Neighbourhood SES and Food Environment? Characteristics and Body Mass Index of Children in the Metropolitan Perth Region

Damber Bahadur Shrestha

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To all the ‘Have-Nots’ children

Contents

Declaration of Originality

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, the contents are original and have not been submitted to any other university or educational institution, except where due acknowledgment is made in the thesis. Parts of the research (listed below) are in process of being published. Contribution made to the research by Professor Billie Giles-Corti and Dr Bryan Boruff with whom I have worked at The University of Western Australia (WA) during my candidature is fully acknowledged.

Manuscript 1: Does Neighbourhood Food Environment Influence Obesity among School Children in Perth metropolitan region?

Manuscript 2: The Associations between Neighbourhood Socio-economic Status and Neighbourhood Food Environment in Perth metropolitan region.

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Candidate

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Dr Bryan J. Boruff

Coordinating Supervisor

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List of Abbreviations

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
BMI	body mass index
CBD	central business district
CCD	Census collector's districts
CI	confidence interval
CT	Census Tract
DIT	Diffusion of innovation theory
DOHA	Department of Health and Aging
DOHWA	Department of Health, Western Australia
ETBL	economic theory of brand loyalty
ETCA	economic theory of comparative advantage
GIS	Geographic Information Systems
HEP	healthy eating pyramid
HFAI	healthy food availability index
NFE	neighbourhood food environment
NFI	neighbourhood food index
NHMRC	National Health and Medical Research Council
NPHT	National Preventative Health Taskforce
OR	odds ratio
p	p-value
r	Pearson's correlation coefficient
PFEI	physical food environment index
POS	point-of-sale
RESIDE	Residential Environments
SAS	Statistical Analysis System
SCT	social cognition theory
SD	standard deviation
SE	standard error
SEIFA	socioeconomic index for areas
SES	socioeconomic status

SLT	Social learning theory
SQL	Structure Query Language
TPB	Theory of Planned Behaviour
TREK	TRavel, Environment and Kids
WA	Western Australia
WHO	World Health Organisation

Abstract

Background

Food available within the local community can affect eating habits and thus influence weight status of many people in the community. Hence, the neighbourhood food environment (NFE), is believed to be one of the important causes for the current global trend in obesity. However, empirical evidence on the relative contribution of the NFE on the development of overweight or obesity still remains unclear. One possible explanation for this lack of understanding is due to limitations in defining the NFE since very few studies have attempted to estimate the overall quantity and quality of the food available within a pre-defined spatial unit or neighbourhood.

Hence, the main purpose of this study was to develop an alternative approach in measuring the neighbourhood food environment by integrating the Geographic Information Systems (GIS) and the Delphi survey. The food-type-specific NFE was examined with the neighbourhood socioeconomic status (SES) and the prevalence of overweight or obesity in primary school children in Perth metropolitan region.

Methods

Food types were categorised into three groups: 'eat most', 'eat moderate' and 'eat least'), based on the 'Healthy Eating Pyramid' (HEP). A food outlets dataset was compiled. We used the online Yellow Pages listings and identified twenty-three types of retail food outlets based on name recognition. Definitions of retail food outlets were developed. The proportion of 'eat most', 'eat moderate' and 'eat least' types of food for each type of food outlet was obtained from the Delphi technique. A 300 metre circular buffer zone was created around home address of each participant. The NFE was estimated by integrating the proportion of a particular type of food for each outlets and number of all the individual types of retail food outlets located within the neighbourhood.

Results

Overall, the Perth metropolitan area was dominated by ‘eat least’ type of food (63 per cent) followed by ‘eat moderate’ (21 per cent) and ‘eat most’ (16 per cent) respectively. The study participants’ neighbourhoods were also dominated by ‘eat least’ type of food (62 per cent) followed by ‘eat moderate’ (25 per cent) and ‘eat most’ (13 per cent).

The total number of retail food outlets available in the participants’ neighbourhoods varied directly with neighbourhood SES ($p = 0.0021$). Similarly, ‘eat most’ ($p = 0.0015$) and ‘eat moderate’ ($p = 0.0052$) types of food available in the neighbourhood were also varied significantly with neighbourhood SES in the Perth metropolitan region. The highest quantity of ‘eat most’ and ‘eat moderate’ types of food were available in high SES areas, followed by medium SES and low SES areas respectively. The ‘eat least’ type of food also showed similar pattern with the neighbourhood SES. However, it varied only moderately with the neighbourhood SES ($p = 0.0108$).

Further, amounts of ‘eat most’ ($p = 0.0157$) and ‘eat moderate’ ($p = 0.0054$) types of food available in the normal weight children’s neighbourhoods were significantly higher compared with overweight or obese children. However, the ‘eat least’ type of food available in the normal weight children’s neighbourhoods did not vary significantly with the overweight or obese children’s neighbourhoods ($p = 0.0575$). Furthermore, the amounts of ‘eat most’ (OR = 0.10, 95% CI = 0.016–0.670, $p = 0.0174$) and ‘eat moderate’ (OR = 0.15, 95% CI = 0.037–0.576, $p = 0.0059$) types of food that were available within the study participants’ neighbourhoods were significantly associated with the prevalence of overweight or obesity among the study participants. However, the association between the availability of ‘eat least’ type of food in the neighbourhood did not show strong association with the prevalence of overweight or obesity in children (OR = 0.62, 95% CI = 0.373–1.017, $p = 0.0584$).

While the prevalence of overweight or obesity in children was higher in low SES neighbourhoods, the influence of neighbourhood SES on prevalence of overweight or obesity among children did not reach a statistically significant level.

Conclusion

Neighbourhood attributes such as SES and NFE are associated with each other. These characteristics of the neighbourhood may influence the development of overweight or obesity in children in Perth metropolitan region.

Chapter 1: Introduction

1.1 Research Context and Rationale

1.1.1 Background

The prevalence of overweight or obesity is increasing. Worldwide, over 500 million people are currently obese and approximately 1.5 billion are overweight (WHO, 2011). The prevalence of overweight or obesity in children has jumped markedly in Australia over the years (O'Dea and Dibley, 2010). Surveys data show that the number of overweight children increased almost two fold between 1985 and 1995 (Magarey et al., 2001b). Data from 2000 to 2006 show that the prevalence of obesity in childhood continued to increase in Australia (O'Dea and Dibley, 2010) particularly among low SES groups (Magarey et al., 2001b; O'Dea and Dibley, 2010). If this trend continues then nearly three-quarters of the Australian population will be overweight or obese in 2025 (National Preventative Health Taskforce, 2008).

