are allowed to play outside but whether this relates to weight status is contested in some studies (128) and supported in others (129). To illustrate, obesity levels were higher in areas where children felt unsafe to walk around at night compared to levels in safer suburbs; obese (31.8% vs 22.4%, respectively) or overweight (18.2% vs 15.7%, respectively) (129). Safety also extends to perceived safeness of roads as higher rates of pedestrian-automobile accidents have been correlated with less physical activity and greater skinfold thickness in young children (130).
Unsafe physical environments may be a barrier to obesity prevention in children as they are not easy to change. Perhaps easier to change are policies regulating environments in which children spend time.

Changes at the policy level can impact on obesogenic environments and this was demonstrated in Texas and California. An evaluation of the effect of the Texas Public School Nutrition Policy on the energy density of lunchtime meals showed a significant reduction in the energy density of the foods eaten at lunchtime falling from 2.80 ±1.08 kcal/g in the first round of data collection to 2.17±0.78 kcal/g in the second round (131). The analysis was single sample, pre-post implementation of the policy (2001/2 & 2005/6). In the first year of data collection 2,616 self-report lunch food records were collected and in the second round of data collection 10,172 records were collected (131). The second study investigated the difference in childhood eating patterns between California, a US state which regulates the nutrition content of competitive foods sold in high schools, with children from states with no such standards (132). The sample included 114 children from California and 566 from 14 other states. The results indicate that the regulations may be succeeding as, at school, California students consumed less than students in other states for every measure that was examined, particularly sugars, fats and overall kilojoules (132). These findings indicate that policy change can have positive effects on obesogenic environments.

Environments have become more obesogenic over time so it is much easier for children to eat large amounts of less healthy food and to be, generally, more inactive. Over consumption of unhealthy food is encouraged through greater availability, larger portion sizes and advertising
of same. At the same time the number of cars on the roads has risen, passive transport is used much more often and children move around less.

Environments have changed to become more obesogenic. There are more opportunities to consume unhealthy diets, to be more inactive and more sedentary. Indeed the environment pushes populations to eat away from home, to use cars, to drink more and to eat in ever larger portions. Changing eating behaviours through environmental change brought about by policy implementation has highlighted the effect of higher level interventions.

1.7 Previous interventions

Reviews of previous interventions bring together the evidence of determinants to target and strategies that have been successful in childhood obesity prevention. For example, a recent Cochrane Review and meta-analysis of interventions for preventing obesity in children found overall evidence of effectiveness although less than half of the individual programs were successful in preventing unhealthy weight gain (133). Fifty of the 55 included studies were set in high income countries, four in upper-middle-income countries and one in Thailand, a low income or developing country. Despite study heterogeneity, the review found that the most effective programmes included a wide range of components such as school curriculum that included healthy eating, physical activity and body image, improvements in the quality of the food supply in schools and encouraging less screen time (133). Furthermore, some of the promising policies and strategies incorporated building community capacity to implement health promotion strategies and activities.
In an earlier systematic review of school-based interventions that focused on changing dietary intake and physical activity level to prevent childhood obesity, Brown and Summerbell (134) identified 38 studies that met the criteria: controlled trials; school-based lifestyle interventions; minimum duration of 12 weeks, and; reported a weight outcome. Of those 38 studies, one of the three diet studies, five of the 15 physical activity studies and nine of the 20 combined diet and physical activity studies demonstrated significant and positive differences in outcomes between intervention and control groups for BMI. It would, therefore, appear that multiple strategies in childhood and adolescent obesity prevention are both more common and more successful. Although all the interventions were school-based, few addressed adolescents in the upper age group; that is above 14 or 15 years of age. In the diet only category one study recruited participants aged 15 years but there were few participants \((n = 54)\) and it was conducted over a short time period (135). A similarly small proportion of studies comprising the physical activities only category included older adolescents. In four of those studies participants were aged around 14 years at baseline but three of those studies six were months or less in duration (136-138). The remaining adolescent study was longer in intervention duration (12 months) but included females only (139). Of the 15 multiple strategy interventions there was one that included older adolescents but the intervention was 12 weeks in duration (140). There were two other studies that were set in schools where baseline recruitment age was 12 (141) or 13 years (142) and the intervention ran for two years but there were no interventions that specifically targeted older adolescents. There was only two studies set in Australia; one was short term, small sample size and in girls only (138) and the other that was conducted in 1990, included 10 to 12 year old children and was nine months in duration (143). Additionally, like the Waters et al. (133) review almost all the included interventions were set in high income countries.
A meta-analysis of school-based obesity prevention interventions from 1997 to 2008 included 66 comparisons from 40 published studies conducted in mainly high income countries (144). Five of those comparisons were from studies in high schools, 20 were from middle schools and 41 were from elementary schools. Despite the small number of high schools involved, the analysis found that older students experienced the strongest BMI outcomes (144). The youngest students also recorded stronger BMI outcomes than students from middle schools (144). Other findings of note were that programs that targeted all students regardless of weight status were associated with more positive BMI outcomes, longer interventions were more effective, nutritional, physical activity and sedentary behaviour interventions had mixed effects, strong parental involvement was beneficial and collaboration of intervention specialists and teachers produced good effects.

A review and meta-analysis published in 2012 evaluated the effect of school-based obesity prevention interventions on childhood BMI (145). The analysis included 43 studies (N = 36,579 students) over a 20 year period from 1991 to 2010. The majority of studies were set in America (n = 19) and Europe (n = 16) with 5 in Asia, 2 in Australia and 1 in Africa (145). In all, results from the meta analysis indicated that school-based interventions were successful in reducing unhealthy weight gain amongst children; BMI change was -0.17 kg/m² (95% CI: -0.26, -0.08, p < 0.001) (145). The effect was stronger in girls (-0.28, 95% CI: -0.50, -0.06, p = 0.012) but did not reach statistical significance in boys (-0.17, 95% CI: -0.26, -0.08, p = 0.533). Following stratification by intervention type, the reduction in BMI was statistically significant for physical activity used in isolation (-0.13, 95% CI: -0.22, -0.04), and in combination with improved nutrition (-0.17, 95% CI: -0.29, -0.06). The two studies from Australia included a small (n = 33; mean age = 12.5 years), short-term (6 months), boys-only study from 2007 that focused on physical activity, sedentary behaviour and nutrition (146)
and the other was a larger study (n = 1,147; age range 10 to 12 years) conducted in 1990 that aimed to improve cardiovascular fitness through improvement in physical activity and nutrition (143). Neither intervention sought to change environments.

A few of the more successful childhood community-based obesity prevention projects that focused on empowering communities by increasing their capacity to recognise and address the obesity issue are described below.

Two Australian community-based obesity prevention projects that targeted children were Romp and Chomp (147) and Be Active Eat Well (148). Romp and Chomp was a community-wide, multi-setting, multi-strategy intervention conducted over a four year time period, was situated in Geelong, Australia and aimed at children less than five years of age (147). The focus was on community capacity building and changing environmental settings to promote healthy eating and active play. Romp and Chomp was successful in reducing anthropometric measurements in 3.5 year old children and changing some less healthy behaviours. Sanigorski et al. concluded that a community-wide, multi-setting, multi-strategy intervention can reduce childhood obesity and improve young children’s diets (147).

Be Active Eat Well (BAEW) was conducted in Colac, a town near Geelong, Australia, and was situated in primary schools (children 4 to 12 years) (148). The BAEW project was also premised on building community capacity to promote healthy eating and physical activity among children. Once again there were positive anthropometric outcomes (e.g. lower increases in body weight, waist, waist/height and BMI-z) (148). Both projects aimed to build
the capacity of the community to prevent obesity and both reported positive anthropometric outcomes. These findings support the efficacy of the capacity-building, community-based approach to obesity prevention but there is still a need for it to be tested in the adolescent age group.

Examples from other parts of the globe include the APPLE project from New Zealand (149) and two from the USA; Shape Up Somerville (150) and Healthy Living Cambridge Kids (151). APPLE was a two year project set among primary school age children in rural New Zealand that commenced in 2003. The aim of APPLE was to enhance extra-curricular opportunities for physical activity, to provide simple dietary advice and to engage the wider community. The results after the first year of the project were encouraging as children in the intervention group spent less time in sedentary behaviours, more time in PA and BMI z-scores were -0.12 units relative to the comparison group (149). At the second follow-up at the end of the intervention period, the difference in BMI z-scores was extended, waist circumference was significantly lower in the intervention group compared to the comparison group and intervention children consumed fewer SSBs and more serves of fruit (152). The final follow-up that was conducted two years post project found that the differences in BMI z-scores persisted and it was concluded that the effects of the intervention were sustained despite the school-based activity co-ordinators being removed (153).

Shape Up Somerville was a community based environmental change intervention that aimed to prevent weight gain in young children through enhanced access to physical activity options and healthy food (150). The three year project was set among elementary school children (approximately the same age as primary school children in Australia and New Zealand) and
was implemented in 2002. This project also recorded lower BMI z-scores post project in the intervention community compared to the comparison communities (-0.10 units) (150). The final project to mention here is Healthy Living Cambridge Kids. This was also a three year project set among elementary school children (151). This project was a multicomponent intervention targeting community, school, family and individuals. The components included city policies, physical education enhancements and food service reforms to name a few. At the end of the intervention period it was found that among the cohort BMI z-scores decreased by 0.63 and the proportion of obese children decreased by about 2% and the mean number of fitness tests passed increased (151). The project had a positive effect at the level of the child but it also influenced changes in policies and embedding of program elements into the community (151). All these five projects were successful in preventing obesity among young children.

These reviews and studies suggest that obesity prevention in childhood has been successful especially in younger children. The commonalities among successful projects included targeting all students, longer intervention periods, building the capacity of the communities in which the projects were set to provide solutions, enlisting support of key stakeholders (parents, principals, teachers etc.), promoting multiple healthy behaviours and changing environments (physical and policy) to be more healthful. The reviews highlight the need for intervention projects that involve older as well as younger adolescents, the need for projects involving Australian children and the need for projects in developing countries. Furthermore, community-capacity building was a cornerstone of many prevention projects but none evaluated whether capacity has been successfully built over the duration of the project. Only the Romp & Chomp quantified levels of community capacity but that was post intervention (154). Had the capacity been assessed prior to project implementation the areas of most need
would have been identified and targeted. This may have resulted in even more successful and sustainable intervention strategies. Until these gaps are filled, it will remain unclear if the lessons learnt can be used to develop and implement obesity prevention projects that are successful across the spectrum of adolescence and generalisable to an Australian setting or a setting in a developing country.

The introduction to this thesis has provided evidence of a rapid increase in childhood obesity from the 1980s to the 2000s which remains high today (7, 8, 47, 155). Furthermore, childhood obesity impacts negatively on physical, social and psychological outcomes and, thus, solutions are urgently required. Part of the solution lies in promoting healthy lifestyles and a good place to start is by encouraging adherence to the relevant dietary guidelines and those in place around levels of PA and sedentary behaviour. Adherence to the guidelines is generally low and so an area for intervention is promotion of healthy diet and PA while, at the same time, discouraging sedentary behaviour. There is some evidence, albeit inconsistent and mainly from the USA, that these are the determinants on which to focus in any prevention exercise. However, preventing obesity is more complex than urging individuals to eat less and exercise more as environmental factors have to be taken into account. Modern environments push populations to consume more and exercise less so it is essential that environmental change is prioritised along with individual behavioural change. Community-based childhood obesity interventions that incorporate intervention strategies aimed at changing multiple behaviours at multiple levels have been successful but mainly among younger children. There are still gaps in the knowledge that need to be filled so that prevention science can be progressed.
1.8 Knowledge gaps

The gaps elucidated include the lack of research in childhood obesity in Australia. There is a large body of research on children from the USA but it is unknown if this is generalisable to countries with different dietary behaviours. The USA has an extremely high prevalence of SSB consumption amongst children so the findings may not be generalisable to children from countries like Australia. This coupled with the dearth of Australian evidence about frequency and quantity of SSB consumption and its relationship with body weight makes further research an imperative.

Along with SSB consumption there is very little evidence of the association between HFF consumption and obesity among Australian children. Again, most of the evidence originates from the USA where the prevalence of consumption of HFFs is high and so the results may not be applicable to Australian children. More evidence is required if these types of foods are to be an intervention target in any obesity prevention project.

There are also few studies that test the independent contribution of both SSB and HFF consumption to childhood obesity. Use of a large, multiple time-point, longitudinal, cohort study may provide power enough to detect independent relationships between SSB and HFF consumption and childhood obesity. Furthermore, additional studies among older Australian children are needed to add to the evidence base.
Other determinants of childhood obesity include low levels of physical activity and high levels of sedentary behaviour. There were very few studies from Australia per se and very few studies from anywhere that included both sedentary behaviour and PA in the same analysis. As such, further exploration is required of the synergistic relationship between levels of physical activity and levels of sedentary behaviours on childhood obesity.

It appears that community-based projects that use capacity building frameworks are promising approaches to childhood obesity prevention especially among younger children (<12 years) in developed countries. It remains unknown if these population approaches would be successful among Australian adolescents or whether the methodology can be used in culturally diverse populations in developing countries.

1.9 Research aim and objectives

The overall aim of this research was to make a substantial contribution to the knowledge of population level solutions to the current childhood obesity epidemic. This important research fills an evidence gap for policy makers to obesity prevention policy and future interventions. The specific objectives were to determine:

1. What are the key obesogenic behaviours to target to reduce childhood obesity?

2. What are the appropriate approaches to intervene in communities to reduce childhood obesity?

3. What are the impacts of community-based, obesity prevention interventions targeting children?
4. What can be concluded about community-based, childhood obesity prevention?

In addressing the aim and objectives, the thesis sought to answer the following research question:

“Does targeting obesogenic behaviours through community-based interventions lead to reduced childhood obesity among adolescents?”

The hypothesis tested was that population community-based approaches to childhood obesity prevention were successful when the appropriate objectives were targeted.

1.10 Significance of this research

The significance of this research can be summarised as follows:

- It is one of the first examples of longitudinal studies regarding patterns of SSB consumption among primary and high school students in Australia;
- It is one of the first examples of longitudinal studies regarding SSB consumption and BMI among primary and high school students in Australia;
- It is the first study to report multi time-point, longitudinal relationships between SSB and HFF and BMI among Australian children;
- It is the first study to examine the association of PA, and the interaction of PA and sedentary behaviour on BMI, among Australian adolescents;
- It is the first study to bring together evidence regarding the role of community capacity building in community-based interventions.
• It reports the first study of a community-based intervention that targeted the whole spectrum of adolescence;
• It reports the first multi-country community-based intervention among adolescents;
• It is the first study to demonstrate the effectiveness of community-based interventions among Australian adolescents;
• It is the first study to examine the relationship between community capacity change and BMI change in an obesity prevention intervention.

The manuscripts that complete this thesis will expand upon these points.

1.11 Thesis structure

This thesis is presented as a series of publishable, stand-alone, manuscripts that, when taken together, address the research aim and objectives as well as answer the research question.

This chapter has provided an introduction to the research, reviewed the relevant literature, and set out the research aim and objectives. Chapter 2 presents the research design, outlining the theoretical perspective adopted, the studies comprising the thesis, and an overview of the methods used in each of the studies.

The manuscripts completing the bulk of the thesis are presented in Chapters 3 to 6 with some manuscripts grouped in forming these chapters. Each of the manuscripts is written in the conventional publication style for their target journals and they are presented as such.

Because each manuscript is designed to stand alone, there is an inevitable degree of repetition
when read together, particularly in the literature presented in their ‘Background’ sections. The references for each manuscript are incorporated as part of the manuscripts and references cited in other parts of the thesis are provided at the end of the thesis. The manuscripts were all written in conjunction with other researchers and the relative contributions of each of the manuscript’s authors are provided.

Chapter 3 consists of four manuscripts that describe the key obesogenic behaviours to target in obesity prevention efforts. Sugar sweetened beverage and high fat food consumption as well as lack of physical activity and sedentary behaviours among children are described. Three of the manuscripts also elucidate the relationship between body weight and obesogenic behaviours among children. These manuscripts include analyses of cross sectional and longitudinal data.

Chapter 4 comprises two manuscripts that inform the appropriate approaches to intervene in communities. The first is a systematic review of the literature surrounding building community capacity and the second is a methods paper from a multi-country project targeting adolescent obesity.

Chapter 5 is made up of three papers that quantify the impacts of community-based interventions in Australia and the Pacific. Impacts on anthropometry and community capacity separately and together are included.
The one manuscript of Chapter 6 describes the challenges and experiences of community-based interventions in four countries. These lessons learned can inform future directions.
Chapter 2: Research design

2.1 Chapter overview

This chapter presents an overview of the research methods used in this thesis to address the research aim and objectives. A variety of research methods were used as considered appropriate for the differing types of study designs and the limitations imposed by the data and time constraints. The different methods used in addressing each of the research objectives are summarised in Table 2.1.