Overweight or obesity has serious health consequences (Ebbeling et al., 2002; Visscher and Seidell, 2001), including cardiovascular disease (Pratt et al., 2007), diabetes (Csabi et al., 2000; Young-Hyman et al., 2001), musculoskeletal disorders, cancer (Visscher and Seidell, 2001; WHO, 2011) and depression (Erickson et al., 2000; Fabricatore and Wadden, 2004). Estimates suggest that approximately 140 people die every day in Australia from obesity-related diseases (Field, 2002; Gray and Holman, 2009) which costs almost $21 billion per annum (Colagiuri et al., 2010).

Overweight or obesity results in excessive fat accumulation in the body, which occurs largely because of individuals' behaviours, such as over-consumption of food (i.e., excess energy intake) and physical inactivity (i.e., insufficient energy expenditure) (Egger and Swinburn, 1997; French et al., 2001; Hill, 2006; Hill and Melanson, 1999; Hill and Peters, 1998). However, the process of development of overweight or obesity is multi-factorial (Papas et al., 2007). It can involve individual, socio-cultural, economic and environmental factors. Hence, from the epidemiological view, we have proposed a conceptual model (Figure 1.1) to illustrate

the associations between environments and individual's behaviours and health outcome.

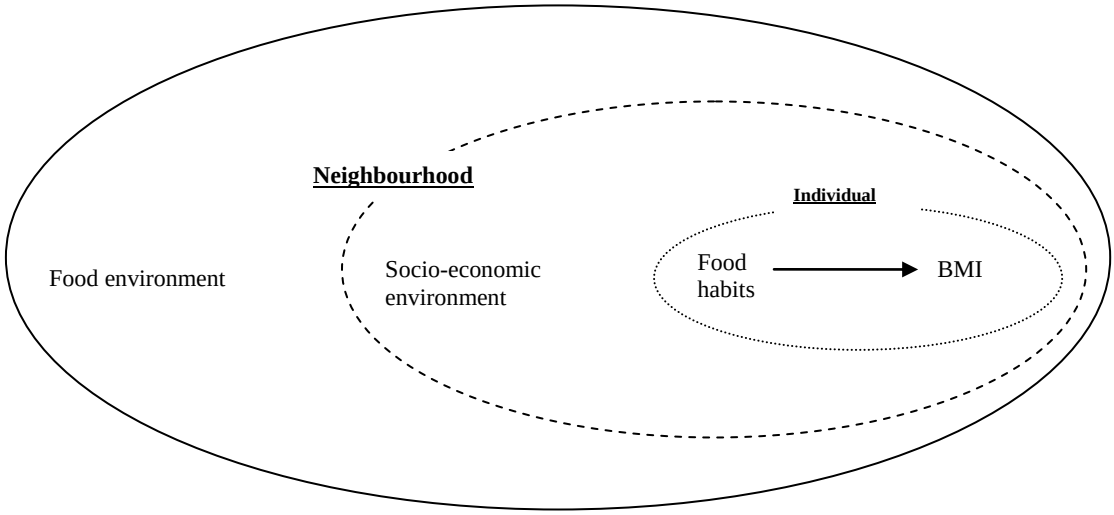

Figure 1.1: Conceptual model illustrating links between neighbourhood attributes and individual level variables

1.1.2 Neighbourhood food environment and overweight or obesity

It is believed that the adoption of population-based strategies can help promote healthy eating and physical activity (Nawaz and Katz, 2001; Story et al., 2008a). Hence, in recent years, research attention has been drawn towards the changing environment as one of the influencing factors for the growing prevalence of overweight or obesity (Ball et al., 2006b; Bertrand et al., 2008; Black and Macinko, 2008; Bodor et al., 2010a; Morland et al., 2006; Morland and Evenson, 2009; Morland et al., 2003; Smoyer-Tomic et al., 2006; Wrigley, 2002; Wrigley et al., 2003). The reason for this shift in research is recognition that an individual's behaviours are influenced by their surroundings or attributes of the neighbourhood (Story et al., 2008b). Moreover, environmental changes, such as the availability of food in the local market or changes in the price of food can have social and economic implications (French et al., 2001; Headey and Fan, 2008; Taylor, 2009).

Some evidence suggests that neighbourhood attributes such as availability of food in the local community (Cheadle et al., 1991; Curhan, 1972) and price of food can

influence the food purchasing and therefore food habits of people (Glanz and Yaroch, 2004). Thus, changes in the attributes of the environments, particularly in the NFE, are considered one of the important factors that influence the current global trends in obesity (Booth et al., 2005b; Popkin et al., 2005). Nevertheless, empirical evidence on the relative contribution of the NFE on the development of overweight or obesity still remains unclear (Cummins and Macintyre, 2006; DeClerck et al., 2011; Giskes et al., 2007a; Holsten, 2009; Jeffery and Utter, 2003). One explanation is the possible limitation involved in defining the neighbourhood (Ball et al., 2006b; Diez Roux, 2003), therefore measuring the NFE (Cummins et al., 2005a; French et al., 2001) for the overall quantity and types of food.

1.1.3 Measurement of neighbourhood food environment

To date, the majority of studies have been using simple approaches such as presence/or absence of a particular type of retail food outlets to indicate the availability of a specific type of food in the neighbourhood. For example, fast food outlet for the unhealthy or energy-dense food (Reidpath et al., 2002; Rundle et al., 2009) whereas supermarket for the healthy type of food (Ball et al., 2009; Morland et al., 2002a; Morland et al., 2002b; Rundle et al., 2009).

Although it is possible to estimate the NFE by using the food store type as a proxy to represent the availability of selected type of food in the neighbourhood, it may not give a clear picture, as it provides only one aspect of the NFE (i.e., the type of food outlet). Thus, the results can be difficult to interpret (Larson et al., 2009). For instance, Wang and her colleagues in the US found a direct correlation between the presence of a supermarket and body mass index (BMI) among women (Wang et al., 2007), whereas another study reported an inverse association between supermarkets in the neighbourhood and the risk of becoming overweight or obese, both among men and women (Morland et al., 2006). Such contradictory results may be because many retail food outlets stock different types of food (Farley et al., 2009; Latham and Moffat, 2007) ranging from healthy to unhealthy. Hence, it is possible that neighbourhoods with greater access to unhealthy food also have access to healthy food options (Larson et al., 2009). This problem has prompted researchers to take a

more comprehensive approach to measuring the NFE (Glanz et al., 2005; Larson et al., 2009).

In recent years, some researchers have attempted to measure the NFE comprehensively (Franco et al., 2008; Truong et al., 2010). However, in their methods, they have not included all types of retail food outlets in addition to quantity of all the food that are available in those stores. Hence, this study attempted to overcome this limitation by integrating number of each type of food outlets along with proportion of a particular type of food that is available in each type of retail food outlets and examine its association with the prevalence of obesity in primary school children in Perth metropolitan region.

1.2 Aims of the Project

The main aims of this project are to develop a comprehensive index for assessing the food available in the neighbourhood, and to examine the influence of the NFE on the prevalence of overweight or obesity among primary school children in the Perth metropolitan region.

1.2.1 Specific Objectives

The specific objectives of the project are to:

1. develop a neighbourhood food index (NFI)
2. examine the association between neighbourhood socioeconomic status (SES) and the NFI in the Perth metropolitan region
3. examine the association between the NFI and the prevalence of overweight or obesity among primary school children in the Perth metropolitan region
4. examine the association between neighbourhood SES and the prevalence of overweight or obesity among primary school children in the Perth metropolitan region.

1.3 Structure of Thesis

This thesis is divided into five chapters. First Chapter contains research background, aims and objectives. Chapter 2 provides a review of the literature that served as an overall guide for the entire project. Chapter 3 presents the study methods, including the methods used in developing the NFI and datasets. The results are presented in Chapter 4. Finally, Chapter 5 discusses the key results and presents the conclusions of the project.

Chapter 2: Literature Review

2.1 Overview

This chapter attempts to identify and describe the relevant factors associated with an individual's food choice behaviours. The first section describes the possible variables responsible for determining an individual's food choice behaviours. Next, the possible theoretical concepts and models that are useful in studying food choice behaviours are considered. The third section presents a brief description of the neighbourhood and the NFE, and reviews the association between neighbourhoods' SES and the NFE, including measurement of the NFE. The fourth section examines the available literature on the influence of the NFE on food choice behaviours before exploring the evidence on food behaviours and BMI. Finally, possible associations between NFE and BMI are presented.

2.2 Background

Food is one of the basic necessities for all human beings. It provides a range of nutrients that are essential for the normal regulation of the body's activities (Kelley and Bendich, 1996). This is critical for growing children. However, it is not possible to obtain all nutrients solely from a particular type of food. That is, good health can be possible only by eating a well-balanced diet consisting of an appropriate amount of a wide variety of food.

The Healthy Eating Pyramid (HEP) is a simple model developed by Nutrition Australia (Australian Nutrition Foundation, Inc., 1999). It provides fundamental information on the proportion and types of food that individuals need to consume as a regular part of their daily meal. For instance, individuals should eat at least two serves of fruit (120–150 grams) and five serves of vegetables (60–90 grams) every day (Miller et al., 1997). Daily meals should also contain a high amount of breads, cereals or rice and a moderate amount of lean meat, fish, poultry and eggs (NHMRC,

2010). However, the consumption of takeaway meals and snacks with higher sugar, fat and salt should be limited (National Heart Foundation, 2009).

Data show that the majority of Australians (Ball et al., 2006a; Magarey et al., 2001a), particularly children, do not eat the recommended amount of healthy food, especially fruit and vegetables (Department of Health and Ageing, 2010; Scully et al., 2007). According to the Australian Bureau of Statistics (ABS, 2009), only six per cent of Australian children aged 5–17 consume five or more serves of vegetables daily. Moreover, their consumption of saturated fat, salt and sugars is considerably higher than the recommended intake (Department of Health and Ageing, 2010; Scully et al., 2007).

2.3 Theoretical Background

Social cognition theory (SCT) assumes that people learn about, and understand, many things from their immediate surroundings (Bandura, 2001a; Bandura, 2001b). It further argues that environmental factors (or events) and personal factors (cognitive, emotional and biological events) can operate bi-directionally. Therefore, they can influence each other (Bandura, 2001a); that is, the food choice behaviour of an individual can be the result of interaction between personal factors (age, gender, SES, knowledge, skills and attitude) and environmental factors (availability of food and their types in the neighbourhood, social norms and cultures that encourage or discourage consumption of certain type of food items).

The SCT has been used in studying the effect of availability, modelling and nutrition education as motivating factors for the consumption of fruit and vegetables by children (Reynolds et al., 1999). This has further prompted the possibility of exploring an integrated approach such as socio-ecological models, which will better explain the direct and indirect effects of psychological, social and physical environmental variables on an individual's food choice behaviour. The ecological theories of behaviour may provide better insights into the effects of multiple factors as determinants of food choice behaviour. Bronfenbrenner (1994) described the environmental context of development as five socially organised sub-systems that

help support and guide human growth. This ranges from the micro-system, which refers to the relationship between a developing person and the immediate environment, such as family and school, to the macro-system, which refers to institutional patterns of culture, such as the economy, customs and bodies of knowledge (Bronfenbrenner, 1994). Based on the socio-ecological theory, an individual's food choice behaviour has been conceptualised as an interaction between multiple level factors such as intrapersonal, interpersonal, institutional, community and legislative or policy (McLeroy et al., 1988).

Story and her colleagues combined SCT with an ecological perspective in order to understand the factors that influence adolescents' food choices and eating behaviours (Story et al., 2002). They described four levels of influences: individual or intrapersonal (e.g., psychological and biological), social environment or interpersonal (e.g., family and peers), physical environment or community settings (e.g., schools, fast-food outlets and convenience stores) and macro-system or societal (e.g., mass media, marketing and advertising, and social and cultural norms). In this regard, physical environments that define food availability and accessibility and the socio-cultural environment, which defines what is socially acceptable, desirable and appropriate to eat, can be equally important in determining the food choice behaviours of individuals (Brug et al., 2008).

Glanz and her colleagues proposed a conceptual model for studying nutrition environments based on an ecological model of health behaviour. They highlighted three possible factors that can affect the eating patterns of an individual: environmental, social and individual. The researchers have incorporated constructs found (or hypothesised) to be related to the healthy-eating outcomes from the fields of public health, health psychology, consumer psychology and urban planning (Glanz et al., 2005). The authors further identified four types of nutrition environments in addition to those environments affected by government policies and other organisations where food environments are shown as having two pathways of influence on eating patterns (Glanz et al., 2005). They considered environmental effects as moderated or mediated by demographic, psychosocial or perceived environment variables (Glanz et al., 2005). The authors concluded that environmental, social and individual factors can affect eating patterns, which in turn

can affect the risk of many chronic diseases (Glanz et al., 2005). The authors believed that this model could serve as a guideline to develop suitable methods that are needed to assess the nutrition environments and eating behaviours of people (Glanz et al., 2005).

The socio-ecological model has become well suited for describing the effect of the NFE on the food choice behaviours of individuals (Glanz et al., 2007; Story et al., 2008b). This model can be successfully applied in intervention studies such as improving food behaviours, because food availability in the environment can suppress personal choice (Richards and Smith, 2007). Further, the environment can influence large segments of the neighbourhood's population (Glanz and Mullis, 1988). This approach has been recently applied in a health-promotion programme intended to improve dietary behaviours such as the consumption of fruit and vegetables among African-Americans (Robinson, 2008). However, more research needs to be conducted to examine whether food- and diet-related environmental factors are the main determinants of the current epidemic of obesity, since much of the evidence appears to be context-specific (Cummins and Macintyre, 2006). Moreover, it is not very useful to compare the results of one study to another due to differences in concepts and methods (Black and Macinko, 2008; Booth et al., 2005b; Feng et al., 2010; Papas et al., 2007), particularly the definition or measurement of the NFE.