The first section of this chapter presents the theoretical perspectives underpinning the research. This is followed by an overview of the research methods used in each of the 10 studies making up this thesis. The discussion of methods in this chapter is brief and includes some details not included in the ‘Methods’ section of the manuscripts in the following chapters.
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<td>1. To determine the pattern and extent of obesogenic behaviours among children</td>
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<td>Consumption patterns of sweet drinks in a population of</td>
<td>To examine the patterns of sweet drink consumption in a sample of Australian children aged from four to 18 years and determine if consumption differs by gender</td>
<td>It’s Your Move! (IYM) and Be Active Eat Well (BAEW)</td>
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<td>(diet, physical activity and sedentary)</td>
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<td>Intake of sweet drinks and two-year change in BMI among Australian children (5-18y)</td>
<td>To examine whether baseline or two-year change in sweet drink intake in children and adolescents is associated</td>
<td>IYM and BAEW</td>
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<td>Relationship between raised BMI and frequency of sugar sweetened beverage and high fat food consumption among children</td>
<td>To determine the relationship between frequency of consumption of sugar sweetened beverages and high fat foods and body weight in Australian children aged from 4 to 10 years</td>
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<td>Associations between activity-related behaviours and standardized BMI among Australian</td>
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<td>2. Determine the appropriate approaches to intervene within communities</td>
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<td>Community based obesity prevention: what role does community capacity development play?</td>
<td>To describe the evaluation and reporting of community capacity building within community-based obesity prevention interventions and to determine the common strategies used to build capacity</td>
<td>MEDLINE, EMBASE, CINAHL, and GLOBAL HEALTH electronic database</td>
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<td>F</td>
<td>The Pacific OPIC Project (Obesity Prevention In Communities) –</td>
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<td>Overview and methods</td>
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<td>Reduction in overweight and obesity from a 3 year community-based intervention in Australia: the “It’s Your Move!” project</td>
<td>To report results of prevalence of overweight/obesity, anthropometric outcomes and relevant obesity-related behaviours</td>
<td>IYM</td>
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<td>Increasing community capacity and decreasing prevalence of overweight and obesity</td>
<td>To report changes in community capacity and their relationships with changes in prevalence of overweight and obesity</td>
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<td>obesity in a community based intervention among Australian adolescents</td>
<td>I</td>
<td>Outcome results for the Ma’alahi Youth Project, a Tongan community-based obesity prevention programme for adolescents</td>
<td>To report results of prevalence of overweight/obesity, anthropometric outcomes and relevant obesity-related behaviours</td>
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2.2 Ecological Systems Theory framework

Childhood obesity is a complex problem that has arisen rapidly over the past 40 years. The rise has been accompanied by societal and environmental changes (156) which must be taken into account in any prevention activity. Population approaches need to take into account the environment in which the individual is located. The physical, cultural, familial and regulatory environments, to name a few, are important and powerful influences on the individual. There is a synergy between the individual and the environment and also between the levels of influence exerted on the individual (156). These bidirectional relationships must be considered when developing and evaluating population-based interventions.

A socio-ecological model is a useful model for clarifying the factors that assist in the development and continuance of childhood obesity. These factors can then be targeted to turn the tide of the obesity epidemic and prevent future incidence. Much of childhood community based obesity prevention is underpinned by the socio-ecological model first proposed by Bronfenbrenner (157, 158) in respect to childhood development and later adapted using Ecological Systems Theory by Davison and Birch (159) to explain the environments and forces acting on the child to influence body weight (Figure 2.2). This model (159) has been used extensively as the theoretical model underpinning childhood obesity prevention projects (79, 160-168).

While it is acknowledged that the basic cause of obesity is an energy imbalance within an individual, the reasons for and drivers behind that imbalance are very complex. Within the child there are immutable factors such as age, gender and familial susceptibility to weight gain then there are factors amenable to change such as dietary intake, sedentary behaviour
and physical activity. These are not only bivariate relationships within each ring of the model but there also interactions between the factors. The next layer of the model contains the proximal influences of parenting styles and family characteristics and the outer layer contains community, demographic and societal influences (Figure 2.2).

Figure 4 Ecological model of predictors of childhood overweight

*=Child risk factors (shown in upper case lettering) refer to child behaviours associated with the development of overweight. Characteristics of the child (shown in italic lettering) interact with child risk factors and contextual factors to influence the development of overweight (i.e. moderator variables) (159).

For prevention efforts to be effective projects must be multi-factorial with intervention strategies aimed at individual behaviours and attitudes as well as more distal environmental
factors. These types of interventions must be evaluated in a systematic manner to ensure the factors contributing to changes in obesity are captured. A logic model like the one below (Figure 5) can be used to guide evaluation of complex projects that employed multiple intervention strategies (p. 229, 156). According to this model, it was hypothesised that the group that received the intervention would increase in levels of community capacity leading to individual level changes in knowledge, attitudes etc. and also to the environments surrounding the individual. These two pathways would then influence behaviours which in turn would influence anthropometry. All these pathways are quantifiable and so the unique contribution of each could be ascribed. This model also takes into account possible confounders such as ethnicity, socio-cultural factors, gender, age and socio-economic situation.

The Ecological Systems Theory Framework is a useful model when thinking about complex, multi-factorial projects. The model clarifies the types of influences exerted on an individual that can impact on the attitudes, beliefs and perceptions of the person as well as on the environment. The model can, therefore, be used to elucidate the leverage points for successful intervention.
Figure 5 Logic model for interventions

The measured links are shown in the dark arrows and non-measured (modelled) links in the light arrows. $\Delta$ means ‘change in’; $^1$Intervention (intervention, control) or dollars (for those with economic evaluations); $^2$Capacity is leadership, partnerships, resources, workforce and organizational environments; $^3$Weight, body mass index, standardized body mass index, %fat, prevalence or disability adjusted life years saved; QoL, quality of life; SES, socioeconomic status (156).
2.3 Manuscript A - Obesogenic behaviours: Diet

2.3.1 Title: Consumption patterns of sweet drinks in a population of Australian children and adolescents (2003–2008) (169)

2.3.2 Research question

What are the sweet drink consumption patterns of Australian children and adolescents?

2.3.3 Study objective

The objective of this study was to examine the patterns of sweet drink consumption in a sample of Australian children aged from four to 18 years and determine if consumption differs by gender. The three aims of the study were to:

1. Examine consumption patterns of sweet drinks (sugar-sweetened soft drink and fruit juice/cordial), and the relative contribution of each beverage type;

2. Determine if sweet drink consumption changes as children age and if this is associated with gender, and;

3. Examine the secular changes in the patterns of consumption of sweet drinks.
2.3.4 Study design

This descriptive study utilised data from two community-based obesity prevention projects set among 5,224 Australian children aged 4 to 18 years. Data from the comparison groups of Be Active Eat Well (BAEW; n=1,183, 44% of the invited population) (148) and It’s Your Move! (IYM; n=1,188, 47% of the invited population) (170) were used in the analysis. Data were collected pre and post intervention periods. The BAEW and IYM comparison groups were situated in Barwon South Western region of Victoria and neither group received any intervention. The comparison groups only were used to ensure there were no differences due to intervention effect.

The two projects were quasi-experimental as the intervention sites were chosen using site-specific community, geographic and access criteria rather than by random allocation. The comparison sites were selected to minimise contamination from the intervention programs, maximise comparability with the intervention group and manage local contexts. Quasi-experimental study designs are acceptable designs for complex interventions such as BAEW and IYM where non-randomisation is utilised (171). Interventions are deemed complex if there are a number of interacting components, multiple behaviours are targeted, the intervention is aimed at different groups or organisational levels, there are a number of outcomes and there is flexibility in intervention delivery (171).

The two samples used in this study were from projects developed and implemented by the World Health Organization Collaborating Centre (WHO CC) for Obesity Prevention, Deakin University, Geelong. The Geelong and Barwon South-West regions are sentinel sites for
obesity prevention in Victoria and the aims of which are to build the programs, skills and evidence necessary to attenuate and eventually reverse the obesity epidemic in children and adolescents (172).

BAEW was a community-based obesity prevention intervention set among primary school children aged 4 to 12 years in the township of Colac, Victoria, with a stratified random sample of the remainder of the Barwon South-Western region of Victoria providing the comparison group. Baseline data (time 1) were collected in 2003/04 and follow-up data (time 2) in 2006. Parent report data were collected via Computer Assisted Telephone Interviews (CATI) on the child’s food and beverage intake, physical activity and family socio-demographic characteristics (see Appendix A: Parent Computer Assisted Telephone Interview (CATI) Survey).

IYM was one arm of the Pacific Obesity Prevention in Communities (OPIC) project; a four countries, multi-focused community-based adolescent obesity prevention project. The other three participating countries were Fiji, New Zealand and Tonga. Each of the projects had similar objectives that were set through a prioritisation process but the intervention strategies were unique to each country.

IYM was set among secondary school children ages 12 to 18 years in the East Geelong and Bellarine Peninsula regions of Victoria with a stratified random sample of schools from the Barwon-South West region of Victoria serving as a comparison group. Baseline data (time 1) were collected in 2005 and follow-up data (time 2) in 2008. Data were collected using the
self-reported Adolescent Behaviours, Attitudes and Knowledge Questionnaire (ABAKQ) and included information on key behaviours such as dietary practises, physical activity and neighbourhood environments (see Appendix B: Adolescent Behaviours, Attitudes and Knowledge Questionnaire (ABAKQ)).

Across the combined studies only children from the comparison groups with complete information on beverage intake at both time points were included in the analysis, resulting in 1,604 participants (845 from BAEW and 759 from IYM, 31% and 30% of invited populations, respectively).
2.4  Manuscript B - Obesogenic behaviours: Diet

2.4.1  Title: Inconsistent associations between sweet drink intake and 2-year change in BMI among Australian children and adolescents

2.4.2  Research question

Is sweet drink consumption associated with increased body weight among Australian children and adolescents?

2.4.3  Study objective

The objective of Study B was to examine whether baseline or two-year change in sweet drink intake in children and adolescents is associated with age- and gender-standardised Body Mass Index (BMI z-scores) two years later.

2.4.4  Study design

Study A described the intake and consumption patterns of sweet drinks among Australian children and adolescents. There was a high proportion of participants reporting sweet drink consumption but how and if this consumption was related to childhood obesity was yet to be determined. Study B extended Study A by including relationship between body weight and
sweet drink intake. The WHO growth standards were used to calculate the child BMI z-scores as these growth standards have been widely adopted since their launch in 2006 (173, 174). These standards were developed using data from children from Brazil, Ghana, India, Norway, Oman and the United States. The standards are based on how a child should grow on average when properly fed and cared for, rather than merely describing how they grew at a particular time and place (175). The WHO standards used data from healthy children of non-smoking mothers, growing in relatively affluent conditions and fed according to recommendations.

In addition to the sweet drink variables in Study A, body weight was included. The addition of body weight allowed for the testing of the association between sweet drink consumption and BMI z-scores. Significant associations between the two variables point to a leverage point to prevent childhood obesity.

Study’s A and B were led by a visiting academic from Denmark; Britt Wang-Jensen. Working with people whose first language is not English is sometimes challenging but always rewarding. Britt stayed with our group for six months and during that time I worked closely with her on the data and the manuscript. The papers were submitted after she returned home and so revisions were done through email exchanges. This was quite difficult given the number of authors involved and the time differences. To make the revision process run more smoothly I visited Britt in Copenhagen and together we sorted the major revisions. I also helped Britt negotiate her dealings with the other authors. The outcome has been fantastic with one paper published and the other now accepted for publication.
2.5 Manuscript C - Obesogenic behaviours: Diet

2.5.1 Title: Relationship between raised BMI and frequency of sugar sweetened beverage and high fat food consumption among children

2.5.2 Research question

What is the relationship between consumption of sugar sweetened beverages and high fat foods and change in body weight over 6 years in Australian children?

2.5.3 Study objective

The objective was to determine the relationship between frequency of consumption of SSBs and HFFs and body weight in Australian children aged from 4 to 10 years.

2.5.4 Study design

Study A determined the pattern of consumption of sweet drinks among Australian children and adolescents and Study B extended this study by relating the consumption of sweet drinks to BMI z-scores. The results from Study B were inconclusive and I thought a longitudinal analysis over multiple time points may prove more conclusive. Study C was designed to provide more robust evidence of the relationship between unhealthy diets and BMI z-scores among Australian children. This study was observational cohort design where the same
participants were followed over time with no intervention. Data from the Longitudinal Study of Australian Children (LSAC) were analysed. LSAC is an ongoing nationally representative cross-sequential longitudinal survey study which aims to examine Australian children’s development and wellbeing and how this relates to social, economic, and cultural aspects of their environment. LSAC includes two cohorts; birth (b) and kinder (k). Only the k cohort was used in this study as the study objective was not relevant to the birth cohort.

Briefly, LSAC employed a two-stage clustered sampling design stratified by a state and capital city statistical division and clustered by postcode within each stratum. Children born between March 1999 and February 2000 were randomly selected to achieve a cohort aged between 4.3 and 5.2 years at interview with all birth months represented.

The design of the analyses was relational and was used to test the covariance of the variables of interest. Multi-level growth modelling was used to account for the clustered nature of the data; multiple data points from each participant nested within postcodes which were nested within States or Territories.

The sample for this analysis comprised all children in the K - cohort (4–5-years old at wave 1) from the four waves (waves 1, 2, 3 & 4) of LSAC (data collected 2004, 2006, 2008 & 2010) with complete height and weight data (11). There were 4,169 children who completed all four waves of data collection and this cohort was representative of the target Australian populations on most demographic features (176).
The SSB and HFF measures were constructed by the developers of the survey and were quite blunt as they asked only how many times the child had the item in the 24 hours preceding the survey. Nonetheless the survey has been administered to the same child in the same format four times so data were reliable.

In addition to my Research Fellow role I am also manage access to the LSAC dataset on behalf of Deakin University. It was through this role that I realised the potential for using these data to test relationships within children. I realised that because of the way the LSAC study was designed multi-level modelling would be an appropriate analysis strategy. I formed a collaboration with the second author, Bosco Rowling, to assist in the analysis and interpretation. I met Bosco while attending a multi-level modelling course during my candidature.

While this study is not yet published, it has been reviewed favourably by reviewers from Obesity. It is anticipated that the reviewers comments will be addressed and the manuscript resubmitted by the 3rd of May, 2013. It has since been accepted for publication (22nd July, 2013).
2.6 Manuscript D - Obesogenic behaviours: physical activity and sedentary behaviour

2.6.1 Title: Associations between activity-related behaviours and standardized BMI among Australian adolescents

2.6.2 Research question

1. What are the patterns of physical activity behaviour during week days among Australian adolescents?

2. What are the patterns of sedentary behaviours during week days among Australian adolescents?

3. Are these patterns associated with the weight of Australian adolescents?

4. Are these patterns consistent across sex?

2.6.3 Study objective

This study aimed to examine the relationships between physical activity, sedentary behaviour and body mass index (BMI) among a sample of Australian adolescents.
2.6.4 Study design

Studies A, B and C investigated obesogenic diets which is one contributor to childhood obesity. It was found that high levels of SSB are being consumed and more frequent consumption of SSBs and HFFs is contributing to increased body weight among Australian children. Another major factor contributing to obesity is lack of physical activity and high levels of sedentary behaviour. Study D determines the association between levels of physical activity and sedentary behaviour with body weight among Australian adolescents. This study utilises the IYM data set which was also used in Studies A and B. Study D uses the pre-intervention baseline data only whereas Studies A and B involved both pre and post intervention data.

Participants self-reported their activity and sedentary behaviours as part of the ABAKQ (Appendix B: Adolescent Behaviours, Attitudes and Knowledge Questionnaire (ABAKQ)) and anthropometry was collected by trained researchers. BMI z-scores were calculated using the WHO growth standards (see section 2.4.4 Study design). The sample of 3,040 drawn from twelve Australian secondary schools (response rate = 48.6%) completed questionnaire surveys.
2.7 Manuscript E - Appropriate approaches to intervene in communities: capacity building

2.7.1 Title: Community based obesity prevention: a systematic review of the role of community capacity development

2.7.2 Research question

1. How is community capacity reported in the literature?
2. What strategies are used to alter community capacity?
3. How is community capacity evaluated?

2.7.3 Study objective

The aim of this systematic review was to describe the evaluation and reporting of community capacity building within community-based obesity prevention interventions and to determine the common strategies used to build capacity.

2.7.4 Study design

Studies A to D provided evidence for targeting dietary, physical activity and sedentary behaviours. The next step in the process is to determine appropriate approaches to prevent further rises in the prevalence of obesity and to facilitate turning back the tide of the obesity
epidemic. Some community-based interventions have highlighted increasing the capacity of
the community to promote healthy eating and physical activity as a focal point of the project.
Through a systematic review of the literature, Study E brings together the evidence on
community capacity building within community-based interventions.

The literature was searched from 1975 to 2012 so as to include very early studies of this kind
as well as the very latest. Use of this approach emphasised the growing importance of
capacity building in obesity prevention and elucidated the strategies used. The lessons from
these findings can be translated to other fields of prevention aimed at populations.

This manuscript is a publishable draft. It is expected that the final draft will be submitted for
publication by June 2013.
2.8 Manuscript F - Appropriate approaches to intervene in communities:
community-based interventions

2.8.1 Title: The Pacific Obesity Prevention in Communities
project: project overview and methods

2.8.2 Research question

What are common methods used in a series of community-based obesity prevention interventions?

2.8.3 Study objective

The objective of this study was to describe the common methods used in a series of community-based obesity prevention interventions set among adolescents.

2.8.4 Study design

Study E found that building community capacity was incorporated into the designs of many successful community-based childhood obesity prevention projects but none quantified the changes in capacity. Study F overviews the methods of a promising approach to obesity prevention that included capacity building as a prime objective. The design of this study was descriptive and drew on information from reports and input from co-authors.
The Pacific Obesity Prevention in Communities (OPIC) was a multi-focused, multi-country, community-based obesity prevention project targeting adolescents in Fiji, Tonga, New Zealand and Australia. The Pacific OPIC project was the first of its kind and, consequently, an enormous undertaking involving many people from each of the countries involved. There were project coordinators in each country as well as research assistants, chief investigators and other staff and volunteers. There were also approximately 18,000 participants who consented to take part in the evaluation but, because of the nature of community-based interventions, the actual strategies reached so many more residents. Implementing a project across both developed and developing countries with many different cultural groups required detailed and sensitive planning, implementation and evaluation.

The Pacific OPIC was a culturally-based, community-led project that used a prioritisation process to determine the objectives of the project within each country. There were similar objectives across all countries with building community capacity featuring high on the priority list. The other objectives were around diet, physical activity, social marketing and evaluation. The strategies employed to meet these objectives varied by country.

My tasks with this manuscript included compiling the sections, writing some of the manuscript and liaising with the other authors. This manuscript was very complex to compile and write as it involved many authors (14) from all the countries that participated in the project. The manuscript comprised sections explaining the evaluation of the interventions including anthropometry and behaviours, capacity, economic, socio-cultural and policy
components. There was also a strict word limit so accommodating all authors required much diplomacy. In addition to my writing I ensured all authors were fairly represented and the paper flowed in a coherent and readable manner. I managed the compilation and submission of the final article. Additionally I ensured review deadlines and all administrative requirements were met.
2.9 Manuscript G - Quantifying the impacts of community-based intervention: anthropometric and behavioural outcomes

2.9.1 Title: Reduction in overweight and obesity from a 3-year community-based intervention in Australia: the ‘It’s Your Move!’ project

2.9.2 Research question

What were the anthropometric and behavioural outcomes of the intervention group compared to the comparison group at the completion of the IYM project?