2.4 Factors Influencing Food Choice Behaviour of Individuals

An individual's food choice behaviour is a complex process (Pollard et al., 2002) that can involve many factors (Hursti, 1999; Koivisto Hursti, 1999; Pearson et al., 2009; Reinaerts et al., 2007; Shepherd, 1999), which can be broadly categorised into three groups: individual, interpersonal and environmental (Devine et al., 1998; Falk et al., 1996; Furst et al., 1996).

2.4.1 Individual Factors

2.4.1.1 Knowledge

An individual's knowledge of nutrition can influence his or her decision to select certain type of food (Brown and Landry-Meyer, 2007; Hughner et al., 2007). For example, individuals who are aware of the critical role of healthy food may consume an adequate amount of fresh fruit and vegetables (Pollard et al., 2008). Similarly, person's knowledge about the food can also influence that particular person's food choice or food habits (Pollard et al., 2008). Conversely, individuals who lack knowledge about importance of food may not consume adequate amount of healthy food such as fruit and vegetables (Wolf et al., 2008). This can be applicable even in case of children and adolescents. For example, Beech et al. (1999) assessed the level of nutrition knowledge, attitudes and practices related to fruit and vegetable consumption among high school students in New Orleans in the United States (US). They observed higher knowledge of the importance of fruit and vegetables among white (Caucasian) adolescents than in African-American adolescents. Consequently, they found a higher consumption of fruit and vegetables among white adolescents than in their African-American counterparts (Beech et al., 1999).

2.4.1.2 Attitude

Attitude is defined as the degree of positive or negative feelings towards a particular object (e.g., food). An individual's attitude towards certain type of food can be formed because of their exposure to that particular food. This attitude can affect an individual's course of action, such as his or her food choice behaviours. Barker et al. (1995) conducted a study on attitudes towards fat and fibre. They found that 'fibre-philic' attitudes of a person were positively associated with the intake of dietary fibre, potatoes, vegetables, wholemeal bread and breakfast cereal. An inverse relationship was found between 'fat-phobic' attitudes and fat intake through a reduced intake of chips, butter and sausages (Barker et al., 1995).

2.4.1.3 Ideology

Ideology is a set of ideas that constitutes an individual's goals, expectations and actions. An individual's ideology can affect his or her ethical judgment in general. As a consequence, individuals may choose certain type of food based on their ideology (Steenhaut and van Kenhove, 2006; Van Kenhove et al., 2001). This may in turn shape their food habits to a certain extent (de Boer et al., 2007; Eertmans et al., 2005). For example, people concerned with the environment may prefer a vegetarian diet (Krech et al., 2004), while others may prefer non-vegetarian food.

2.4.1.4 Taste Preference

The taste of food can act as one of the major factors influencing on an individual's food choice (Glanz et al., 1998). This can be particularly evident among children and adolescents, as they may worry more about the taste of the food than the nutrient content. Hence, many children and adolescents eat more fast food (Pereira et al., 2005a) or meats (Gossard and York, 2003), as they appreciate the taste of these foods (Hesketh et al., 2005). Further, children and adolescents may not eat an adequate amount of fruit (Molaison et al., 2005; O'Dea, 2003) and vegetables (Aranceta et al., 2003), as they may not like the taste. However, the dietary pattern of individuals may vary across the life-course (McNaughton, 2011). For instance, older people may relate food in terms of health benefits (Gustafsson and Sidenvall, 2002); therefore, they may often avoid high-fat food (Gustafsson and Sidenvall, 2002) but eat more healthy food (ABS, 2009), particularly fresh fruit (Morland and Filomena, 2008) and vegetables (Ball et al., 2006a; Morland and Filomena, 2008).

2.4.1.5 Gender

Gender has also been shown to be associated with food choice behaviour. For instance, in general, women are more likely to eat a healthy diet (Roos et al., 1998; Wardle et al., 2004), including fresh fruit (Dibsdall et al., 2003; Wardle et al., 2004), vegetables (Dibsdall et al., 2003) and high-fibre food (Wardle et al., 2004). A study conducted in Queensland reported that approximately 58 per cent of females and 44 per cent of males consumed the recommended daily serves of fruit (Ibiebele et al.,

2006). A similar trend was observed nationally in Australia (ABS, 2009) and in England (Margetts et al., 1998; Thompson et al., 1999).

In general, women may avoid food containing high levels of fat and salt (Wardle et al., 2004), whereas males may prefer food containing high levels of fat, sugar (McNaughton et al., 2008b) and salt, including fast food (Pereira et al., 2005a). However, this may be confounded by other attributes such as marital status. For example, married males appear to consume a higher amount of fruit and vegetables compared to single or widowed men (Morland and Filomena, 2008). This in turn may influence children's food habits.

2.4.1.6 Ethnicity/Race

Ethnicity or race refers to selected cultural and physical characteristics of individuals. The ethnicity of a person can influence his or her food choice behaviour. For example, African–Americans and Latinos may eat more fast food (Pereira et al., 2005a; Pereira et al., 2005b), whereas Caucasians may eat more fruit and vegetables (Morland and Filomena, 2008).

2.4.1.7 Socioeconomic Status

The cost of food and therefore the SES of individuals (Giskes et al., 2006; Turrell et al., 2004), can influence their decision making when selecting types and amounts of food. This is particularly relevant for low-income people. For example, evidence from Australia suggests that many low-income people like to purchase healthy food (Inglis et al., 2009; Turrell et al., 2004). However, they still choose unhealthy food, primarily because they are unable to afford healthy food (Inglis et al., 2009; Kettings et al., 2009). One Australian study demonstrated that, if low SES families wanted to eat according to the recommendation as illustrated in the 'Healthy Eating Pyramid', it would cost them almost 40 per cent of their total household disposable income (Kettings et al., 2009). This is a clear indication that the price of food can prevent many low SES people from buying (Eikenberry and Smith, 2004; Inglis et al., 2005; Turrell et al., 2003; Turrell et al., 2002) or eating healthy food (Inglis et al., 2005). Moreover, the higher prices associated with healthy food in turn force many low-

income people to choose unhealthy type of food (Dibsdall et al., 2003; Giskes et al., 2006), such as fast food (Darmon et al., 2003; French et al., 2001), biscuits, sweets and soft drinks (Roux et al., 2000) as alternative sources of energy. This may explain why the food habits of low SES people contrast with the dietary recommendation (Giskes et al., 2006).

Further, the educational attainment of a person can also correlate with that particular person's knowledge of food. As a result, people with lower levels of education may consume less fruit and vegetables compared with those with higher levels of education (Wrigley et al., 2002).