2.9.3 Study objective

The objective of the current study was to report the anthropometric and dietary and physical activity behavioural outcomes of the IYM project.

2.9.4 Study design

Studies A to D provided evidence for behaviours to target to prevent and reduce obesity. Next, Studies E and F set out approaches to intervene at a population level. Study G presents findings from a community-based obesity prevention project that focused on building the
capacity of the community to promote healthy eating and physical activity. Study G utilises the IYM dataset which was also analysed for Studies A, B and D.

IYM was the Australian arm of the wider Pacific OPIC project. This project was the first large, multi-country, community-based, obesity prevention project among adolescents. At all sites a quasi-experimental design was applied (see 2.3.4 Study design) and the analysis design for the Australian, Fijian and Tongan data was pre/post intervention with repeat measures within participants. The New Zealand data were analysed using cross-sectional methods.

The aim of IYM was to build the community of the capacity to promote healthy eating and physical activity. The five intervention schools each had the same 10 project objectives but the strategies implemented around these objectives were school specific.

IYM was the first published successful community-based obesity prevention intervention targeting Australian adolescents. The IYM intervention group recorded less unhealthy weight gain and lower increases in BMI z-scores at follow-up in contrast to the comparison group. The primary evaluation was based on the differences between the intervention group and comparison group at follow-up but heterogeneity among the schools was expected because of differences in the strategies implemented. Different strategies can lead to different levels of intervention dose. School differences in changes in prevalence of overweight/obesity over the course of the project supported this hypothesis; three of the five intervention schools recorded a decrease in prevalence and two recorded no change. There were no recorded behavioural
outcomes that explained the anthropometric outcomes. This may have been because the instruments used to measure behavioural change at a population level were quite blunt and there may have been small unmeasured changes that when taken together contributed to the shift in anthropometry. This could be further tested through use of more precise measurement methods in future interventions. However, the measures have to be applicable to large populations and practical to administer. Another way to measure the success of complex interventions may be to evaluate other measures of population change.

This actual manuscript was tricky to write as I received feedback from 12 co-authors who were not only from differing disciplines but lived in different countries. This required negotiation and concessions to be managed in order that the manuscript was completed in a timely and orderly manner. Additionally, I managed the cleaning of the Pacific OPIC data set which, given the differences in data quality from each country, was a massive undertaking. Negotiation and management skills were also required when discussions over data management and analysis plans were conducted during the combined Pacific OPIC meetings.
2.10 Manuscript H - Quantifying the impacts of community-based intervention: community capacity

2.10.1 Title: Increasing community capacity and decreasing prevalence of overweight and obesity in a community based intervention among Australian adolescents

2.10.2 Research question

1. When compared to a non-intervention comparison group, did the IYM intervention increase community capacity?; and,

2. Was increased capacity related to reductions in prevalence of overweight/obesity?

2.10.3 Study objective

The objective of this study was to report changes in community capacity and their relationships with changes in prevalence of overweight/obesity.

2.10.4 Study design

Studies A to D provided evidence for behaviours to target to prevent and reduce obesity. These behaviours included decreasing consumption of sweet drinks and high fat foods,
decreasing time spent in sedentary behaviour and increasing physical activity. Next, Studies E and F set out approaches to intervene at a population level. These approaches comprised multi-faceted, community-based obesity prevention interventions that focused on building the capacity of the community to develop solutions. Study G reported findings from IYM, a successful community-based obesity prevention project that focused on building the capacity of the community to promote healthy eating and physical activity. IYM was successful in improving the anthropometry of the intervention compared to the comparison group but no explanatory behaviours were found. Another avenue for exploration was changes in community capacity. According to the logic model (Figure 5) used to evaluate the Pacific OPIC project, the intervention should impact directly on changes in community capacity. This pathway had not been tested. Study H quantifies the changes in capacity and relates these changes to changes in prevalence of overweight/obesity within the schools participating in IYM.

The IYM project was quasi-experimental in design (see section 2.4.2) and the analysis design was pre/post with repeat measures within schools. The aim of IYM was firstly to build the capacity of the community to promote healthy eating and physical activity. Building community capacity is often an aim of community-based obesity prevention interventions but quantitative evaluation of this construct is rare. This was the first obesity prevention intervention to report changes in community capacity over the course of a project. Group results of differences between intervention and comparison groups were analysed and there were increases in capacity in the intervention group but not the comparison. I then plotted within school changes and found heterogeneity amongst the level of individual school changes. All intervention schools improved their scores but by differing amounts. In contrast,
only two comparison schools improved, one decreased in levels of capacity and the remainder remained at baseline levels.

I then went back to the analysis reported in the previous IYM outcomes paper and found that the schools that increased the most in community capacity were also the schools that recorded a decrease in prevalence of overweight/obesity. I subsequently plotted the two results onto one graph and noted a dose response. This is the first time this relationship has been reported.
2.11 Manuscript I - Quantifying the impacts of community-based intervention: anthropometric and behavioural outcomes

2.11.1 Title: Outcome results for the Ma’alahi Youth Project, a Tongan community-based obesity prevention programme for adolescents

2.11.2 Research question

What were the anthropometric and behavioural outcomes of the intervention group compared to the comparison group at the completion of the Ma’alahi Youth project?

2.11.3 Study objective

The objective of the current study is to report the anthropometric and dietary and physical activity behavioural outcomes of the Ma’alahi Youth Project (MYP).

2.11.4 Study design

We learnt from Studies A to D that diet, exercise and sedentary behaviours are areas to target in obesity prevention interventions. From Studies E and F we learnt that community-based interventions that aimed to increase the capacity of the community to provide solutions to the obesity crisis were appropriate approaches to obesity prevention. Study G found that IYM was a successful obesity prevention programme in Australian adolescents which resulted in
740 g less weight gain compared to a comparison population but no pattern of positive behavioural changes was detected. Study H was the first manuscript to report that schools that increased in community capacity over the period of an intervention also decreased in prevalence of overweight/obesity. It appears the IYM project did influence population change in capacity and this in turn may have influenced unmeasured behavioural change at an individual level. Therefore, IYM was successful on two fronts; anthropometry and capacity. What remains to be shown is whether these complex community-based interventions can generalise to other populations and cultures. Study I partially answers this question by reporting on the Tongan arm of the Pacific OPIC project.

The study design of MYP was similar to IYM; quasi-experimental (see 2.3.4 Study design), and the analysis design was pre/post with repeat measures within participants. MYP differs from IYM in that the primary sampling unit was district with three intervention districts and one comparison district not schools as in IYM.

MYP was the first community-based obesity prevention intervention to be conducted in Tonga. The prevalence of overweight/obesity among Tongan adults was more than 90% so a high proportion of adolescents were expected to be overweight/obese. Clearly urgent action was needed to prevent further incidence and reverse the epidemic.

MYP was a very large project for an area which is still developing and where the research culture is quite young. This required capacity to be built among the research team and also other volunteers. It also required experienced researchers to learn the cultural mores from the
local people. The geographical location was also challenging both from the view of the Australian team who were assisting with the project and for program implementation and evaluation. The intervention group comprised Tongan secondary school students aged 11–19 years in the districts of Houma, Nukunuku and Kolonga on the main island of Tongatapu. The sites were selected on the basis of having: an adequate adolescent population, sufficient settings for interventions (e.g. schools, churches, community organizations), the presence of ‘champions’ for change, well-demarcated boundaries, a single administrative area and ease of access for the research team. The objectives of MYP were similar to those of IYM but the strategies were quite different as they were culturally and country relevant.

The comparison group was drawn from all six secondary schools on the island of Vava’u, the second largest island in the Kingdom. This island is situated off the north coast of Tonga. The distance between the intervention and comparison areas made data collection quite complicated. The two different areas made comparisons more difficult but using the two areas reduced the potential for contamination.

Managing, cleaning and analysing the data from MYP was challenging due to variable data quality, language barriers plus impaired communication with the researchers from Tonga. When I felt that the barrier of distance was too great I went to Tonga to assist with their data management. Whilst there I helped sort, file and enter data into a database and I also learnt much about the Tongan people and their way of life. We eventually sorted the data and analysis was undertaken. I worked closely with the first author to ensure the manuscript was written to scientific specifications while she contributed invaluable local knowledge. Again
team writing (13 authors from different disciplines and countries) was a little awkward at times and relationships had to be managed.
2.12 Manuscript J: Conclusions and future directions

2.12.1 Title: Experiences and challenges in implementing complex community-based research project: the Pacific Obesity Prevention in Communities project

2.12.2 Research question

What are the experiences and challenges presented in implementing complex community-based obesity prevention projects?

2.12.3 Study objective

The aim of this study was to reflect on the strengths and major challenges of the Pacific OPIC project, consider issues affecting these types of research and report on the developmental direction for future obesity prevention.

2.12.4 Study design

Studies A to D highlighted behaviours to target in obesity prevention interventions. Studies E and F provided approaches to obesity prevention. Study G reported on IYM; a successful community-based obesity prevention intervention among Australian adolescents. Study H
drew together building community capacity and positive changes in prevalence of overweight/obesity over the course of IYM. Study I reported MYP outcomes. It was found that MYP had no effect on anthropometry or behaviours among Tongan adolescents. The study also reported high prevalence of overweight/obesity among Tongan adolescents at baseline and higher at follow-up. It appears that these type of approaches work among white populations in developed countries but may not work as well in developing countries or among culturally diverse populations. Self-reflection by the Pacific OPIC team could provide valuable information for future projects. Study J presents an exploration of the experiences and challenges faced through delivering a huge multi-county, multi-faceted, community-based, obesity prevention project.

The design of this study was descriptive and included the synthesis and integration of information from reports and co-authors.

The entire Pacific OPIC project comprised several independent, but related, research components across four countries with markedly different cultures, populations, and food and physical activity environments in order to address adolescent obesity. The Pacific OPIC project was an immensely collaborative research project with diverse research teams representing multiple disciplines, points of view and cultural backgrounds. The academic partner institutions (Deakin University, University of Auckland and the Fiji School of Medicine) worked together closely to oversee the planning, conduct and coordination of the whole project. In addition, research staff based in Australia and New Zealand shared their expertise by providing training and supporting the research teams in Fiji and Tonga. In turn, the Fijian and Tongan teams provided valuable local contextual experience and knowledge to
the project. Partnership among the four countries was developed through the sharing of experiences, resources and practical support.

This study was an exemplar for collaborative writing. The authors (9) met in one room and the main points of the manuscript were drafted on a white board. The writing process required patience and tolerance from all parties.

The lessons learned from the Pacific OPIC project and IYM in particular have been incorporated into an obesity prevention project based in the Australian Capital Territory; ACT - IYM. This project builds on the original IYM to utilise a whole-of-systems approach to community-based obesity prevention among adolescents. I am managing this project and also co-ordinating the evaluation of this complex intervention.
Chapter 3: Obesogenic behaviours – diet

Chapter overview

This chapter comprises three manuscripts (A, B and C) either published (2) or accepted for publication (1) which together describe the pattern of unhealthy diet consumption of Australian children and that relationship with body weight. The manuscripts are entitled:


B: ‘Inconsistent associations between sweet drink intake and 2-year change in BMI among Victorian children and adolescents’. Pediatric Obesity, 8(4), 271–283

C: ‘Relationship between frequency of sugar sweetened beverage and high fat food consumption with raised BMI z-scores among a cohort of Australian children from 4 to 10 years of age’ (accepted 22/7/2013 – Obesity)
Manuscript A: statement of contribution of co-authors


http://www.biomedcentral.com/content/pdf/1471-2458-12-771.pdf

Background: Intake of sweet drinks has previously been associated with the development of overweight/obesity among children and adolescents. The present study aimed to assess the consumption pattern of sweet drinks in a population of children and adolescents in Victoria, Australia.

Methods: Data on 1,604 children and adolescents (4-18 years) from the comparison groups of two quasi-experimental intervention studies from Victoria, Australia were analysed. Sweet drink consumption (soft drink and fruit juice/cordial) was assessed as one day's intake and typical intake over the last week or month at two time points between 2003 and 2008 (mean time between measurement: 2.2 years).

Results: Assessed using dietary recalls, more than 70% of the children and adolescents consumed sweet drinks, with no difference between age groups (p = 0.28). The median intake among consumers was 500 ml and almost a third consumed more than 750 ml per day. More children and adolescents consumed fruit juice/cordial (69%) than soft drink (33%) (p < 0.0001) and in larger volumes (median intake fruit juice/cordial: 500 ml and soft drink: 375 ml). Secular changes in sweet drink consumption were observed with a lower proportion of children and adolescents consuming sweet drinks at time 2 compared to time 1 (significant for age group 8 to < 10 years, p = 0.001).

Conclusion: The proportion of Australian children and adolescents from the state of Victoria consuming sweet drinks has been stable or decreasing, although a high proportion of this sample consumed sweet drinks, especially fruit juice/cordial at both time points.
3. Declaration on the individual elements

of an article or manuscript.

4. Co-authors' signatures

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Manuscript B: statement of contribution of co-authors

‘Inconsistent associations between sweet drink intake and 2-year change in BMI among Victorian children and adolescents’

Britt W Jensen, Melanie Nichols, Steven Allender, Andrea de Silva-Sanigorski, Lynne Millar, Peter Kremer, Kathleen Lacy, Boyd Swinburn


Summary

What is already known about this subject
Sugar-sweetened beverages have been suggested as a possible contributor to the development of obesity.
However, longitudinal evidence is limited, and most previous studies were conducted in the United States. It is unclear if the results are applicable to other parts of the world.
What this study adds
We assessed the longitudinal association between sweet drink intake and body mass index in a large sample of children and adolescents in the Australian state of Victoria.
We generally found limited evidence for a longitudinal association between various indicators of sweet drink consumption and body mass index.
Objective
The aim of this study was to examine whether baseline (T1) or 2-year change in sweet drink intake in children and adolescents was associated with age- and gender-standardized body mass index (BMIZ) at time two (T2), 2 years later.
Methods
Data on 1465 children and adolescents from the comparison groups of two quasi-experimental intervention studies from Victoria, Australia were analysed. At two time points between 2003 and 2008 (mean interval: 2.2 years) height and weight were measured and sweet drink consumption (soft drink and fruit juice/cordial) was assessed.
Results

No association was observed between T1 sweet drink intake and BMIz at T2 among children or adolescents. Children from higher socioeconomic status families who reported an increased intake of sweet drinks at T2 compared with T1 had higher mean BMIz at T2 ($\beta$: 0.13, $P = 0.05$). There was no evidence of a dose–response relationship between sweet drink intake and BMIz. In supplementary analyses, we observed that more frequent usual consumption of fruit juice/cordial was associated with a higher BMIz at T2 among children.

Conclusion

This study showed limited evidence of an association between sweet drink intake and BMIz. However, the association is complex and may be confounded by both dietary and activity behaviours.
Declaration of co-authorship (PhD thesis)

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Inconsistent associations between sweet drink intake and 2-year change in BMI among Australian children and adolescents

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<td>Boyd Swinburn</td>
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5. Candidate’s signature

*The Danish Ministerial Order on the PhD Programme at the Universities (PhD order), no. 18 of 14 January 2008

**Vancouver rules: "All persons named as authors must satisfy the authorship requirement. The order of names must be a joint decision taken by all the authors. The individual author must have participated in the work to a sufficient extent to be able to accept public liability for the content of the scientific work. Authorship can only be based on substantial contribution with regard to: 1) conception and design or analysis and interpretation of data, 2) drafting the article or revising it critically for important intellectual content, and 3) final approval of the version to be published. Involvement based only on obtaining funding for the work or collecting data does not qualify for authorship. Neither does general supervision of the research group itself qualify as authorship. If the authorship is collective, key persons who are responsible for the article must be identified. The editors of the scientific periodical may ask authors to account for their part in the authorship."
### 3. Declaration on the individual elements

of an article or manuscript.

### 4. Co-authors' signatures

<table>
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<tr>
<th>Date</th>
<th>Name</th>
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<td>20/3/11</td>
<td>Andrea de Silva-Sanigorski</td>
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<td>Lynne Millar</td>
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Manuscript C: statement of contribution of co-authors

Relationship between frequency of sugar sweetened beverage and high fat food consumption with raised BMI z-scores among a cohort of Australian children from 4 to 10 years of age.

Millar L, Rowland B, Nichols M, Swinburn B, Bennett, C, Allender S.

(accepted by Obesity 22/7/2013)

Abstract

Objective: Longitudinal evidence of relationships between unhealthy diets and BMI in children is crucial for appropriately targeting obesity prevention activities. The objective was to determine the relationship between frequency of consumption of sugar sweetened beverages (SSBs) and high fat foods (HFFs) and body weight in Australian children aged from 4 to 10 years.

Design and methods: Data from 4,164 children participating in four waves (wave 1, 2004; wave 2, 2006; wave 3, 2008; and wave 4, 2010) of the Longitudinal Study of Australian Children were analysed. A multi-level growth model tested relationships between consumption of SSB and HFF and BMI z-scores.

Results: BMI z-scores were associated with daily consumption of HFF, SSB and maternal BMI independent of BMI z-scores at wave 1 (baseline); with each additional occurrence of SSB and HFF consumption intake per day, BMI z-score increased by 0.015 units (p <0.01) and 0.014 units (p <0.001), respectively. With each additional maternal BMI unit, BMI z-score increased by 0.032 (p <0.001).

Conclusions: Higher BMI z-scores were strongly associated with the consumption of SSBs and HFFs. Future efforts to prevent obesity should consider urgent action to address the impact of the consumption of SSBs and HFFs in childhood.
Chapter 4: Obesogenic behaviours – physical activity and sedentary

Chapter overview

This chapter consists of one manuscript (D) that analyses the relationships between physical activity and sedentary behaviour with body weight amongst a sample of Australian adolescents. The manuscript which has been published in Journal of Science and Medicine in Sport is entitled:

D: ‘Associations between activity-related behaviours and standardized BMI among Australian adolescents’
Manuscript D: statement of contribution of co-authors

Associations between activity-related behaviours and standardized BMI among Australian adolescents

Steven Allender, Peter Kremer, Andrea de Silva-Sanigorski, Kathleen Lacy,

Lynne Millar, Louise Mathews, Mary Malakellis, Boyd Swinburn

http://www.sciencedirect.com/science/article/pii/S1440244011001101#

Objectives: To examine the relationships between physical activity, sedentary behaviour and body mass index (BMI) among a sample of Australian adolescents.

Methods: Anthropometric, demographic and behavioural data were collected from students (n = 3040 mean age 14.6, 44% female) from 12 secondary schools in South West Victoria, Australia (response rate = 48.6%). The appropriate descriptive, univariate and regression analysis were used to examine the strength of the associations between physical activity, sedentary behaviour and odds of overweight or obese and the effect of interaction between physical activity and sedentary behaviour on odds of overweight and obese.

Results: Males were more likely to be active during the school day than females and had higher median hours of screen time per school day. Physical activity during the school day was associated with higher standardized BMI (BMI-z) among males. Higher levels of activity after school were associated with lower BMI-z for males and females. For both males and females the odds of overweight or obese were higher among the least active. An interaction was observed for females whereby the prevalence of overweight and obesity among the most physically active was lowest for the least sedentary and highest for the most sedentary.

Conclusions: The relationships between physical activity, sedentary behaviour and BMI-z were complex. Interventions to reduce BMI through increasing physical activity or decreasing sedentary behaviour need to consider the complex inter-relationships between these variables and moderating factors such as age, sex and socio economic status in their design and interpretation.
Chapter 5: Approaches to intervene within communities

Chapter overview

This chapter consists of two manuscripts (1 under review (E) and 1 published (F) in Obesity Reviews) that describe appropriate approaches to preventing obesity at a population level. The manuscripts are entitled:

E: ‘Community based obesity prevention: a systematic review of the role of community capacity development’ (submitted to Obesity Reviews)
F: ‘The Pacific OPIC Project (Obesity Prevention In Communities) – Overview and methods’ (published – Obesity Reviews)
**Manuscript E: statement of contribution of co-authors**

Community based obesity prevention: what role does community capacity development play?

Obesity Reviews (submitted)

**Millar L**, Nichols M, Foulkes C, Wolfenden L, Allender S.
Declaration for author contributions

Paper Title: "Improving Efficiency in Energy Production"

Declaration by candidate:

Please confirm the accuracy of the following details:

Name: John Doe
Position: Researcher
Department: Electrical Engineering

In the nature of my contribution:

[Details of contribution]

By submitting this declaration, I certify that the above information is true to the best of my knowledge.

Candidate's Signature: [Signature]
Date: [Date]

Declaration for co-authors:

The authors have contributed to this work and all authors are in agreement with the submission.

Declaration by co-author 1:

Name: Jane Smith
Position: Professor
Department: Computer Science

Date: [Date]

Declaration by co-author 2:

Name: Michael Brown
Position: Researcher
Department: Environmental Science

Date: [Date]

By submitting this declaration, I certify that the above information is true to the best of my knowledge.

Candidate's Signature: [Signature]
Date: [Date]
Community based obesity prevention: a systematic review of the role of community capacity development

Lynne Millar
Melanie Nichols
Chad Foulkes
Luke Wolfenden
Steven Allender

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Phone: +61 3 52278420
Abstract

Aims: The aim of this systematic review was to describe the evaluation and reporting of community capacity building within community-based obesity prevention interventions and to determine the common strategies used to build capacity.

Method: Literature searches were conducted in the CINAHL, EMBASE, PUBMED and MEDLINE electronic databases for English language studies published after January 1970 and before September 2012. Studies were included if capacity building was identified as an aim and outcomes considered were methods of evaluation, effectiveness of capacity building and strategies used to build capacity.

Results: A total of nine studies were included; one in adults and eight in children. A total of 9 studies were included; 1 in adults and 8 in children and adolescents. Using a narrative synthesis it was found that while only two studies formally evaluated capacity building, most of the studies concluded that capacity building was successful. The most common strategies to build capacity focused on resource allocation/programs and workforce/community development.

Conclusion: Community capacity should be measured in the design of community-based, obesity prevention interventions. Ongoing evaluation of community capacity throughout the intervention would support implementation and ensure the project is working to its full potential.
Introduction

Obesity is a major global public health issue with about 1.1 billion adults and 10% of children classified as overweight or obese (1, 2). Given the extent of the problem, comprehensive prevention interventions targeting broad population groups are clearly required. Multi-faceted, community-based, obesity prevention interventions have shown promising results (1, 2)

Multi-faceted approaches are required as many behavioural patterns contributing to this high obesity prevalence. These include increased consumption of high energy density foods, low consumption of fruit and vegetables and a shift to less active transport and more sedentary leisure time activities (3, 4). These behaviours occur in obesogenic environments (3) characterised by (5) low walkability (6), a high density of fast food outlets (7), and the cheap price and heavy promotion of energy dense foods (8).

Recent Cochrane reviews have supported targeting multiple behaviours and multiple levels of influence (1). This indicates requires a settings-based, multi-faceted approach to interventions. Several reviews have found that this type of approach has been successful in preventing obesity in schools, workplaces and communities (1, 2, 9-14). It appears that when capacity building approaches are incorporated into the design of obesity prevention interventions outcomes are improved (1, 14) as capacity building can enhance the abilities of the communities to develop, implement and monitor the intervention.

Capacity refers to the potential of communities to identify, mobilize and address social and public health problems (15, 16). The capacity of the community to tackle the problem of
obesity needs to be assessed prior to project implementation so that intervention strategies are applicable and have more chance of being well-received by the community (17). Multiple definitions of community capacity exist, however, according to the New South Wales Department of Health’s framework, over the duration of the project building community capacity should involve efforts across several domains that include the development of knowledge, skills, structures, resources, and commitments to health improvement (18, 19). Given that capacity building is an integral part of community-based interventions the evidence around the implementation and evaluation of capacity-building activities needs to be compiled so it can be used to guide future projects.

While there have been several reviews of the effectiveness of community-based, obesity prevention interventions however, there are none that describe the way capacity is built during an intervention, how it is evaluated nor the strategies that are employed to build community capacity. The aim of this systematic review was to describe the evaluation and reporting of community capacity building within community-based obesity prevention interventions and to determine the common strategies used to build capacity.

Methods
In this study we sought to identify all papers reporting primary data on building community capacity during community-based interventions for the prevention of obesity.

Inclusion criteria
To be eligible for inclusion, a study was required to be a community-based, multi-focused intervention that targeted more than one risk factor that had among its objectives the primary prevention of overweight, obesity or weight gain. Studies were considered to be community-
based if they focused on whole ‘populations’ or ‘communities’. This included projects delivered at or through community settings and projects that were centrally-organised but community-delivered. Interventions that focused on high risk populations (e.g. disadvantaged, geographic regions or ethnic groups) were included. Interventions which specifically recruited high risk individuals (e.g. diagnosed co-morbidity, increased risk due to obese parents) were excluded. Because this review is exploratory in its nature, specific programmes or components of programmes were not specified a priori as it was expected that activities will vary between initiatives.

An additional criterion that interventions should be of a minimum of six months duration was applied as recommended by Doak et al. (20). Due to the diversity of approaches to evaluating community-based interventions, and the difficulties of employing traditional approaches such as randomised controlled trials to community settings, no limits were placed on the study designs eligible for inclusion.

The focus of this review was capacity building and so only interventions that specified capacity building approaches among the aims or strategies, and reported capacity building outcomes were included.

*Information sources and search*

We piloted the search terms in the PUBMED database using top level MESH terms for overweight, obesity, physical activity, nutrition and community using the appropriate truncation and wildcards. Papers returned in this initial PUBMED search were reviewed and the MESH terms from papers identified in this pilot were used to develop full search terms for the overall review.
Full searches were conducted in the CINAHL, EMBASE, PUBMED and MEDLINE electronic databases for peer-reviewed English language papers published after January 1970 and before September 2012. The reference lists of included papers, as well as relevant reviews were hand-searched to validate the search terms and check for any papers that may have been missed in the initial searches. In addition lead authors of each study identified in each search were contacted for additional information or additional publications relating to the included studies. A broad search strategy was used that included exploded terms that relating to a) overweight and obesity b) prevention and c) intervention, initiative or community. Details of the search terms are available on request form the corresponding author. An example of the search strategy applied in MEDLINE is presented here:

Overweight/Obesity; Physical activity; Unhealthy nutrition Terms AND (community or communities).ti,ab,sh.; (nationwide or statewide or countrywide or citywide).ti,ab,sh.; (nation adj wide).ti,ab,sh.; (state adj wide).ti,ab,sh.; ((country or city) adj wide).ti,ab,sh.; outreach.tw.; (multi adj (component or facet or faceted or disciplinary)).ti,ab,sh.; (inter adj disciplinary).ti,ab,sh.; (field adj based).ti,ab,sh.; local.ti.; citizen$.tw.; (multi adj community).ti,ab,sh.

Study selection

After removal of duplicates, papers were assessed for eligibility for inclusion based on the criteria outlined above. Before the main screening process was undertaken, a sub-sample of 100 papers was screened by LM, CF, MN and SA and discrepancies (<5%) were discussed and resolved by consensus. Papers were then divided among LM, CF and MN and separately screened for eligibility based on title and abstract.
After initial screening, the full texts of potentially eligible papers were extracted for further assessment. Decisions about any papers for which eligibility was uncertainty were resolved by discussion and consensus among LM, CF and MN. After the final list of included studies was complete, study authors were contacted to identify any additional publications related to the intervention study.

_Data collection and data items_

Data from each of the included studies were extracted by LM into a spread sheet form that was developed and piloted by authors LM, CF and MN. Corresponding authors were contacted by email for further information where necessary data were not available in the publication(s).

Data extracted from each study were evaluation of capacity building, effectiveness of capacity building and strategies used to build capacity. Strategies were arranged under the headings of partnerships, leadership, resource allocation, workforce development and organisational development as these were key areas for intervention to build community capacity as proposed by the New South Wales Department of Health’s framework for building capacity to improve health (18, 19).

RESULTS

The general characteristics of each of the included studies (n=9), including sample and study design, focus and summary results are shown in Table 1. Table 2 contains the design of the capacity building evaluation, the focus and measures used, the types of evaluation methods used and the reported effectiveness. Table 3 classifies the capacity building intervention
strategies used by each of the projects under the headings of partnerships, leadership, resource allocation, workforce development and organisational development. All tables are arranged by year of study implementation.

**Study Characteristics**

A total of nine studies and 14 articles were included in the final sample (Table 1). There were four studies from the USA; Healthy Living Cambridge Kids (HLCK) (21), Heart to Heart (22), Shape Up Somerville (SUS) (23, 24) and HOP’N (25), four from Australia; Be Active Eat Well (BAEW) (26), Romp & Chomp (R&C) (27, 28), Tooty Fruity Vegie Project (TFV) (29, 30) and It's Your Move! (IYM) (31, 32) and, one from the Kingdom of Tonga; The Ma’alahi Youth Project (MYP) (33, 34). Of the nine studies one focussed on adults (22) and the remainder on children; six in younger children (21, 24-26, 28, 30) and two in adolescents (32, 33). Most were quasi-experimental, repeat measures, cluster, non-randomised controlled trials and most reported BMI or BMI z-scores as primary outcomes. All the studies that targeted children reported successful intervention outcomes except for HOP’N (25). The Heart to Heart project that targeted adults reported positive intervention effects on some cardiovascular risk factors but not on anthropometry (22).
Table 1: Intervention studies that report community capacity building

<table>
<thead>
<tr>
<th>Study name, year and location</th>
<th>Sample and design (original study)</th>
<th>Intervention focus and description (original study)</th>
<th>Outcome and measure (original study)</th>
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</thead>
</table>
| Heart to Heart  
  Goodman et al. (1995) (22)  
  Florence, South Carolina, USA  
  5 year project  
  1986-1990 | Quasi-experimental, matched comparison design, repeat measures, cluster, non-randomised controlled trial  
  Adults (≥ 18y)  
  Intervention - Florence  
  n = 1,642  
  Comparison - Anderson  
  n=1,551 | To develop and then replicate cost-effective, public health-based programs in communities across the country which will result in sustained reductions in behavioural risk factors and, ultimately reductions in CVD. | Anthropometry – measured height, weight  
  BMI (calculated)  
  Blood pressure (measured)  
  High cholesterol (blood samples)  
  Smoking status (self-report)  
  Physical inactivity (self-report) |
| Shape Up Somerville (SUS)  
  Original outcomes paper  
  Economos et al. (2007) (24)  
  Capacity building paper  
  Economos et al. (2010) (23)  
  Somerville, Massachusetts, USA  
  3 year project  
  2002–2005 | Quasi-experimental, repeat measures, cluster, non-randomised controlled trial  
  Children 7 to 8 years at pre-intervention  
  Intervention - Somerville  
  n = 385  
  Comparison - 2 matched cities  
  n = 793  
  (561 control 1 & 232 control 2)  
  This evaluation  
  One school year  
  (2003 - 2004) | To evaluate whether an environmental change intervention could prevent a rise in BMI z-scores in young children through enhanced access and availability of physical activity options and healthy food throughout their entire day. | Anthropometry – measured height, weight  
  BMI z-scores – CDC growth standards  
  Questionnaire on diet, PA, sedentary plus demographics (parent/caregiver- report) |
<table>
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<tr>
<th>Study name, year and location</th>
<th>Sample and design (original study)</th>
<th>Intervention focus and description (original study)</th>
<th>Outcome and measure (original study)</th>
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<tr>
<td>Be Active Eat Well (BAEW) Original outcomes paper Sanigorski et al. (2008) (26) Victoria, Australia 3 year project 2003/4-2006</td>
<td>Quasi-experimental, repeat measures, cluster, non-randomised controlled trial Children – Preschool and Primary school aged Intervention – Colac (n=4 preschools and n=6 primary schools) n = 833 Comparison - Barwon (n=4 preschools and n=12 primary schools) South Western region n = 974 This evaluation Pre/post intervention</td>
<td>Designed to build the community’s capacity to create its own solutions to promoting healthy eating, physical activity and healthy weight in children aged 4-12 years and their families</td>
<td>Anthropometry – measured height, weight waist BMI z-scores – CDC growth standards Waist/height ratio Prevalence overweight/obesity</td>
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<td>Romp and Chomp (R&amp;C) Original outcomes paper de Silva-Sanigorski et al. (2010) (28) Capacity building paper de Groot et al. (2010) (27) Victoria, Australia 4 year project 2004-2008</td>
<td>Quasi-experimental, repeat cross sectional, cluster, non-randomised controlled trial Children 2 years old 3.5 years old Intervention group – City of Greater Geelong and Borough of Queenscliff Baseline Anthropometry 2y; n = 1,589 3.5y; n = 1,194 Behavioural</td>
<td>To increase the capacity of CoGG and BoQ (the intervention site) to promote healthy eating and active play and to achieve healthy weight in children &lt;5 y of age.</td>
<td>Anthropometry All anthropometric measurements were from electronic records Questionnaire on diet, PA, sedentary plus demographics (parent/caregiver-report)</td>
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<tr>
<td>Study name, year and location</td>
<td>Sample and design (original study)</td>
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<td>All; n = 950</td>
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<td>Follow-up</td>
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<td>Anthropometry</td>
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<td>2y; n = 1,611</td>
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<td>3.5y; n = 1,239</td>
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<td>Behavioural</td>
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<td>All; n = 377</td>
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<td>Comparison group - Victoria</td>
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<td>Baseline</td>
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<td>Anthropometry</td>
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<td>2y; n = 17,732</td>
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<td>3.5y; n = 14,647</td>
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<td>Behavioural</td>
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<td>Anthropometry</td>
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<td>2y; n = 21,911</td>
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<td>3.5y; n = 19,050</td>
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<td>Behavioural</td>
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<td></td>
<td>All; n = 799</td>
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<td>This evaluation</td>
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<td></td>
<td>Pre/post intervention</td>
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<tr>
<td>Healthy Living Cambridge Kids (HLCK)</td>
<td>Single cohort, pre-post intervention study</td>
<td>The evaluation used “real world” measurement to assess the impact of HLCK on child BMI and fitness outcomes.</td>
<td>Anthropometry Measured height and weight collected annually by schools BMI z-scores – CDC growth standards</td>
</tr>
<tr>
<td>Chomitz et al. (2010) (21) Cambridge, MA, USA</td>
<td>Children Mean age 7.7 (1.8) years pre-intervention</td>
<td>Fitness tests were conducted annually by schools and included: endurance cardiovascular test;</td>
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<td>3 year project 2005 to 2007</td>
<td>Intervention – Cambridge n = 1,858</td>
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<td>Study name, year and location</td>
<td>Sample and design (original study)</td>
<td>Intervention focus and description (original study)</td>
<td>Outcome and measure (original study)</td>
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<tr>
<td>Tooty Fruity Vegie (TFV) project</td>
<td>This evaluation Pre/post intervention</td>
<td>The intervention aimed to improve the Fundamental Motor Skills, increase the amount of fruit and vegetable serves, and reduce the amount of unhealthy snack items, brought to and consumed in preschools.</td>
<td>Anthropometry – measured height, weight BMI z-scores – IOTF growth standards Questionnaire on diet, PA, sedentary plus demographics (parent/caregiver-report) Fundamental Motor Skills Lunch box audit</td>
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<tr>
<td>Original outcomes paper Zask et al. (2012) (30) Capacity building paper Adams et al. (2011) (29) NSW, Australia 10 month project 2006 to 2007</td>
<td>Quasi-experimental, repeat measures, cluster, randomised controlled trial Children 3 to 6 years Overall n = 560 Intervention n = 18 pre-schools Comparison n = 13 pre-schools This evaluation Pre/post intervention</td>
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<td>HOPN after-school project Dzewaltowski et al. (2010) (25) Kansas, USA 3 year project 2005/6-2007/8</td>
<td>Nested cross-sectional group randomized controlled effectiveness trial Children aged between 9 and 10 years Overall n = 246 Intervention (n = 3 programs) n=134 Comparison (n = 3 programs) n=112</td>
<td>This approach combines community level development, organizational level staff training, after-school program level environmental change, and skill building curriculum activities.</td>
<td>Anthropometry – measured height, weight BMI z-scores – CDC growth standards Demographic measures school administration record system PA – accelerometers Afterschool environment and healthy eating and physical activity opportunities evaluated using observation</td>
</tr>
<tr>
<td>Study name, year and location</td>
<td>Sample and design (original study)</td>
<td>Intervention focus and description (original study)</td>
<td>Outcome and measure (original study)</td>
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| It’s Your Move! (IYM)                                 | Quasi-experimental, repeat measures, cluster, non-randomised controlled trial                   | The project was developed to test the effectiveness and economic efficiency of a multi-focused, multi-site, community-based intervention to reduce adolescent overweight and obesity by building community capacity to promote healthy. | Anthropometry – measured height, weight, BMI z-scores – WHO growth standards, BMI (calculated), Fat percent (calculated).  
Self-report survey  
Questionnaire on demographics, nutrition, PA, sedentary behaviours, attitudes, perceptions, quality of life (self-report) |
| Millar et al. (2011) (32)                             | Children aged between 12-18 years                                                               |                                                                                                               |                                                                                                  |
| Capacity building paper Mathews et al. (2010) (31)    | Overall  
n = 2,054  
Intervention (n = 5 schools)  
n = 1,276  
Comparison (n = 7 schools)  
n = 778 |                                                                                                               |                                                                                                  |
| Victoria, Australia                                   |                                                                                                  |                                                                                                               |                                                                                                  |
| 3 year project 2006-2008                              |                                                                                                  |                                                                                                               |                                                                                                  |
| Ma’alahi Youth Project (MYP)                         | Quasi-experimental, repeat measures, cluster, non-randomised controlled trial                   | MYP aimed to build the capacity of communities and schools to create their own solutions for promoting healthy eating, physical activity and healthy weight gain in adolescents aged 11–19 years and their families | Anthropometry – measured height, weight, BMI z-scores – WHO growth standards, BMI (calculated), Fat percent (calculated).  
Self-report survey  
Questionnaire on demographics, nutrition, PA, sedentary behaviours, attitudes, perceptions, quality of life (self-report) |
| Original outcomes paper Fotu et al. (2011) (33)      | Children aged between 11-19 years                                                               |                                                                                                               |                                                                                                  |
| Capacity building paper Fotu et al. (2011) (34)       | Overall  
n = 1,712  
Intervention (n=3 communities)  
n = 815  
Comparison (n=1 community)  
n = 897 |                                                                                                               |                                                                                                  |
| Kingdom of Tonga                                      |                                                                                                  |                                                                                                               |                                                                                                  |
| 3 year project 2006-2008                              |                                                                                                  |                                                                                                               |                                                                                                  |
Evaluation and reporting of community capacity building