2.4.1.8 Lack of Time (Time Poor)

Time availability plays a crucial role in the food habits of many people. For example, a lack of time may affect food habits (Devine, 2005; Inglis et al., 2005). Studies show that people eat healthy food less frequently (Welch et al., 2009) particularly vegetables because they often require resources such as time to prepare or cook (Eikenberry and Smith, 2004; Inglis et al., 2005). A study on the effect of the 'Go for 2&5' campaign reported time needed for preparation as one of the main barriers to the consumption of vegetables among the Western Australian public, despite their awareness and positive attitudes towards the vegetables (Pollard et al., 2008). The time required for shopping, preparing, cooking and cleaning up after meals also reduces vegetable intake, even among older individuals (Dixon et al., 2004).

The consequence of being time poor may result in higher consumption of energy-dense food such as convenience food (Kouba, 2004) and fast food (Driskell et al., 2006). This is particularly evident among busy people (Jabs and Devine, 2006), including students (Driskell et al., 2006), women in the workforce (Kouba, 2004; Welch et al., 2009) and people with manual jobs (Hunter and Worsley, 2009).

2.4.2 Interpersonal

Food choice behaviours can also be affected by interpersonal relationships, family members or the home food environment. Family food habits, such as eating meals

together (McGee et al., 2008), particularly in the home, can affect the food habits of children (Patrick and Nicklas, 2005). The habit of eating family meals together can often encourage children to eat more fruit (Befort et al., 2006; Larson et al., 2007) and vegetables (Ball and Crawford, 2006; Larson et al., 2007). The positive effect of the home food environment on children's food choices has also been demonstrated in a longitudinal study (Arcan et al., 2007).

Children also learn certain food habits from their friends (Hesketh et al., 2005). This is important (Campbell et al., 2006; Contento et al., 2006; McGee et al., 2008), as many children are often exposed to unhealthy food, including meat pies, potato chips, cakes, ice cream and soft drinks from their friends (Woodward et al., 1997).

2.4.2.1 Role Models

Many children and adolescents may have their own role models (i.e., real or fictional characters). The actions of these role models can help or hinder the persuasiveness of messages among the target group of individuals in the community (Bandura, 2001b) such as children. This concept is successfully applied in the advertising industry. For example, food promotion campaigns are very effective when children's favourite role models (characters) are used to convey the commercial messages to the target audience (i.e., children). This is the main reason why many television, movie and cartoon characters (Morley et al., 2008) have become popular in food promotion campaigns in the advertising industry (Chapman et al., 2006a).

2.4.3 Environment

2.4.3.1 Food Advertisements

Food advertisements can portray particular type of food as more attractive than others. Exposure to food advertising can change the target audience's judgment, values and conduct (Dixon et al., 2007; Halford et al., 2004), and therefore their attitudes towards the advertised food products. This in turn can increase awareness among target groups thereby their desire and intention to buy the advertised food products (Harris et al., 2009).

Children's exposure to advertisements for unhealthy food can encourage them to choose the advertised food (Aranceta et al., 2003; Buijzen et al., 2008; Utter et al., 2006). Further, exposure to advertisements for unhealthy food can also discourage children to choose healthy food such as fruit and vegetables, thereby reducing their intake (Driskell et al., 2006; Feldman et al., 2007; Scully et al., 2007).

An increased intake of unhealthy food, coupled with a reduced intake of healthy food such as fruit and vegetables, can increase body weight. An ecological study examining the links between advertisements and the risk of becoming overweight among children in the US, Australia and eight European countries showed a significant association between the prevalence of overweight children and the number of advertisements screened per hour on children's television programmes, particularly advertisements that encouraged children to consume energy-dense and micronutrient-poor food (Lobstein and Dibb, 2005).

Similarly, exposure to advertisements for healthy food can encourage the target audience to choose the healthy food. For example, the 'Go for 2&5' healthy-eating campaign was able to increase the consumption of fruit and vegetables significantly in Western Australia (Pollard et al., 2008). A similar observation was reported with children in Thailand, when fruit and vegetables were promoted using children's favourite role models (Sirikulchayanonta et al., 2010).

Unfortunately, only a limited number of food advertising campaigns promote healthy food, not only in Australia, but also globally, compared with advertisements for unhealthy food (Story and French, 2004). Processed food dominates commercial food advertisements (Jones et al., 2008), particularly high-fat food and sugary food, both in Australia (Neville et al., 2005) and elsewhere (Hammond et al., 1999). This trend has remained consistent over the years, not only in Australia (Chapman et al., 2006b; Morley et al., 2008), but also worldwide (Story and French, 2004).

2.4.3.2 Socio-culture

Culture can be defined as a set of habits, practices and customs of people that have been established over time and accepted as a way of life. The social norms or culture

of a particular society can give its members values and beliefs associated with certain type of food or food products. This in turn can influence the food choice behaviours of a particular group or member of the society (Cullen et al., 2000; Cummins and Macintyre, 2006; Glanz et al., 1998; Glanz and Mullis, 1988; McGee et al., 2008; Mercer et al., 2003).

The social norms of a society can prohibit its members from eating a particular food item. For example, Muslims and Jews avoid pork because of their religious and cultural beliefs (Brooks, 2004; Rogers, 1983; Rozin, 2005). Upper-caste Hindus do not eat beef because they consider the cow a sacred animal (Brooks, 2004; Kouba, 2004; Rogers, 1983). Some orthodox Hindus also avoid eating spicy food, onions, garlic, mushrooms and tomatoes. Hence, it is possible that existing social norms or traditions will act as a barrier for the development of healthy food habits (Hargreaves et al., 2002) among certain groups.

However, culture is dynamic in nature (Bandura, 2002); it can change over time (temporal) and space (spatial). Hence, the cultural beliefs of people about food can undergo changes (Kuhnlein and Receveur, 1996), which can be brought about by personal exposure or experience, education, knowledge, skills, interests, ideology and environmental factors (e.g., geo-climate or season, availability or unavailability of food).

2.4.3.3 Geo-climate (Natural Environment)

The geo-climatic conditions of a particular region can favour the production of certain types of food (plant or animal). This can make the production of a particular type of food abundant in one region, and not in another. As a consequence, people tend to eat foods that are abundant in their own locality (Nam et al., 2010). Notably, the increased availability of a particular food item in the locality can prompt local people to eat that food, even though it is restricted culturally. For example, the Hindus particularly higher-caste Brahmins eat no meat, fish or seafood because of their religious belief (Brooks, 2004) or belief about non-violence towards sentient beings (Kouba, 2004; Simoons, 1978). However, in the West Bengal region of India, even the higher-caste Hindus (Brahmins) consume fish.

However, traditional diets have changed dramatically in recent times as a result of globalisation coupled with technical advancements in food production and processing, storage, distribution and marketing (Kouba, 2004). Globalisation has not only brought people together from all over the world, but it has also provided opportunities to learn and embrace other cultures, including food. The emergence of 'fusion food', which is the blending of different ingredients including culinary traditions (Anderson, 2007) is an example of the possible consequences of the globalisation of food habits.