The evaluation and reporting of capacity building efforts were mixed. The project that published the most extensive evaluation was R & C (27). The three fold evaluation of community capacity was conducted at the end of the project with results from document analysis, key stakeholder interviews and the Community Capacity Index (CCI) (35) triangulated (27). The document analysis revealed that there were 53 capacity building activities conducted during the course of the project. Almost half the activities (n=21) were implemented under partnerships, another quarter in resource allocation (n=12), about one third in organisational development (n=16), a few in workforce development (n=4) and none in leadership. The results from the CCI suggested that capacity had not reached the substantial level (27) for any of the measured constructs. A round of interviews provided more detail for the context around these other findings. Tellingly, under the theme of ‘structures’ the consensus view was that there was ambiguity around roles and responsibilities which indicates lack of leadership. This lack of leadership appears to have been a dominant theme throughout the analysis. The authors concluded that at follow-up a moderate level of capacity had been reached (27).

Another other project to quantify capacity building efforts using was the TFV project (29). Data were collected pre and post intervention, and at follow-up; either two or three years after the intervention. The authors reported that the seven successful strategies still in use at follow-up were a nutrition policy, parent newsletter tips on healthy eating and physical activity, fruit and vegetable tasting sessions, children’s cooking classes, regular FMS sessions and use of the TFV manual. Strategies used least were the fruit and vegetable puppet show and parent workshops on healthy eating or fundamental movement skills (29). The directors of the preschools rated their staff as having good or excellent knowledge in FMS instruction.
post intervention and at follow-up. The quality of the FMS sessions improved from pre to post intervention. Before the intervention no preschools included structured play sessions (FMS) into their daily routine but post intervention all 17 reported that they did. This was not fully sustained at follow-up where 10 out of the 17 preschools still fully incorporated FMS, 4 partially and 3 not at all (29). The authors do not conclude any specific verdict as to capacity building.

Three studies extensively reported capacity building strategies and experiences in the form of a commentary (23) or as part of process papers (31, 34) but there was no quantifiable evaluation. Economos and Curtatone provided an overview of the capacity building strategies that were successfully implemented (23). The strategies were designed to build leadership and community involvement, and promote sustainability. The capacity building strategies used in the IYM and MYP projects were reported in respective process papers (31, 34). The results suggest that IYM did successfully build capacity (31). For example, resources invested into the project included financial and human resources to assist with the implementation of other objectives in the intervention action plan. Leadership was promoted in staff and in students through the use of the Student Ambassador Model. There were also opportunities for workforce development and partnerships to link with both existing and emerging projects and organisations within the region were created or strengthened (31). Similarly, the results presented in the MYP process paper suggest that MYP was partly successful in building community capacity (34). The MYP staff were successful in attracting additional resources from a range of both local and regional donors, and there were leadership and workforce development activities undertaken with staff, community members and students. The fact that such strategies were employed implies that capacity building was effective over the duration of these projects.
The remaining three studies reported on their capacity building efforts but there was no formal evaluation or area dedicated to reporting strategies (22, 25, 26). Heart to Heart (22) reported interview data which showed that capacity building was effective as community awareness was raised, partnerships with service providers formed, leaders emerged in the form of champions, programs were instigated, the community’s readiness to engage in intervention projects was increased and community members were up-skilled in areas of program implementation (22). The HOP’N intervention reported that capacity was built in the areas of workforce development, partnerships and program implantation (25). For example, after the staff members were trained they changed practices in relation to provision of physical activity sessions for the children, an agency to coordinate improving after-school programs was formed and the program was successfully implemented at intervention sites (25). The BAEW project did not publish any evaluation of capacity building efforts but did include capacity building in the objectives of the project (26). While these three studies did claim some capacity building over the duration of the projects, none formally reported any evaluation or systematically reported the strategies used.
<table>
<thead>
<tr>
<th>Study</th>
<th>Study sample and design (capacity study)</th>
<th>Intervention focus and description (capacity study)</th>
<th>Outcome and measure (capacity study)</th>
<th>Capacity building evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart to Heart</td>
<td>Case-study design</td>
<td>No aim specific to capacity building</td>
<td>Counts of number of times themes mentioned in interviews and archive data</td>
<td>Content analysis of interview and archive data</td>
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<td>Shape Up Somerville</td>
<td>Case-study design</td>
<td>No aim specific to capacity building</td>
<td>No formal measure</td>
<td>Narrative in common paper</td>
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<tr>
<td>Original outcomes paper</td>
<td>Intervention - Somerville</td>
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<tr>
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<td>This evaluation - retrospective</td>
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<td>Somerville, Massachusetts, USA</td>
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<td>Be Active Eat Well</td>
<td>Case study design</td>
<td>The capacity-building objective included broad actions around governance, partnerships, coordination, training and resource allocation.</td>
<td>No formal measure</td>
<td>Not evaluated</td>
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<tr>
<td>Original outcomes paper</td>
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<td>Sanigorski et al. (2008)</td>
<td>Intervention– Colac</td>
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<td>(26)</td>
<td>This evaluation - retrospective</td>
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<td>Romp and Chomp</td>
<td>Case study design</td>
<td>To determine if the capacity of the Geelong</td>
<td>Document analysis – counts of activities</td>
<td>Data triangulation: document analysis;</td>
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<td>Study</td>
<td>Study sample and design (capacity study)</td>
<td>Intervention focus and description (capacity study)</td>
<td>Outcome and measure (capacity study)</td>
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<td>de Groot et al. (2010) (27)</td>
<td>Key informant interviews (n=16) Community Capacity Index (n = 8) This evaluation - retrospective</td>
<td>community to support healthy eating and physical activity for young children was increased after Romp &amp; Chomp</td>
<td>Interviews - thematic analysis CCI – scored as per manual (35) on following domains: network partnerships; knowledge transfer; problem solving; infrastructure (policy, financial, human, social)</td>
<td>key informants interviews; Community Capacity Index (CCI)</td>
</tr>
<tr>
<td>Tooty Fruity Veggie (TFV) project</td>
<td>Case study design Pre/post intervention 17 preschool directors interviewed Pre-intervention: 2006 (n=6) 2007 (n=11) Post intervention: 2009 (n=17)</td>
<td>To determine the number of strategies at baseline and which strategies had been maintained two and three years after the initial one-year intervention</td>
<td>Scoring of structured interviews. Number of interview strategies compared pre, post and follow-up Staff knowledge of teaching FMS compared pre, post and follow-up Number of preschools teaching FMS compared pre, post and follow-up</td>
<td>Number of preschools implementing strategies pre/post intervention follow-up Directors rating staff knowledge in teaching Fundamental Motor Skills (FMS) Number of preschools teaching FMS</td>
</tr>
<tr>
<td>HOP’N after-school project</td>
<td>Case study design This evaluation - retrospective</td>
<td>The HOP’N intervention was designed to target the development of the skills and efficacy of adult leaders and children to build healthy after-school environments.</td>
<td>No formal measure</td>
<td>Not evaluated</td>
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<tr>
<td>It’s Your Move! (IYM)</td>
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<td>The aim of the Capacity</td>
<td>Narrative in process paper</td>
<td>No formal evaluation</td>
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<td>Study</td>
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<tr>
<td>Original outcomes paper Millar et al. (2011) (32)</td>
<td>12 secondary schools Intervention n = 5 Comparison n = 7 This evaluation - retrospective</td>
<td>Building objective was to build the capacity of families, schools, and community organisations to promote healthy eating and physical activity.</td>
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<tr>
<td>Capacity building paper Mathews et al. (2010) (31)</td>
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<tr>
<td>Ma’alahi Youth Project (MYP)</td>
<td>Case study design 4 communities Intervention n = 3 Comparison n = 1 This evaluation - retrospective</td>
<td>MYP aimed to build the capacity of communities and schools to create their own solutions for promoting healthy eating, physical activity and healthy weight gain in adolescents aged 11–19 years and their families</td>
<td>Narrative in process paper</td>
<td>No formal evaluation</td>
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<td>Original outcomes paper Fotu et al. (2011) (33)</td>
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</table>
Strategies used to build capacity

The strategies used to build capacity are listed in Table 3 under the headings of Partnerships, Leadership, Resource allocation/programs, Workforce/community development and Organisational development. All of the studies except TFV (29) listed strategies under the heading of partnerships. Many projects partnered with some level of government (21, 23, 26, 31, 34), key personnel (including staff, teachers, parents and students) (23, 25), non-government organisations (31, 34) and/or service providers (22, 25, 31).

Five of the projects nominated some leadership strategies (21-23, 31, 34) which included the formation of organising committees (22, 23) and the overt support from community leaders, organisations and champions (22, 23, 31, 34). Leaders demonstrated their skills through presentations and community advocacy (21, 31, 34) and leadership qualities were further enhanced through attendance at meetings, summits and forums (34).

The most common capacity building strategy reported was in allocating resources and particularly to programs. Additional capacity was represented in the form of extra funds brought into the project through successful grant submissions (31, 34), new physical activity and nutrition programs were conducted (21-23, 25, 31, 34), the purchase of infrastructure and equipment and creation of new salaried positions (22, 23, 25, 27, 31, 34). All of the projects engaged in workforce/community development. Professional development, training workshops, tertiary courses, workshops and training were provided for teachers, parents, students, canteen managers, project staff and other partners.
Heart to Heart (22) and HOP’N (25) were the only two projects that failed to list any strategies under organisational development. The most usual initiatives were the implementation of policies which included policies to promote healthy eating and physical activity through changes in environments and general wellness policies (21, 23, 27, 29, 31, 34).
<table>
<thead>
<tr>
<th>Study</th>
<th>Partnerships with</th>
<th>Leadership</th>
<th>Capacity building strategies</th>
<th>Workforce/community development</th>
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<td>Heart to Heart</td>
<td>Service organisations</td>
<td>Formation coordinating council</td>
<td>Development of surveillance system</td>
<td>Professional education</td>
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<tr>
<td>Goodman <em>et al.</em> (1995)</td>
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<td>Participation of influential community members</td>
<td>Media coverage</td>
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<td>(22) Florence, South Carolina, USA</td>
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<td>Identifying community resources for evaluation purposes</td>
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<td>PA &amp; nutrition programs</td>
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<td>Other: Walking trails marked</td>
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<td>Annual community walks</td>
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<td>Healthy meals marked on restaurant menus</td>
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<td>Screening programs</td>
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<tr>
<td>Shape Up Somerville</td>
<td>City Hall Key informants Teachers Parents Children</td>
<td>Leaders at university and of city worked together Key leaders and community organisations supported the initiative</td>
<td>School food service reform; Enhanced nutrition and physical activity curricula Healthy restaurants initiative Increased number of community garden Renovated parks Improved bike, pedestrian, and public</td>
<td>Community champions created momentum and enthusiasm</td>
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<tr>
<td>Original outcomes paper Economos <em>et al.</em> (2007)</td>
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<td>Formation of taskforce</td>
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<td>Professional development for key stakeholders Training sessions for: food service staff teachers school nurses project staff</td>
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<td>Study</td>
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<td>Resource allocation/programs</td>
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<td>Be Active Eat Well</td>
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<td>Sponsorship of events</td>
<td>Transit</td>
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<td>Media coverage</td>
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<td>Creation of employment:</td>
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<td>Access to information</td>
<td>External courses</td>
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<td>Specialist advice</td>
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<td>Cambridge Kids</td>
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<td>Chomitz et al. (2010)</td>
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<td>Provide opportunities for Community advocacy</td>
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<td>PE programs such as Project Adventure and ballroom dancing</td>
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<td>Food service projects</td>
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<td>School garden programs</td>
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<td>Increased opportunities for sport</td>
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<td>School stakeholders were Staff trained to implement new guidelines and policies</td>
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<td>Raise community awareness through media</td>
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<td>Family event nights</td>
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<td>Raise community awareness through media</td>
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<td>It's Your Move! (IYM)</td>
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<td>Tonga</td>
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DISCUSSION

This systematic review aimed to describe the evaluation and reporting of community capacity building within community-based obesity prevention interventions. A secondary aim was to determine the common strategies used to build capacity. This review found that despite building the capacity of the community to promote healthy eating and physical activity being an objective of many community-based obesity prevention studies, there were few instances of formal evaluation of this construct. The review has, however, brought together and collated the strategies used to build community capacity within community-based, obesity prevention interventions.

Each of the studies in this review included community capacity building as part of a suite of strategies aimed at obesity prevention intervention and most found positive intervention effects on anthropometry (21-24, 26, 27, 29-34) but few formally evaluated community the effectiveness of these strategies (27, 29). Given these largely successful interventions all claimed to address community capacity it is essential to evaluate the construct of community capacity before, during and after a community based obesity prevention intervention. Low levels of capacity may impact negatively on the potential for successful outcomes in any prevention intervention. Post-intervention evaluation provides evidence for where capacity was successfully built and in which areas more work was required. All studies included in this review except TFV (29) provided a retrospective assessment of capacity building over the course of the intervention. It would be more ideal to measure capacity and provide feedback at several time points throughout the project as this could allow for any necessary changes to be made to capacity building strategies. There are several tools that quantify community capacity and so could be used for evaluation of change over time. One is the Community Capacity Index (CCI) (35) which was designed
to help identify the extent of existing capacity available within a network of organisations and
groups at the local level (35). Among other applications, the CCI can be used to establish
baseline indicators of the capacity of a network to implement a program and later determine
improvements from baseline. Also, for capacity building mapping and planning, that is, to
identify what capacities have been achieved from time to time and to plan development of
further capacities (35). The developers of the CCI do caution against using the as a numerical
tool to rate or rank communities according to their capacity (35) but it could be used to assess
change within a community over time. De Groot and colleagues (27) used measurements
from this tool and other methods to report community capacity at the completion of the Romp
& Chomp study. The findings revealed low levels of capacity on some areas particularly in
the domain of leadership (27). Perhaps if capacity had been evaluated in the lead-up to
project implementation, the areas in which low levels of capacity were apparent could have
been targeted.

Ongoing monitoring of capacity indicators can highlight areas where capacity is being built
and areas where more attention is required. One other tool that has been used to measure
community capacity is the Readiness to Change (RTC) interview (36). This tool can be used
as capacity is considered similar to readiness in that both are potential states that may lead to
community action (37). The RTC tool was designed with program evaluation in mind. It can
be used to evaluate change over time of multi-component, community-wide prevention
efforts as it can give insight into key outcomes such as shifts in community norms, support of
local leadership, etc (36). The tool has been used pre-intervention by Silwa and colleagues
(38) who used the RTC tool to rank communities for their readiness to implement a
childhood obesity prevention project. The tool has more recently been used in the Pacific
Obesity Prevention in Communities (OPIC) project at baseline and follow-up (39).
The RTC tool has been used in other types of prevention interventions to assess changes in capacity over time. For example, the readiness of communities to engage in community-initiated traumatic brain injury prevention (40) and youth substance abuse (41, 42). It may be that one reason these quantitative methods of evaluating capacity (CCI and RTC) have not been used more widely is because they are time-consuming to administer and score plus both are quite subjective in interpretation. One avenue that should be explored is the development of a user friendly tool that captures capacity indicators in a more objective fashion.