The worldwide interracial mingling of people with different cultures and food habits is now a modern-day reality. When people relocate, they often adopt new food or food habits common to that particular country or region (Wandel et al., 2008). This can reduce the intake of the traditional diet common to the country of origin or geography (Wandel et al., 2008; Zhang et al., 2002). There are two possible reasons for this. First, the availability of traditional food common to the country of origin may not be available in the new place. Second, people adopt new food and food habits when they relocate to a new place, as this may help make their new lifestyles more compatible with the new environment or system (Kouba, 2004).

2.4.3.4 Policy

Public policies and laws, such as quarantine laws, can prohibit the importation or exportation of certain food products from one region (or country) to another. This will reduce the availability of certain food items in particular regions or markets. Specifically, the policy of the government can make one type of food abundant in one region, and other foods scarce. This food dynamic can influence the food choice behaviours of people (Glanz et al., 1998; Glanz and Mullis, 1988). For example, the incidence of Avian influenza, or 'bird flu', barred importing and exporting chickens to and from certain countries. This resulted not only in a shortage of chicken in many markets around the world, but forced many chicken consumers to eat pork, fish (Ishida et al., 2010; Obayelu, 2007) and beef (Obayelu, 2007). However, chicken demand had risen sharply earlier following a mad cow disease outbreak (Leeming and Turner, 2004 ; Setbon et al., 2005).

Similarly, government policies, including subsidies on agriculture inputs such as fertilisers, pesticides, seeds, machinery and irrigation, and taxation on certain type of commodities (Repetto, 2006), can directly affect the production of a particular type of food crops, which may result in higher production (therefore, surplus) of a particular type of food. A surplus of cereals, beef, milk and wine are typical examples of government subsidies in agriculture (Krebs et al., 1999). One immediate consequence of the over-production of food is a reduction in price. This not only makes the food more accessible for more people, but it also changes their food habits.

However, the government tax on agriculture inputs such as water can discourage many farmers from cultivating certain crops. This may reduce the production of some crops, especially those that require more water (such as lettuce). This can affect supply (i.e., availability of lettuce in the market), and therefore its accessibility.

In summary, government policies on agriculture (e.g., subsidies and tax) can affect the production of certain type of food and therefore its availability in the market. This in turn may affect food habits of population in general and their health status.

Conclusion: Food choice behaviour is a complex process that involves interaction between multiple factors associated with characteristics of individuals (e.g., knowledge, skills, attitude, education, income and demography), attributes of food (taste, texture, type, price and quantity) and surroundings (geophysical—season or climate—social, cultural, religious, legal or government policy).

2.5 Environment (Neighbourhood)

In a broad sense, environment refers to immediate surroundings, which can directly or indirectly affect behaviour (Bandura, 2001a; Bandura, 2001b), including food (French et al., 2001; Li et al., 2009a; Li et al., 2009b; Li et al., 2009c) and physical activity (Dygryn et al., 2010; Giles-Corti and Donovan, 2002; Li et al., 2009a; Li et al., 2009b; Li et al., 2009c).

The environment can be broadly classified into three types: physical (e.g., climate, built environment, community and information environment), social (e.g., social norms, beliefs and attitudes) and policy. The environment also can be objective (actual) or subjective (perceived) (Saelens et al., 2003b).

The environment (neighbourhood) can be measured in terms of (a) political/or administrative unit, and (b) researcher defined neighbourhood. Please refer Table 2.1 for different types of (geographical definitions) of neighbourhood and their scales.

Table 2.1: Possible types of neighbourhood and their scales

Author(s)	Neighbourhood type/or size
Apparicio et al. (2007), Farley et al. (2009), Franco et al. (2009), Morland and Evenson (2009), Truong et al. (2010)	Census tract
Reidpath et al. (2002)	Postal district
Sturm and Datar (2005)	Zip code area
Truong et al. (2010)	County
Turrell and Giskes (2008)	Census collector district
Zick et al. (2009)	Block group
Austin et al. (2005)	Buffer (400 m, 800 m)
Block et al. (2004)	Buffer (0.5 mile, 1 mile
Bodor et al. (2010a), Bodor et al. (2008)	Buffer (100 m, 1 km, 2 km)
Crawford et al. (2008)	Buffer (2 km)
Ford and Dzewaltowski (2010c)	Buffer (1, 3, 5 mile)
Spurrier et al. (2003)	Buffer (1, 3, 8 km)
Rundle et al. (2009)	Buffer (805 mile)
Seliske et al. (2009b)	Buffer (1 km, 5 km)
Skidmore et al. (2010), Timperio et al.(2009)	Buffer (800 m)

2.5.1 Neighbourhood Food Environment

The NFE is defined as a critical component of the built environment (Ford and Dzewaltowski, 2008), which can indicate the quantity and quality of the food available within the neighbourhood.

Theoretically, the NFE can be determined by the total number of retail food outlets available in the neighbourhood. However, the availability of retail food outlets and

their types may vary from neighbourhood to neighbourhood (Burns and Inglis, 2007; Frank et al., 2006; Galvez et al., 2008; Hemphill et al., 2008; Hosler, 2009; Hosler et al., 2008; Kwate et al., 2009; Smith et al., 2010; Turrell and Giskes, 2008). This can result in differences in the quantity and quality of the NFE (Alwitt and Donley, 1997; Baker et al., 2006; French et al., 2001; Kumanyika and Grier, 2006; Morland et al., 2002a; Zenk et al., 2005a).

2.5.1.1 Measurement of Neighbourhood Food Environment

Physical access to food can be defined as the ease with which residents can reach the potential food stores located within their neighbourhood (Handy and Niemeier, 1997; Hewko et al., 2002). This makes the geographic location of the food store (distance to the food store from participants' homes) one of the most important variables in studying the accessibility of food in the neighbourhood. However, in some instances, the distance to the destination can be moderated by the attractiveness of the destination (Kim and Fesenmaier, 1990), including quality, type and price of food.

To date, no standard guidelines (protocols) have been established to assess the NFE for the availability of all types of food in the neighbourhood (Kelly et al., 2011). Hence, researchers have used different approaches to measure the NFE. Most have broadly estimated the total quantity of food available in the neighbourhood by estimating the total number of retail food outlets that are available within the given neighbourhood (Cannuscio et al., 2010; Glanz, 2009). Others have measured the NFE in terms of the mean number of retail food outlets per unit population (Cummins et al., 2005b; Hosler, 2009; Turrell and Giskes, 2008) and the number of food outlets in a unit area or density (Algert et al., 2006; Ball et al., 2006a; Ball et al., 2009; Block et al., 2004; Crawford et al., 2008; Daniel et al., 2009; Franco et al., 2009; Murakami et al., 2009; Sturm and Datar, 2005). Distance to the selected type of retail food outlet from participants' homes (Ball et al., 2009; Bertrand et al., 2008; Franco et al., 2009; Handy and Niemeier, 1997; Laraia et al., 2004; Rose and Richards, 2004; Timperio et al., 2009; Turrell and Giskes, 2008; Wang et al., 2007) was also measured. Physical access to food in the neighbourhood can also be measured in terms of travel time to shopping outlets (Burns and Inglis, 2007) or the travel cost involved in purchasing food (Handy and Niemeier, 1997).

More recently, Truong and colleagues measured the NFE as a 'physical food environment index (PFEI)', expressed in terms of the ratio between the sum of certain type of retail food outlets (i.e. fast-food outlets, convenience stores and other small-sized stores) and the total number of all types of outlets (i.e. fast-food outlets, convenience stores, other small-sized stores, supermarket and produce vendors) (Truong et al., 2010). This is the extended (modified) version of prior method used by Spence and his colleagues who calculated 'Retail Food Environment Index or RFEI' (Spence et al., 2009).

However, none of these store-based approaches can provide the overall status of the food (that is, the qualitative and quantitative aspects of the NFE) available in the neighbourhood, primarily because any retail food outlet can stock a variety of food ranging from healthy to unhealthy types with varying amounts (more in sub-section 2.5.1.2).

Shelf space allocated for a particular type of food in a store is an alternative way of measuring the amount of food available in the neighbourhood (Bodor et al., 2010b; Farley et al., 2009). This approach was used in marketing research in the past (Cox, 1970; Curhan, 1972; Curhan, 1974). However, it has not been used in public health research. Franco and his colleagues in the USA developed a comprehensive approach and attempted to measure the availability of healthy food in the neighbourhood. They constructed a healthy food availability index (HFAI) for each store by adding scores for the presence of different items ranging from 0 to 27 points, where 0 indicates the absence of healthy food and 27 indicates that all healthy foods are available in high proportions. The HFAI for each neighbourhood is estimated as the mean of the availability scores measured in all stores located in the neighbourhood (Franco et al., 2008). However, one major limitation of this approach directly relates to its definition, as it can indicate only one aspect of the NFE (i.e., the availability of healthy food) in addition to being resource-intensive in terms of data collection. Further, the authors included only specific type of retail food outlets (such as supermarkets, grocery stores, convenience stores and public markets). They did not consider speciality stores, despite the fact that any type of food outlet can stock healthy foods (described earlier). Table 2.1 presents a summary of the possible

methods used in measuring the NFE. Sections 2.6 to 2.10 provide further descriptions.

Table 2.2: Measurement of neighbourhood food environment (access to food)

Measure	Reference(s)
1. Number of outlets per head population	Cummins et al. (2005), Hosler (2009), Turrell and Giskes (2008)
2. Density (number of outlets/unit area)	Algert et al. (2006), Ball et al. (2006a), Ball et al. (2009), Block et al. (2004), Bodor et al. (2010b), Crawford et al. (2008), Daniel et al. (2009), Franco et al. (2009), Moore et al. (2008b), Moore et al. (2008c), Murakami et al. (2009a), Sturm and Datar (2005)
3. Distance to food store	Apparicio et al. (2007), Ball et al. (2009), Bertrand et al. (2008), Bodor et al. (2008), Franco et al. (2009), Handy and Niemeier (1997), Laraia et al. (2004), Rose and Richards (2004), Timperio et al. (2009), Turrell and Giskes (2008), Wang et al. (2007), Pearce et. al. (2009), Pearce et. al. (2006)
4. Travel time	Burns and Inglis (2007), Pearce et. al. (2008), Pearce et. al. (2007), Pearce et. al. (2006)
5. Travel cost	Handy and Niemeier (1997)
6. Price of food	Block and Kouba (2006), Cummins et. al. (2010), Jetter and Cassady (2006), Powell and Bao (2009), Sturm and Datar (2005)
7. Shelf space	Bodor et al. (2008), Bodor et al. (2010c), Farley et al. (2009), Cox (1970), Curhan (1972), Curhan (1974)
8. Availability of selected type of food	Cummins et al. (2010)
8. Healthy food availability index (HFAI)	Franco et al. (2008)
9. Physical food environment index (PFEI)	Truong et al. (2010)

Note: The terms access and availability are used interchangeably throughout this thesis.

2.5.1.2 Retail Food Outlet Type and Food Types

To date, the majority of studies have estimated the NFE by taking into account the type of retail food outlet as a proxy to indicate the availability of a specific type of food in the neighbourhood. However, it may not represent the overall quantity and quality of food available in the neighbourhood. There are two possible explanations for this.

First, many retail food outlets including fast food restaurants can stock more than one type of food (Bader et al., 2010a). Some of the food items sold by these outlets may belong in a healthy category, whereas others belong in an unhealthy category (Bader et al., 2010a; Farley et al., 2009).

Second, the quantity and range of food options may differ markedly according to the type of store (Farley et al., 2009; Latham and Moffat, 2007). For example, retail food outlets such as supermarkets (Latham and Moffat, 2007; Skidmore et al., 2010) stock a range of food in terms of general variety and specifically fresh produce such as fruit and vegetables. Chain and discount stores may also provide a wider range of food options compared with other types of retail food outlets (Cummins and Macintyre, 2002). However, retail food outlets such as butchers provide a limited option to customers because they specialise in fresh meat and meat products (Bader et al., 2010b; Pettinger et al., 2008; Wang et al., 2008; Wang et al., 2007; Zenk et al., 2009a; Zenk et al., 2005a; Zenk et al., 2009b). Similarly, fruit and vegetable outlets provide a limited choice of total foods, as they concentrate mainly on fresh fruit and vegetables (Bader et al., 2010b; Zenk et al., 2009a; Zenk et al., 2005a; Zenk et al., 2009b). Other types of retail food outlets such takeaway and fast food restaurants on the other hand, may serve primarily energy-dense food (Bader et al., 2010a; Macintyre et al., 2005).

In brief, some food outlets provide a greater variety of food than others. Many of these food stores act as important sources of healthy and unhealthy type of food, including supermarkets (Pettinger et al., 2008) and other small retail food outlets (Bowyer et al., 2009) such as fast food restaurants, takeaway, café (Bader et al., 2010a; Macintyre et al., 2005) and convenience stores (Farley et al., 2009). However, the availability (proportion) of a particular type of food may vary with the type of food outlet (Bader et al., 2010a; Cummins et al., 2009b). For example, the availability of healthy food in a bigger sized outlets (Cummins et al., 2010) for instance, supermarket is higher, particularly fresh fruit and vegetables (Liese et al., 2007; Morland and Filomena, 2007). However, other types of retail food outlets (fast food restaurants, takeaway, café) (Bader et al., 2010a; Macintyre et al., 2005) and convenience store may stock higher proportion of unhealthy food or energy-dense

food (Liese et al., 2007) such as snacks (Morland et al., 2006), chocolates, sweets and soft drinks (Bader et al., 2010b; Macdonald et al., 2009).