There were many capacity building strategies common across studies. A majority of the capacity building efforts were centred on resource allocation/programs and workforce/community development. These commonalities may underpin development of generic methodology for capacity building strategies across different prevention activities. Moreover, the capture of all existing published approaches in this paper provides a starting point for understanding the commonalities and differences within the current academic literature. The common strategies could also be used in measurement to capture the initial level of capacity and changes in capacity over time during a community prevention project.

These commonalities also highlight the areas where capacity building interventions could be improved. These are perhaps the easier strategies to sell to the community and to implement but for sustainability projects need to form strong and ongoing partnerships, create and nurture champions and embed the changes into the organisation.

The limitations include the excluding of studies published in languages other than in English, although most community-based prevention interventions have been conducted in English
speaking developed countries. This review comprised only studies that included capacity building as an aim of the study and published some type of outcome in respect to capacity building. There are probably many more community-based interventions that used this approach but did not publish the results in journal articles.

Conclusion

Capacity building during community-based, obesity prevention projects is important and worthy of evaluation. Community capacity should be measured in the lead-up to any community-based obesity prevention project and ongoing evaluation would help ensure the project is working to its full capacity. If this knowledge is incorporated into future interventions then positive gains in obesity prevention may ensue.
References


Manuscript F: statement of contribution of co-authors

The Pacific OPIC Project (Obesity Prevention In Communities) – Overview and methods.


Abstract

Obesity is increasing worldwide with the Pacific region having the highest prevalence among adults. The most common precursor of adult obesity is adolescent obesity making this a critical period for prevention. The Pacific Obesity Prevention in Communities project was a four-country project (Fiji, Tonga, New Zealand and Australia) designed to prevent adolescent obesity. This paper overviews the project and the methods common to the four countries. Each country implemented a community-based intervention programme promoting healthy eating, physical activity and healthy weight in adolescents. A community capacity-building approach was used, with common processes employed but with contextualized interventions within each country. Changes in anthropometric, behavioural and perception outcomes were evaluated at the individual level and school environments and community capacity at the settings level. The evaluation tools common to each are described. Additional analytical studies included economic, socio-cultural and policy studies. The project pioneered many areas of obesity prevention research: using multi-country collaboration to build research capacity; testing a capacity-building approach in ethnic groups with very high obesity prevalence; costing complex, long-term community intervention programmes; systematically studying the powerful socio-cultural influences on weight gain; and undertaking a participatory, national, priority-setting process for policy interventions using simulation modelling of cost-effectiveness of interventions.
Chapter 6: Quantifying the impacts of community-based intervention

Chapter overview

This chapter comprises three manuscripts (G, H and I) that report findings from the Pacific OPIC project. Two report on anthropometric and behavioural outcomes and one on community capacity changes. All have been published. The manuscripts are entitled:

G: ‘Reduction in overweight and obesity from a 3-year community-based intervention in Australia: the ‘It’s Your Move!’ project’ (published - Obesity Reviews)

H: ‘Increasing community capacity and decreasing prevalence of overweight and obesity in a community based intervention among Australian adolescents’ (published – Pediatric Obesity)

I: ‘Outcome results for the Ma’alahi Youth Project, a Tongan community-based obesity prevention programme for adolescents’ (published - Obesity Reviews)
Manuscript G: statement of contribution of co-authors

Reduction in overweight and obesity from a 3-year community-based intervention in Australia: the 'It's Your Move!' project


Abstract

'It's Your Move!' was a 3-year intervention study implemented in secondary schools in Australia as part of the Pacific Obesity Prevention In Communities Project. This paper reports the outcome results of anthropometric indices and relevant obesity-related behaviours. The interventions focused on building the capacity of families, schools and communities to promote healthy eating and physical activity. Baseline response rates and follow-up rates were 53% and 69% respectively for the intervention group (n=5 schools) and 47% and 66% respectively for the comparison group (n=7 schools). Statistically significant relative reductions in the intervention versus comparison group were observed: weight (-0.74 kg, P < 0.04), and standardized body mass index (-0.07, P<0.03), and non-significant reductions in prevalence of overweight and obesity (0.75 odds ratio, P=0.12) and body mass index (-0.22, P=0.06). Obesity-related behavioural variables showed mixed results with no pattern of positive intervention outcomes. In conclusion, this is the first study to show that long-term, community-based interventions using a capacity-building approach can prevent unhealthy weight gain in adolescents. Obesity prevention efforts in this important transitional stage of life can be successful and these findings need to be translated to scale for a national effort to reverse the epidemic in children and adolescents.
Manuscript H: statement of contribution of co-authors

Increasing community capacity and decreasing prevalence of overweight and obesity in a community based intervention among Australian adolescents

Lynne Millar, Narelle Robertson, Steven Allender, Melanie Nichols, Catherine Bennett, Boyd Swinburn


Abstract

BACKGROUND: Community capacity building is a promising approach in reducing childhood obesity. The objective was to determine changes in capacity over a 3 year intervention (2005-2008) in schools and whether greater increases in capacity were associated with greater decreases in overweight/obesity.

METHODS: "It's your Move!" (IYM) was an obesity prevention project, in 12 Australian secondary schools (5 intervention; 7 comparison), that aimed to increase community capacity to promote healthy eating and physical activity. Capacity was assessed pre/post intervention using the 'Community Readiness to Change (RTC)' tool. Comparisons from baseline to follow-up were tested using Wilcoxon Signed-Ranks and results plotted against changes (Newcombe's paired differences) in prevalence of overweight/obesity (WHO standards).

RESULTS: RTC increased in intervention schools (p=0.04) over time but not for comparison schools (p=0.50). The intervention group improved on 5 of 6 dimensions and the three intervention schools that increased three levels on the RTC scale each had significant reductions in overweight/obesity prevalence.

CONCLUSION: There were marked increases in capacity in the intervention schools and those with greater increases had greater decreases in the prevalence of overweight/obesity. Community-based obesity prevention efforts should specifically target increasing community capacity as a proximal indicator of success.
Declaration for author contributions:

Paper: [Insert Paper Title]

Publication Details: [Insert Journal Name, Volume, Issue, Pages, etc.]

I, [Author Name], declare that I am the sole author of the present manuscript and that I have contributed significantly to the conception and design of the work, or the acquisition, analysis, or interpretation of data, or the drafting of the manuscript or the critical revision of it for important intellectual content. All persons named as authors have approved the final version of the manuscript.

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Manuscript I: statement of contribution of co-authors

Outcome results for the Ma’alahi Youth Project, a Tongan community-based obesity prevention program for adolescents.

Kalesita Fifita Fotu, Lynne Millar, Helen Mavoa, Peter Kremer, Marj Moodie, Wendy Snowdon, Jennifer Utter, Paula Vivili, Jimaima Schultz, Mary Malakellis, Marita McCabe, Graham Roberts, Boyd Swinburn


Abstract

Tonga has a very high prevalence of obesity with steep increases during youth, making adolescence a critical time for obesity prevention. The Ma’alahi Youth Project, the Tongan arm of the Pacific Obesity Prevention in Communities project, was a 3-year, quasi-experimental study of community-based interventions among adolescents in three districts on Tonga’s main island (Tongatapu) compared to the island of Vava'u. Interventions focused mainly on capacity building, social marketing, education and activities promoting physical activity and local fruit and vegetables. The evaluation used a longitudinal design (mean follow-up duration 2.4 years). Both intervention and comparison groups showed similar large increases in overweight and obesity prevalence (10.1% points, n = 815; 12.6% points, n = 897 respectively). Apart from a small relative decrease in percentage body fat in the intervention group (-1.5%, P < 0.0001), there were no differences in outcomes for any anthropometric variables between groups and behavioural changes did not follow a clear positive pattern. In conclusion, the Ma’alahi Youth Project had no impact on the large increase in prevalence of overweight and obesity among Tongan adolescents. Community-based interventions in such populations with high obesity prevalence may require more intensive or longer interventions, as well as specific strategies targeting the substantial socio-cultural barriers to achieving a healthy weight.
## Declaration for author contributions

### Paper Type:

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### Declaration of author contributions:

In the row of paper, list the name and order of any contributors to the work. Use the following:

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### Notes:

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### Conditions:

The undersigned hereby certify that:

1. The above declaration correctly reflects the author's and editor's contributions and that the work has been conducted in accordance with the ethical standards of publication.
2. The author is aware of the responsibility for the accuracy and integrity of the published work.
3. The author is aware of the importance of discussing the work with peers and the public.
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Chapter 7: Conclusions from the intervention studies and future directions

Chapter overview

In this chapter there is one published manuscript that explores the experiences and challenges faced in implementing a large, multi-country community-based obesity prevention project. The manuscript is entitled:

J: ‘Experiences and challenges in implementing complex community-based research project: The Pacific Obesity Prevention in Communities Project’ (published - Obesity Reviews)
Manuscript J: statement of contribution of co-authors

Experiences and challenges in implementing complex community-based research project:
The Pacific Obesity Prevention In Communities Project


Abstract

Policy makers throughout the world are struggling to find effective ways to prevent the rising trend of obesity globally, particularly among children. The Pacific Obesity Prevention in Communities project was the first large-scale, intervention research project conducted in the Pacific aiming to prevent obesity in adolescents. The project spanned four countries: Australia, New Zealand, Fiji and Tonga. This paper reports on the strengths and challenges experienced from this complex study implemented from 2004 to 2009 across eight cultural groups in different community settings. The key strengths of the project were its holistic collaborative approach, participatory processes and capacity building. The challenges inherent in such a large complex project were underestimated during the project's development. These related to the scale, complexity, duration, low research capacity in some sites and overall coordination across four different countries. Our experiences included the need for a longer lead-in time prior to intervention for training and up-skilling of staff in Fiji and Tonga, investment in overall coordination, data quality management across all sites and the need for realistic capacity building requirements for research staff. The enhanced research capacity and skills across all sites include the development and strengthening of research centres, knowledge translation and new obesity prevention projects.
**Declaration for authorship**

**Publication Details:**
- Author(s): [Author Names]
- Journal: [Journal Name]
- Volume: [Volume]
- Issue: [Issue]
- Year: [Year]

**Declaration by authors:**

The following individuals contributed to the work and the extent of their contributions is as follows:

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- Signature: [Signature]

**Conflict of Interest:**

None declared.

**Reviewer:**

[Reviewer Name]

**Date:** [Date]
Chapter 8: Discussion

8.1 Chapter overview

This chapter summarises the key results from this research and the implications for future interventions, policy and practice. The primary limitations of the research are identified, and directions for future research are highlighted. Given that the conclusions of the ten individual studies that made up the thesis have already been discussed in their respective manuscripts, the focus of this chapter is on the broader questions, the way in which the ten studies inter-relate, and the conclusions that can be drawn from the collective results.

8.2 Key findings and their population health implications

This thesis provides strong evidence that the appropriate target behaviours for reducing childhood obesity are the consumption of SSBs and HFFs (169, 177, 178). This thesis also provided strong evidence that community-based obesity prevention projects that used a capacity building approach were successful in some populations but less so among others (179-182). This thesis also showed moderate evidence for encouraging high levels of physical activity as a means of reducing childhood obesity and mixed evidence for targeting low levels of sedentary behaviour (183).

8.3 Key findings compared to the literature

The findings from this thesis on the appropriate modifiable risk factors to target in childhood obesity prevention efforts are similar to those found in a review by Must et el. (184). The
review included articles from 1990 to 2007 that published longitudinal findings of the relationship between weight or fatness changes and diet, physical activity, and sedentary behaviour in children. They found strong evidence for the relationship between increasing SSB consumption and changes in weight or fatness but other foods showed a less consistent pattern (184). Physical activity was inversely related to changes in weight or fatness and there was mixed findings for the relationship with sedentary behaviour.

There were only two studies from Australia included in the review; both were state-based with relatively small sample sizes. One found an association between intake of SSBs and excess weight gain in early adolescence (53). These baseline data were collected in 1996/7 from a sample of children (n=268) from Western Sydney, New South Wales. These children were followed up five years from baseline when aged approximately 13 years old (53). The other study found no relationship between macronutrient intake and body fatness but did find that body fatness was predicted by current body fatness and parent’s adiposity (185). Data were collected over 15 years from a state-based birth cohort (baseline 1975; 143 ≤ n ≥ 243). Like this thesis Must et al. (184) reported gender differences in findings in relation to sedentary behaviour and childhood obesity but the patterns were not consistent. In contrast other studies have found positive relationships between sedentary behaviour and childhood obesity (108, 109). While three are mixed findings about the success of reduction in sedentary behaviour and lower levels of obesity it remains an important target because of the negative relationship it shares with health related quality of life (186) and with mental health (187).
8.4 Lessons for interventions

Intensive intervention efforts are required to target these unhealthy behaviours because they are entrenched among children the world over. The positive strong relationship that is consistently found between SSB consumption and childhood obesity is concern given the large amounts that are being consumed by children in Australia (40, 41, 60, 62, 169), the USA (42, 43) and some countries in Europe (50). This coupled with diets high in discretionary foods that are not essential to healthy growth (59, 60, 62, 64-66), low levels of physical activity and high levels of sedentary behaviour (94, 100, 101, 103, 105) and limited evidence of effective intervention strategy indicate that stronger intervention strategies are needed to promote healthy lifestyles. Few children meet the current dietary, PA and sedentary behaviour guidelines (31-34, 40, 41, 43, 60, 62, 64, 100, 101, 103, 105, 169) in any country and this may be adding to the obesity epidemic as studies have shown that children who do meet the guidelines pertaining to activity are much less likely to be overweight/obese (106, 107).

These negative behaviours exist despite national guidelines being in place that encourage recommended levels. The low adherence is contributing to the childhood obesity epidemic. Policy makers must prioritise developing strategies to ensure stricter adherence to the guidelines and these efforts must be multi-faceted, multilevel and multi strategy (133).

8.4.1 Lessons for interventions: Community-based interventions

Community-based obesity prevention intervention projects that built community capacity to promote healthy eating and physical activity were successful in obesity prevention among
Australian adolescents (170). This success was mirrored in other projects among younger Australian children (147, 148, 188) and children from other developed countries (149-151). These are early successes in the fight against obesity and recent reviews show that these types of approaches have great promise (133). Multi-faceted approaches to childhood obesity prevention must include strategies at the levels of policy and curriculum within schools, environments and individual behaviours to make communities more healthful, with enhanced capacity to combat the obesity epidemic (133). While promising the field is young; the authors of the review report success among children aged six to 12 years. Only six of the 37 studies included samples of children aged between 13 and 18 years and none of those were from Australia. This thesis provides new evidence that older aged children and adolescents are responsive to community-based intervention efforts. Success in Australia is tempered by results in Fiji and Tonga (181, 189) and in New Zealand where it was tested among a culturally diverse population with high obesity prevalence (190). This may be due to the complexities inherent in the implementation and evaluation of these approaches. Implementation and evaluation of multi-faceted intervention projects requires coordination of many different activities at the one time and so assumes that research and other key personnel possess the skills and knowledge commensurate with the task. A key challenge associated with the Pacific OPIC project was the low research capacity that was not addressed sufficiently throughout the duration of the project (191). Other major issues included the cultural influences around body image, and dietary and physical activity beliefs and practises (191). These factors added to the complexity of the project but had these been explored prior to implementation they may have been used to the advantage of the project.

Multi-faceted prevention intervention projects are difficult to implement as they require efforts aimed directly at individual level change and also at higher level changes like policies,
environments, curriculum and so on. While all projects employed suites of these strategies, it remains unclear which of the strategies singly or in combination, were more successful and why. This thesis provides one part of the jigsaw puzzle by quantifying changes in capacity over the course of a project and associating the change with changes in the prevalence of overweigh/obesity (179). While promising, more investigation into the nexus between increased capacity and decreased prevalence is needed. This thesis echoes the call of Waters et al. (133) to challenge the prevention community to develop robust methods to capture and quantify the processes and strategies employed in both successful and less successful intervention projects. This information could then be used to inform policy makers and future prevention efforts so that stronger effects may be realised.

8.5 Strengths of the research

One of the main strengths of this thesis was that it drew on evidence from analysis of large, longitudinal cohort datasets. The size of these datasets ensured adequate power to test multiple relationships. For example, use of the Pacific OPIC dataset comprised pre/post data from adolescents in four countries (Australia, Fiji, New Zealand and Tonga; n > 18,000). This large sample allowed confidence in the finding that the community-based approach to obesity prevention was successful amongst a mainly white population from a developed country and was not as successful in developing countries or areas of greater cultural diversity and/or where the prevalence of overweight/obesity is high. The LSAC dataset is also a large dataset (n>4,000), is ongoing, observational and comprises four waves of biennial data collection. The data are collected using rigorous methodology that ensures comparability over time.
Capacity was built not just in communities but in researchers as well. For example, during my candidature I visited McGill University, Montreal, to work with leading statisticians to extend my skills’ base. I also spent three months at the University of Oxford to form and strengthen collaboration with our research group and to build my research competences. During that time I attend the Short Course on Prevention Strategies for Non-Communicable Diseases. This helped me to think about prevention across a range of conditions. I used a variety of statistical analyses techniques to best answer the research questions and that suited the structure of the data. For example the findings from the non-parametric analysis in Manuscript H (179) were aligned with the prevalence results from Manuscript G (170) and the overall results graphed to clarify relationships. Multilevel growth modelling was used on Manuscript C (178). This required attendance at a relevant statistics course. In addition, I assisted in building the capacity of researchers and students from Fiji and Tonga through assistance with data management, statistical analysis and general research skills. In turn, they added to my education by helping me to understand the cultural influences impacting on projects in their countries and so we were able to overcome barriers and help prevent misunderstandings.

8.6 Limitations of the research and directions for future research

There are several limitations to the research, many of which have already been identified in the ‘Discussion’ section of each of the manuscripts. This section highlights the key limitations, and notes ways in which these could be addressed in future research.
8.6.1 Measurement of obesogenic risk factors

Measurement of obesogenic risk factors at a population level is quite difficult as tools need to be sensitive enough to capture changes in behaviours but they also need to be pragmatic. Collecting population level data is expensive so the cost of data collection must be weighed against the cost of the project overall (172). Other considerations include prioritising evaluations as data collection can take quite some time. It is important to collect as much data as is needed to answer the research questions but to not collect data that are redundant to the needs of the project.

A general weakness in the field of obesity prevention is the inconsistencies in the way dietary, physical activity and sedentary behaviours data are collected. Self-reported recall data are not overly reliable as people can forget what they have consumed and the activities in which they have engaged. Under-reporting and over-reporting are common among self-report and parent-report of dietary (192), physical activity (193) and sedentary behaviours (194). This inconsistency in reporting may be one reason for the lack of findings in respect to positive behavioural change in the presence of successful anthropometric outcomes in the IYM project (170). Another was that there were small changes that singly did not reach significant association but each may have contributed to an overall healthful change. One alternative is to use doubly labelled water but the high expense and difficult of use make it an impractical method of measurement at a population level. Another is for researchers to use tools that have been validated and are reliable measures of dietary and activity behaviours in children (195, 196).
Behavioural measures aimed at collecting population level data are often difficult to analyse as differing methods are used. For example, the definition of SSB’s includes different drinks across articles, quantities differ from cups, bottles, cans, millilitres, ounces and serves and the methods capturing frequencies range from the number of times consumed per day to number of serves per day or week (51-54, 169, 177, 178). Even the manuscripts contained in this thesis used differing measures to gauge SSB consumption. Manuscripts A and B used millilitres and Manuscript C used frequency of consumption. Like SSBs, HFFs are also variously defined and measured in the literature (69, 72, 81, 83, 178). Nonetheless, regardless of methods, the relationships between SSB and HFF consumption and child body weight are often significant.

The mixed findings from Manuscript D that investigated the association between physical activity and sedentary behaviour with weight status (183) were congruent with a recent review of the literature (108). Besides the usual limitations of different forms of data collection methods, self-report data and biases there remains differences in the actual behaviours captured. While the physical activity component varies between moderate and vigorous physical activity, sport after school, active during recess and lunch time each requires some effort on behalf of the participant and generally does not afford the opportunity to eat at the same time.

Conversely, screen time generally does not differentiate between television viewing and other screen activities like electronic games, video games, smart phone use, tablets or the myriad other types of screens in use by today’s children. Except for television watching, each of the other forms of screen time requires active input and some even require the user to be moving
around. Also, whilst watching television people have more opportunity to eat as they are generally just sitting at the time. These differences may be the reason for the mixed findings in this study.

It is recommended that one way to overcome some of these measurement limitations is for there to be greater international collaboration between leading researchers especially during the design phase of large, community-based interventions so that comparable measures can be used. Also an international committee could be formed to collate and assess the utility, validity and reliability of the measures used in community-based obesity prevention initiatives. This information could then be used to guide evaluation of future interventions.

8.6.2 Challenges of obesity research

MYP in Tonga was novel as it was the first obesity prevention intervention set in Tonga among adolescents (181) but this may have also contributed to the lack of healthy changes in anthropometry and behaviours. There is a strong research culture in developed countries especially in places like the USA, Canada, Europe and Australia whereas in developing countries such as Tonga the research culture is limited (197). This may indicate that a long lead time would be necessary to ensure the communities in developing countries are ready, willing and able to implement the necessary strategies when the project starts.

A relative long lead time is essential as it allows for the forming of partnerships between the research team and participants through community engagement. These relationships can then assist in the priority-setting processes. A long lead time also allows for the collection and
analysis of pre-intervention measures that can inform and guide priority setting and implementation. For example, socio-cultural studies can provide knowledge on the cultural barriers and facilitators to health promotion, and community readiness and capacity measures can provide knowledge on the communities’ awareness of the problem, willingness to act and ability to act. Another reason for a long lead time in countries where research capacity is low is time to build research skills in the local team to ensure they have the capabilities and confidence to implement and evaluate the project.

To overcome the lack of lead time, realistic timeframes should be built into funding applications. Also publications whether they be in the form of peer reviewed literature or in the grey literature need to include a discussion on the actual time required to develop and implement projects.

8.6.3 Challenges of obesity research evaluation

Research into community-based prevention interventions is limited by the theoretical models underpinning the science. While the socio-ecological model is useful in its present form it does not adequately account for the interactions between the levels of the model. Similarly the logic model on which the evaluation of the interventions was based presumes linearity; the intervention dose is administered at one end which sets off a chain of actions and results in changes in anthropometry at the other end, but this is not how complex interventions work. The Foresight model (198) highlights the complexity of the causes of obesity but is not a useful model on which to base interventions. Current methodology is grappling to understand and adopt to real life complexity (199, 200).
Complex interventions work with multiple targets on multiple levels at the one time. It is likely that these types of interventions grow organically, change in response to needs in ways that could not be predicted a priori (199). This type of change in response to feedback is not captured through the present theoretical models and many are now key to the potential of systems (199, 200). Systems science takes into account the integration of multiple intervention strategies at multiple levels and can be in the implementation and evaluation of future community-based prevention projects (199). The prevention community needs to develop evaluation methodology that captures and quantifies the complexity involved so that the generic prevention systems can be mapped (200). These prevention systems can then be used to help prevent other chronic conditions.

8.6.4 Future research

This research has added important knowledge to the field of childhood obesity prevention; it has identified alternate population measures of intervention success, and; provided directions for future research in the area. These future directions include:

- greater collaboration between leaders in the field to use agreed upon standardised measurement tools for evaluating obesogenic behaviours;
- incorporating longer lead times into projects so that baseline characteristics can be assessed prior to implementation;
- developing theoretical models to better explain the complexity inherent in community-based prevention projects;
- developing ways to quantify community capacity in a way that can be used multiple times over the duration of a project so that capacity building can be tracked;
- advancing the science to include a systems approach to prevention which includes evaluation methods;
• developing policies and regulations to limit children’s exposure to the determinants of obesity, and;
• understanding how to structure future interventions so that they may be generalisable to different cultural groups

8.7 Thesis conclusion

This thesis found that obesogenic behaviours which are targeted through community based interventions lead to reduced childhood overweight/obesity.

This thesis has demonstrated that giving communities the skills and tools to promote healthy eating and physical activity is one way to prevent childhood obesity. The evidence clearly shows that soft drinks and other sugary drinks should be removed from the diets of children. Other food types which are not essential for healthy growth should also be limited if not eliminated. Physical activity is to be encouraged and sedentary behaviour discouraged as both affect childhood obesity. When all these factors are packaged and presented as a whole they are more successful in preventing childhood obesity than they are when targeted singly.
References


34. National Health and Medical Research Council, Department of Ageing. Eat for health: Australian Dietary Guidelines summary. Canberra: Commonwealth of Australia; 2013 [cited 2013 19 March]; Available from:


100. Hardy LL. NSW schools physical activity and nutrition survey (SPANs) 2010: Executive Summary. Sydney: University of Sydney 2010.


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Appendix A: Parent Computer Assisted Telephone Interview (CATI)

Survey

CATI Interview Schedule (Parent/Guardian)

Introduction Script for CATI Interviewer
[Ask to speak with person listed below, or if the person is unavailable, another parent/guardian who is prepared to be interviewed.]

Good-morning/ afternoon/ evening. My name is .......... and I am calling on behalf of Professor Boyd Swinburn of Deakin University, the Principal Investigator for the Colac project. Thankyou for agreeing to be interviewed.

As you are probably already aware, this project is interested in the food and beverage intake and activities of children 4-12 years of age. In a few moments, I will be asking you some questions about your child/children, as well as some about your household and neighbourhood. It is anticipated that for each child, the interview should take about 15 minutes. If you have more than one child, it is possible to complete the interview for each of them at different times.

[Check if this applies, and if respondent would like to do the interview over different days/dates – and then record the follow-up interview days/dates below.]

If you would like to find out any information – let me know. Also, if you feel you would like to speak with someone in relation to this interview or any aspect of the project- you should contact Dr Colin Bell on 03-52278414.

Let me begin by checking some details about your child/children.

[Check both Pre-School and School Children details below and note any corrections]
[Check to see if there are any additional Pre-School and School children not listed below – within the household. If there are, record these and then conduct/arrange a date and time to conduct an interview.]

<table>
<thead>
<tr>
<th>CONTACT</th>
<th>Parent/Guardian #1</th>
<th>Parent/Guardian #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent/Guardian First Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent/Guardian Surname:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Code:</td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
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<tr>
<td>Household ID Number:</td>
<td></td>
<td></td>
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<tr>
<td>Comment:</td>
<td></td>
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</tr>
<tr>
<td>DATE/DAY</td>
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<td></td>
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<tr>
<td>Date (DDMMYYYY)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>M Tu W Th F Sa Su</td>
<td></td>
</tr>
<tr>
<td>Interviewer Name</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## CHILD IDENTIFICATION

<table>
<thead>
<tr>
<th>Surname</th>
<th>First Name</th>
<th>DOB (DD.MM. YYYY)</th>
<th>Gender</th>
<th>Year Level (Pre/P-6)</th>
<th>ID Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smith</td>
<td>Betty</td>
<td>12.03. 1999</td>
<td>F</td>
<td>Pre</td>
<td>1214</td>
</tr>
<tr>
<td>School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smith</td>
<td>John</td>
<td>14.11. 1995</td>
<td>M</td>
<td>3</td>
<td>1215</td>
</tr>
<tr>
<td>Pre-School children that have returned the consent form who are not listed?</td>
<td>[List here]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there any other primary school children that have returned the consent form who are not listed?</td>
<td>[List here]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up interview dates for multiple interviews?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask after Interview #1 is complete</td>
<td>Day/Date 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask after interview #2 is complete</td>
<td>Day/Date 2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask after interview #3 is complete</td>
<td>Day/Date 3:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## SECTION

### Item

#### PRE-SCHOOL CHILDREN

### PRE-SCHOOL - GENERAL

I would like to start by asking you a number of general questions about <insert the child’s first name>.

What is your relationship to <insert the child’s first name>?  
Mother  
Father  
Step-mother  
Step-father  
Female carer/guardian  
Male carer/guardian

Was <insert the child’s first name>‘s mother born in Australia or overseas?  
Australia  
Overseas (which country? Please specify: _____________)

Was <insert the child’s first name>‘s father born in Australia?  
Australia  
Overseas (which country? Please specify: _____________)

### PRE-SCHOOL FOOD AND BEVERAGE INTAKE

Now I am going to ask you a number of questions about <insert the child’s first name>‘s food and
beverage intake.

How many serves of fruit did <insert the child's first name> eat yesterday?  
[By a serve we mean a medium size apple, orange, banana, or pear, OR two small pieces of fruit such as kiwi fruit, mandarins, or apricots, OR a bunch of grapes, OR a cup of diced pieces]  
Number  
Don't know  

How often does <insert the child's first name> eat fruit?  
[eg. Apple, banana, orange, diced fruit, fruit salad, …]  
Never  
Less than once a week  
Once a week  
Two-four times a week  
Five-six times a week  
Once per day  
2 or more times per day  
Don't know  

On average, how many different types of fruit does <insert the child's first name> usually eat each week?  
Number  
Don’t know  

How many serves of vegetables or legumes (eg. peas, beans …) did <insert the child's first name> eat yesterday? Don’t count potatoes.  
[By a serve, we mean ~ 1 cup of salad vegetables, or ½ a cup of cooked vegetables, beans, peas, … – NOT potato]  
Number  
Don’t know  

How often does <insert the child’s first name> eat vegetables or legumes?  
[again NOT including potatoes]  
Never - less than once a week  
Once a week  
Two-four times a week  
Five-six times a week  
Once per day  
2 or more times per day  
Don’t know  

On average, how many different types of vegetable or legumes does <insert the child’s first name> usually eat each week? [DON’T count potatoes]  
Number?  
Don’t know  

Often children don’t like certain vegetables when they first try them.  
How many times would you offer a new vegetable to <insert the child’s first name> before you gave up?  
1-2  
3-4  
5-6  
7-8  
9-10  
> 10  

201
Don’t know

How many serves of potato crisps or other packaged snacks (such as corn chips, twisties, cheezels, cheetos, burger rings …) did <insert the child’s first name> eat yesterday?
[By a serve we mean half a standard (50 gm) bag of crisps, or one small snack pack]
Number
Don’t know

How often does <insert the child’s first name> eat potato crisps or other similar packaged snacks (such as corn chips, twisties, cheezels, cheetos, burger rings …)?
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How many serves of ‘take-away’ or fast food (such as fish and chips, pies/pasties, hamburgers, fried chicken, pizza, Chinese …) did <insert the child’s first name> eat yesterday?
[By a serve we mean a pie/pastie, a bucket of hot chips, a plain hamburger, one hot dog, …]
Number
Don’t know

How often does <insert the child’s first name> eat takeaway or fast-foods?
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How many cans of soft drink (eg. Coke, Solo, lemonade) did <insert the child’s first name> drink yesterday?
[By cans, we mean the 375 mls cans that you would see in supermarkets or convenience stores. Diet soft drinks are NOT included.]
Number
Don’t know

How often does <insert the child’s first name> drink non-diet soft-drinks?
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How many serves of fruit juice or cordial did <insert the child’s first name> drink yesterday?
[By serves we mean the small 250 ml tetra paks or a standard glass. The types of drinks include 100% Fruit Juices, diluted fruit juice drinks, and cordials. Examples include Prima, Just Juice,
tetra-paks of diluted fruit juice, and cordial drinks like Kia-Ora, Cottees …]
Number
Don’t know

How often does <insert the child’s first name> drink fruit juice or cordial?
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How often do you offer <insert the child’s first name> water to drink with meals or snacks?
Always
Quite often
Sometimes
Rarely or never
Don’t know

PRE-SCHOOL – ACTIVITY
In this section I am going to ask you a number of questions about how <insert the child’s first name> spends his/her free time.

How much time did <insert the child’s first name> spend outside yesterday after pre-school?  
Number (record in total minutes)
Don’t know

At this time of the year, how much time does <insert the child’s first name> usually spend outside, after pre-school?  [Record using following categories]
None
Half an hour
One hour
One and a half hours
Two hours
Two and a half hours
Three hours
Three and a half hours
Four hours
Four and a half hours
Five hours
More than five hours
Don’t know

How many times each week is <insert the child’s first name> involved in organised games, sports, or dance – outside of pre-school hours?
7 or more times per week
Less than once per week
1-2 times per week
3-4 times per week
5-6 times per week
Don’t know

How much time did <insert the child’s first name> watch TV (including videos) yesterday?  
Number (record in total minutes)
Don’t know

On average, how much time per day does <insert the child’s first name> watch TV (including videos)?
[Record using following categories]
None
Less than half an hour
Half an hour
One hour
One and a half hours
Two hours
Two and a half hours
Three hours
Three and a half hours
Four hours
Four and a half hours
Five hours
More than five hours
Don’t know

How much time did <insert the child’s first name> play electronic games (such as computer games or Play Station) yesterday?
Number (record in total minutes)
Don’t know

On average, how much time per day does <insert the child’s first name> play electronic games (such as computer games or Play Station)?
Number (record in total minutes)
Don’t know

[Proceed to next pre-school child on list. If, no further pre-school children then move onto school children. If no further pre-school children, and no school children to interview, then move to Household-Neighbourhood section.]

SCHOOL CHILDREN

SCHOOL - GENERAL
I would like to start by asking you a number of general questions about <insert the child’s first name>.
What is your relationship to <insert the child’s first name>? 
Mother
Father
Step-mother
Step-father
Female carer/guardian
Male carer/guardian

Was <insert the child’s first name>’s mother born in Australia or overseas?
Australia
Overseas (which country? Please specify: _____________)

Was <insert the child’s first name>’s father born in Australia or overseas?
Australia
Overseas (which country? Please specify: _____________)
SCHOOL – FOOD AND BEVERAGE INTAKE
Now I am going to ask you a number of questions about <insert the child’s first name>’s food and beverage intake.
How many serves of fruit did <insert the child's first name> eat yesterday?
[By a serve we mean a medium size apple, orange, banana, or pear, OR two small pieces of fruit such as kiwi fruit, mandarins, or apricots, OR a bunch of grapes, OR a cup of diced pieces]
Number
Don’t know

How often does <insert the child's first name> eat fruit?
[e.g. Apple, banana, orange, diced fruit, fruit salad …]
Never
Less than once a week
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

On average, how many different types of fruit does <insert the child’s first name> usually eat each week?
Number
Don’t know

How many serves of vegetables or legumes did <insert the child’s first name> eat yesterday?
[By a serve, we mean ~ 1 cup of salad vegetables, or ½ a cup of cooked vegetables, beans, peas, … – NOT potato]
Number
Don’t know

How often does <insert the child’s first name> eat vegetables or legumes?
[again NOT including potatoes]
Once a week or less
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

On average, how many different types of vegetable and legumes does <insert the child’s first name> usually eat each week? [DON'T count potatoes]
Number?
Don’t know

How many serves of potato crisps or other packaged snacks (such as corn chips, twisties, cheezels, cheetos, burger rings …) did <insert the child’s first name> eat yesterday?
[By a serve we mean half a standard (50 gm) bag of crisps, or one small snack pack]
Number
Don’t know

How often does <insert the child’s first name> eat potato crisps or other packaged snacks (such as corn chips, twisties, cheezels, cheetos, burger rings …)?
Less than once a month
One-three times a month

205
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How many serves of ‘take-away’ or fast food (such as fish and chips, pies/pasties, hamburgers, fried chicken, pizza, Chinese …) did <insert the child’s first name> eat yesterday?
[By a serve we mean – a pie/pastie, a bucket of hot chips, a plain hamburger, a hot dog, …]
Number
Don’t know

How often does <insert the child’s first name> usually eat takeaway or fast-foods (such as fish and chips, a pie or pastie, hamburgers, fried chicken, pizza, Chinese, …)?
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How many cans of soft drink (eg. Coke, Solo, lemonade) did <insert the child’s first name> drink yesterday?
[By cans, we mean the 375 mls cans that you would see in supermarkets or convenience stores.
Diet soft drinks are NOT counted.]
Number
Don’t know

How often does <insert the child’s first name> drink non diet soft-drinks (such as Coke, Fanta, Sprite, Solo, …]
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How many serves of fruit juice or cordial did <insert the child’s first name> drink yesterday?
[By serves we mean the small 250 ml tetra paks or a standard glass. These drinks include 100%
Fruit Juices, diluted fruit juice drinks, and cordial. Examples would be Prima, Just Juice, tetra-
paks of diluted fruit juice, and cordial drinks like Kia-Ora, Cotees …]
Number
Don’t know

How often does <insert the child’s first name> drink fruit juice or cordial?
Less than once a month
One-three times a month
Once a week
Two-four times a week
Five-six times a week
Once per day
2 or more times per day
Don’t know

How often do you offer <insert the child’s first name> water to drink with meals or snacks?
Always
Quite often
Sometimes
Rarely or never
Don’t know

SCHOOL CHILD - ACTIVITY
In this section I am going to ask you a number of questions about how <insert the child’s first name> spends his/her free time.
How many hours did <insert the child’s first name> spend outside yesterday after school?
Number (record in minutes)
Don’t know

At this time of the year, how many hours does <insert the child’s first name> usually spend outside after school?
[Record response using the following categories]
None
Half an hour
One hour
One and a half hours
Two hours
Two and a half hours
Three hours
Three and a half hours
Four hours
Four and a half hours
Five hours
More than five hours
Don’t know

How many hours did <insert the child’s first name> spend watching videos or TV yesterday?
Number (record in minutes)
Don’t know

How many hours per day does <insert the child’s first name> usually spend watching videos or TV?
[Record response using the following categories]
None
Less than half an hour
Half an hour
One hour
One and a half hours
Two hours
Two and a half hours
Three hours
Three and a half hours
Four hours
Four and a half hours
Five hours
More than five hours

207
Don't know

How many hours did <insert the child’s first name> spend playing electronic games (such as computer games or Play Station) yesterday?
Number (record in minutes)
Don’t know

How many hours per day does <insert the child’s first name> usually spend playing electronic games after school?
[Record response using the following categories]
None
Less then half an hour
Half an hour
One hour
One and a half hours
Two hours
Two and a half hours
Three hours
Three and a half hours
Four hours
Four and a half hours
Five hours
More then five hours
Don’t know

On average, how many times per week is <insert the child’s first name> involved in organised games, sports, or dance - outside school hours
Less than once per week
1-2 times per week
3-4 times per week
5-6 times per week
7 or more times per week
Don’t know

What method, or methods, of travel did <insert the child’s first name> use to get to and from school yesterday? [NB. Two methods can be nominated for this Qn – from the following list]
Train
Bus
Ferry
Car
Motorcycle
Bicycle
Walk
Don’t know
Other (Please specify: ____________)
[CATI operator to record response]
Response 1
Response 2

How does <insert the child’s first name> usually get to and from school each day?
[ONE response only. If multiple, record the most frequent.]
Walking
Car
Bicycle
Bus
Train
Other (Please specify: ____________)
[CATI operator to record response]

What is <insert the child’s first name>’s preferred method of getting to and from school each day?
Walking
Car
Bicycle
Bus
Train
Other (Please specify: ____________)
[CATI operator to record response]

How many minutes would it take an adult to walk from your place to <insert the child’s first name>’s school?
Number (record in minutes; maximum = 60 minutes)
More than 60 minutes
Don’t know

SCHOOL CHILD – WEIGHT
In this section I am going to ask you several questions about <insert the child’s first name>’s weight.

How concerned are you about <insert the child’s first name>’s weight now?
Not at all concerned
A little concerned
Quite concerned
Very concerned

Do you consider <insert the child’s first name> to be …?
Overweight
Slightly overweight
About the right weight
Slightly underweight
Underweight

[Proceed to next school child on list. If no further school children, then proceed to Household-Neighbourhood section.]

HOUSEHOLD-NEIGHBOURHOOD

HOUSEHOLD
In this section we are interested in obtaining information about some of the activities and rules in your household.

I am going to ask you three questions relating to family rules. For each question I would like you to make a rating about how strong you feel the rules is, and then to make a rating about how tightly the rules is enforced. Please indicate your responses using the two separate rating scales that follow.

Very strict
Quite strict
Not very strict
Non-existent [i.e. skip the second rating in these cases]

We have family rules that encourage children to try new foods?
Strictness rating [using above scale]
Enforcement rating [using above scale]

We have family rules that encourage children to play outside?
Strictness rating [using above scale]
Enforcement rating [using above scale]

We have family rules limiting the number of children watch TV/videos?
Strictness rating [using above scale]
Enforcement rating [using above scale]

How often, per week, does your family have the television on during the evening meal?
Number
Don't know
Not applicable (don’t own a television)
How many televisions do you have in your house?
Number
Don't know

How many children (aged 4-12 yo) in the household have a TV in their bedroom?
Number
Don’t know

Were there any days last month when your family didn’t have enough food to eat or enough money to buy food?
Yes (How many? Specify: __________) No
Don’t know

NEIGHBOURHOOD
In this section we are interested in obtaining some information about your neighbourhood.
How many stores selling fresh fruits and/or vegetables are there within 10 minutes walking distance of your house?
Number
Don’t know

How would you rate the availability of sport, dance and physical activity/games programs (such as football, netball, swimming classes, ballet or other dance classes, …) for children in your area?
Very good
Good
Average
Poor
Very poor
Don’t know

How many parks or open spaces for children to play in (ie. playgrounds, council reserves, public gardens …) are within 10 minutes walking distance of your house?
Number
Don’t know

Does your street have a footpath?
Yes, on both sides
Yes, on one side
Yes, in places
No

I would like you to rate three aspects of your neighbourhood in terms of safety using the rating
scale below:

Very safe
Safe
Neither safe or unsafe
Unsafe
Very unsafe
Don’t know

How safe is it for a 12 y.o child to walk alone in your neighbourhood during the day?
Rating

How safe is the closest park or open space for children to play in? Rating
How safe is it for a 12 y.o. child to cycle in your neighbourhood during the day? Rating
Now I would like you to rate the following potential dangers or risks to children in your neighbourhood using the following rate scale:

High risk
Moderate risk
Low risk
Don’t know

Risk of injury from a traffic accident
Rating

Risk of injury from strangers (e.g. assault, abduction)
Rating

Risk from other children (i.e. bullying, theft of property)
Rating

Risk of attack from animals (e.g. dogs)
Rating

Risk of injury from dangers in the physical environment (e.g. ponds, lakes, cliffs, holes)
Rating

DEMOGRAPHICS

HOUSEHOLD DEMOGRAPHICS
In this section I am going to ask you a number of questions about the people who live in your household.

How many adults (i.e. ≥ 18 y.o.) usually live in your household?
Number

How many children (i.e. < 18 y.o.) usually live in your household?
Number

What is the highest level of education attained by the adult female in the household?
Didn’t complete high school
Completed high school (i.e. Year 12)
Has completed a TAFE qualification (e.g. Certificate, Diploma)
Has completed a University degree (e.g. Bachelor’s degree)
Has completed a University higher degree (e.g. Masters, PhD)
No female adult in the household

What is the highest level of education attained by the adult male in the household?

211
Didn’t complete high school
Completed high school (i.e. Year 12)
Has completed a TAFE qualification (e.g. Certificate, Diploma)
Has completed a University degree (e.g. Bachelor’s degree)
Has completed a University higher degree (e.g. Masters, PhD)
No male adult in the household

What was your household income before tax in the last financial year?
≤ $30,000
> $30,000 - $40,000
> $40,000 - $50,000
> $50,000 - $60,000
> $60,000 - $70,000
> $70,000

CLOSING
That completes the interview/interview for today. Thank you very much for your providing us with your time. We will be in contact with you again in about 24 months time to complete a follow-up interview and potentially at other times in the future. For this reason we would like to know the contact details of close relative or friend who would know your contact details if you moved from your current address.

<table>
<thead>
<tr>
<th>First name</th>
<th>Surname</th>
<th>Address</th>
<th>Phone number</th>
<th>Relationship to you</th>
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Again, thank you very much for your participation.

[Record any 2nd /3rd/… interview dates/times (if relevant/required) in the Table at start of CATI]
Appendix B: Adolescent Behaviours, Attitudes and Knowledge

Questionnaire (ABAKQ)

Instructions:

Is this today’s date? 

_____/_____/_____

What is the name of your school? 

____________________

1. What year are you in? 

   Year 

   9 

   10 

   11 

   12 

   13 

2. Which ethnic group do you most associate with?

   European Australian

   Indian

   Chinese

   Indigenous Australian

   Other
3. Were you born in Australia?  
   Yes
   No

4. I am  
   Male
   Female

5. What is your date of birth?  
   Day
   Month
   Year

6. Do you live with your parents/step-parents during the school week?  
   Yes with two parents
   Yes with one parent
   Don’t live with my parents

7. Do you live with other ADULT relatives during the school week?  
   (e.g. grandparents, uncle, aunt, cousin)

214
Yes

No

12. How many people usually live at your home including yourself during the school week?

1-15

13. On school days, where do you usually get your breakfast from?

Home

School canteen or tuck shop

Shop (outside school)

From friends

I don’t eat breakfast

14. In the last 5 school days, on how many days did you have something to eat for breakfast before school started?

0 days

1 day

2 days

3 days
15. Where do you usually get your morning tea for recess from?

Home

School canteen or tuckshop

Shop (outside school)

From friends

I don’t eat morning tea

16. In the last 5 school days, on how many days did you eat at morning recess/interval?

0 days

1 day

2 days

3 days

4 days

5 days

17. Where do you usually get your lunch from?
18. In the last 5 school days, on how many days did you eat lunch at lunchtime?

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

19. How many serves of fruit do you usually eat each day? (a serve = 1 apple, 1 banana, 1 mandarin or 1 cup of diced fruit)

1 serve or less
2 to 3 serves
4 serves or more
20. How many serves of vegetables do you usually eat each day? (1 serve = ½ cup cooked vegetables or 1 cup of raw vegetables/salad)

1 serve or less

2 to 3 serves

4 serves or more

21. In the last 5 school days (including time spent at home), on how many days did you have regular (non diet) soft drinks? (Soft drinks = drinks like Coke, Sprite, Fanta)

0 days

1 day

2 days

3 days

4 days

5 days

22. On the last school day, how many glasses or cans of non-diet soft drinks did you have?

0-More than 2 litres
23. In the last 5 school days, on how many days did you have fruit drinks or cordial? (Such as Ribena and Cottées)

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

24. On the last school day, how many glasses of fruit drinks or cordial did you have?

0-9 glasses ____

25. How often do you usually eat food from a takeaway? (e.g. McDonalds, KFC, Subway, fried chicken, fish and chips, hamburgers, Chinese takeaway)

Once a month or less
2-3 times a month
Once a week
2-3 times a week
26. In the last 5 school days, on how many days did you buy snack food from a shop or takeaway after school?

   0 days

   1 day

   2 days

   3 days

   4 days

   5 days

27. How often do you usually eat fruit after school?

   Everyday or almost everyday

   Most days

   Some days

   Hardly ever or never

28. How often do you usually eat bread, toast, buns or sandwiches after school?

   Everyday or almost everyday
Most days

Some days

Hardly ever or never

29. How often do you usually eat biscuits, potato chips or snacks such as instant noodles after school?

Everyday or almost everyday

Most days

Some days

Hardly ever or never

30. How often do you usually eat pies, takeaways or fried foods such as French fries after school?

Everyday or almost everyday

Most days

Some days

Hardly ever or never

31. How often do you usually eat chocolates, lollies, sweets or ice cream after school?
32. In the last 5 school days, how many times did you walk or bike to or from school? (walking from home to school and back on 1 day is 2 times: walking to school and taking the bus home is 1 time)

0-more than 10 times

33. How long does it take you to walk from home to your school?

Less than 15 minutes

15-30 minutes

More than 30 minutes

34. Over the last 5 school days, what did you do most of the time at morning recess/interval (apart from eating)?

Mostly just sat down

Mostly stood or walked around

Mostly played active games
35. In the last 5 school days, what did you do most of the time at lunchtime (apart from eating)?

- Mostly just sat down
- Mostly stood or walked around
- Mostly played active games

36. In the last 5 school days, on how many days after school did you do sports, dance, cultural performances or play games in which you were active?

- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days

37. In the last 5 school days, how many days did you watch TV, videos or DVDs in your free time? 0 days
1 day
2 days
3 days
4 days
5 days

38. On the last school day that you watched TV, videos or DVDs, how long did you watch for?

Less than 1 hour – More than 4 hours

39. Last Saturday, how many hours did you spend watching TV, videos or DVDs?

0-more than 10 hours

40. Last Sunday, how many hours did you spend watching TV, videos or DVDs?

0-more than 10 hours

41. During the school week, do your parents (or caregivers) limit the amount of TV you are allowed to watch? (including videos and DVDs)

No limits, I can watch anything
Yes, but not very strict limits

Yes, strict limits

42. In the last 5 school days, how many times did you watch TV while eating your evening meal?

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

43. Do you have a TV in your home?
Yes
No

44. Do you have a TV in your bedroom?
Yes
No
45. In the last 5 school days, how many days did you play video games, electronic games or use the computer (not for homework)?

- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days

46. On the last school day that you spent time playing video games or using the computer (not for homework), how long did you play for?

- Have not played for ages
- Less than 1 hour
- 1 hour
2 hours

3 hours

4 hours

More than 4 hours

47. Last Saturday, how many hours did you spend playing video games or using the computer (not for homework)?

0 – More than 5 hours

48. Last Sunday, how many hours did you spend playing video games or using the computer (not for homework)?

0 – More than 5 hours

49. Do you have video games, electronic games or a computer in your home?

Yes

No

50. How would you describe your weight?  

Very underweight

Slightly underweight
About the right weight

Slightly overweight

Very overweight

51. How happy or unhappy are you with your BODY WEIGHT?

Very happy

Happy

In between / OK

Unhappy

Very unhappy

Never thought about my body weight

52. How happy or unhappy are you with your BODY SHAPE?

Very happy

Happy

In between / OK

Unhappy

Very unhappy
Never thought about my shape

53. Which of these statements most closely applies to you?

I am…

Trying to lose weight

Trying to gain weight

Trying to stay at my current weight

Not doing anything about my weight

54. Which of the following statements most closely applies to you?

I am…

Trying to gain muscle size

Trying to stay at the same muscle size

Not doing anything about my muscles

55. How much does your mother (or female caregiver) encourage you to eat healthy foods?

A lot

Some

A little
Not at all

Don’t live with my mother

56. How much does your father (or male caregiver) encourage you to eat healthy foods?

A lot

Some

A little

Not at all

Don’t live with my father

57. How often do you have food from a takeaway shop for dinner?

More than once a week

About once a week

2-3 times a month

Once a month or less

58. How often is fruit available at home for you to eat?

Everyday or almost everyday

Most days
59. How often are potato chips or similar snacks available at home for you to eat?

- Everyday or almost everyday
- Most days
- Some days
- Hardly ever or never

60. How often are chocolates or sweets available at home for you to eat?

- Everyday or almost everyday
- Most days
- Some days
- Hardly ever or never

61. How often are non-diet soft drinks available at home for you to drink? (soft drinks = drinks like Coke, Sprite, Fanta)

- Everyday or almost everyday
- Most days
Some days

Hardly ever or never

62. In the last 5 school days, how much money did you spend in total on food or drinks for yourself at takeaway shops or milkbars (not at the school canteens)?

0 – 20 Dollars

63. How much does your mother (or female caregiver) encourage you to be physically active or play sports?

A lot

Some

A little

Not at all

Don’t live with my mother

64. How much does your father (or male caregiver) encourage you to be physically active or play sports?

A lot

Some

A little
Not at all

Don’t live with my father

65. How much do your older brothers or male cousins encourage you to be physically active or play sports?

A lot

Some

A little

Not at all

Don’t have older brother/cousin

66. How much does your older sister or female cousins encourage you to be physically active or play sports?

A lot

Some

A little

Not at all

Don’t have older sister/cousin
67. How much do your best friends encourage you to be physically active or play sports?

A lot

Some

A little

Not at all

68. In the last 5 school days, how many times did all or most of your family living in your house eat an evening meal together?

0 days

1 day

2 days

3 days

4 days

5 days

69. How much does your school encourage ALL students play organised sport?

A lot
Some
A little
Not at all

70. How much does your school encourage ALL students to be physically active at lunchtime?

A lot
Some
A little
Not at all

71. How do you rate the teachers at your school as role models for being physically active?

Excellent
Good
OK
Not very good
Poor

72. How do you rate the teachers at your school as role models for healthy eating?
73. How do you rate the food and drink choices available at your school canteen?

Mostly healthy

Half healthy/half unhealthy

Mostly unhealthy

74. How much does your school encourage students to make healthy food choices?

A lot

Some

A little

Not at all

75. How safe do you feel being out alone in your neighbourhood at night?

Very safe
76. How safe do your parents (or caregivers) think it is for you to be out alone in your neighbourhood at night?

Very safe
Safe
Unsafe
Very unsafe
Don’t know

77. How much do dogs bother you when you are walking in your neighbourhood?

A lot
Somewhat
A little
Not at all
78. How much does traffic bother you when you are walking in your neighbourhood?

A lot

Somewhat

A little

Not at all

79. How much do other people bother you when you are walking in your neighbourhood?

A lot

Somewhat

A little

Not at all

How strongly do you agree or disagree with the following statements

80. Skipping breakfast or lunch is a good way to lose weight

Strongly agree

Agree

Neither agree nor disagree

Disagree
Strongly disagree

81. Fruit drinks and cordials have less sugar than non-diet soft drinks like Coke and Sprite

Strongly agree

Agree

Neither agree nor disagree

Disagree

Strongly disagree
82. Watching a lot of TV does not lead to weight gain

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

83. Eating a lot of fruit and vegetables is bad for your weight

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

This completes the questionnaire!!

Thank you for your participation!!…well done!