Conclusion: The measurement of the NFE based on food outlet type as a proxy for food type may not represent the complete picture of the food available in the neighbourhood. This is primarily because many retail food outlets stock a range of foods belonging to multiple categories (i.e., healthy and unhealthy). Further, the amount of each type of food can vary with store type.

2.6 Neighbourhood Socioeconomic Status and Neighbourhood Food Environment

The NFE shows mixed association with neighbourhood SES (Beaulac et al., 2009). For instance, lower SES neighbourhoods have been shown to have a lower number of retail food outlets (Alwitt and Donley, 1997), particularly supermarkets (Larson et al., 2009), fruit and vegetable stores, bakeries, and speciality and natural food stores (Moore et al., 2006). This has been consistently reported in Australia (Burns and Inglis, 2007; Coveney and O'Dwyer, 2009) and elsewhere (Alwitt and Donley, 1997; Baker et al., 2006; Block and Kouba, 2006; Bodor et al., 2010b; Burns and Inglis, 2007; Coveney and O'Dwyer, 2009; Moore et al., 2006; Morland et al., 2002b; Powell et al., 2007; Zenk et al., 2005b). However, others have found few or no differences in the availability of supermarkets between socio-economically advantaged and disadvantaged areas (Apparicio et al., 2007; Latham and Moffat, 2007; Pearce et al., 2007; Smoyer-Tomic et al., 2008; Winkler et al., 2006).

Similarly, an ecological study exploring the possible causes for the higher prevalence of obesity found a higher number of fast-food outlets (Pizza Hut, MacDonald’s, Hungry Jacks, KFC and Red Rooster) per head population within a postal district in the lower SES areas in Melbourne (Reidpath et al., 2002). Poor neighbourhoods in England and Scotland also had a higher number of fast-food outlets such as McDonald's restaurants (Cummins et al., 2005b; Macdonald et al., 2007), Burger King, KFC and Pizza Hut (Macdonald et al., 2007). A higher concentration of fast-

food outlets in poor neighbourhoods has also been reported in Canada (Hemphill et al., 2008; Jones et al., 2009) and the US (Block et al., 2004; Larson et al., 2009).

Researchers in Canada calculated the number of food outlets (fast food and supermarkets) within a street network distance of 500m, 800m, 1000m and 1500m from the geometric centre of a census block (Smoyer-Tomic et al., 2008). They derived a mean number of food outlets per census block population and calculated the weighted mean minimum distance to the nearest fast-food outlet and supermarket for each neighbourhood (census block). They found a higher number (2.3 times) of fast-food outlets in low SES areas compared with the most affluent neighbourhoods (Smoyer-Tomic et al., 2008). Similarly, Wang and colleagues in the USA demonstrated that residents in low SES areas lived closer to small grocery and convenience stores, while residents in middle SES areas were likely to live closer to fast-food outlets, ethnic markets and supermarkets (Wang et al., 2007). This indicates mixed results in associations between the NFE and SES.

Further, a study in Glasgow reported the highest number of total food outlets per 1,000 populations in the most deprived neighbourhoods compared with economically advantaged neighbourhoods (Macdonald et al., 2009). More recently, a study in Scotland also found better access to grocery stores selling fresh fruit and vegetables in the most deprived neighbourhoods (Smith et al., 2010). Winkler and her colleagues examined whether access to retail outlets was similar across areas of varying socioeconomic disadvantage in Brisbane in Australia. They found that supermarkets and greengrocers were located closer to residents in disadvantaged areas (Winkler et al., 2006). However, residents from high SES areas may need to travel further to reach the closest shop, including takeaway food (Turrell and Giskes, 2008). However, in Brisbane, the distance to the convenience store remained almost the same in all types of neighbourhoods, irrespective of the neighbourhood's SES (Winkler et al., 2006).

Despite the inconsistencies described above, many studies found a higher number of retail food outlets in high SES neighbourhoods. For example, Baker and colleagues (2006) discovered area-level characteristics such as SES of the neighbourhood and its association with the supermarket and fast-food restaurants. The researchers

obtained locations of food outlets from secondary sources (e.g., company websites and US census data) and verified the details by direct observation. They defined neighbourhood as a census tract (political jurisdiction) and poverty rate (percentage of the population living below the US federal poverty level) as a measure of the neighbourhood's SES. The number of supermarkets and fast-food restaurants available per 100,000 populations was calculated separately as a measure of the NFE. Overall, this study reported a higher availability of retail food outlets (e.g., supermarkets and fast-food outlets) in higher SES neighbourhoods compared with lower SES neighbourhoods (Baker et al., 2006).

More recently, researchers in Melbourne, Australia assessed the total number of supermarkets and fruit and vegetable outlets within a 2 km buffer zone (via road network) from study participants' homes. The researchers determined the number of each type of retail food outlet per 10,000 populations as a measure of geographic accessibility to healthy food. They found a positive correlation between higher SES areas with a greater number of supermarkets and fruit and vegetable outlets (Ball et al., 2009), further indicating better geographical accessibility of healthy food among those living in more advantaged neighbourhoods. The presence of a higher number of supermarkets in wealthier neighbourhoods was also reported earlier in the US (Powell et al., 2007). Research indicates that people living in the most advantaged neighbourhoods travel the minimum distance to retail food outlets, particularly supermarkets and fruit and vegetable outlets (Ball et al., 2009). However, the availability of a higher number of supermarkets in the neighbourhood may not mean higher availability of healthy foods, since supermarkets also stock lot of unhealthy foods (Farley et al., 2009).

Further, higher SES neighbourhoods also have a higher number of fast-food restaurants (Baker et al., 2006). Similar results were found in a study on children's takeaway and fast-food intake and their associations with the NFE, and the researchers determined access to the NFE from the participant's home as a number of retail food outlets within 800 metre (Timperio et al., 2009). The study found a higher number of takeaway or fast-food outlets in higher SES neighbourhoods compared with lower SES neighbourhoods (Timperio et al., 2009), further indicating that children from higher SES neighbourhoods can have a higher exposure to

takeaway or fast food (Timperio et al., 2009). The authors found similar results when the number of takeaway or fast-food outlets along the route to school was analysed against each type of neighbourhood (Timperio et al., 2009).

Other studies have shown a higher number of retail food outlets in middle SES neighbourhoods. For example, a US study that examined socioeconomic and food-related physical characteristics of the neighbourhood, as well as their association with BMI, found that there was an a higher number of fast-food store in middle SES areas compared with higher and lower SES neighbourhoods (Wang et al., 2007). A similar trend was reported earlier with the availability of convenience stores in Brisbane (Winkler et al., 2006). In Glasgow city, more number of out-of-home eating outlets (restaurant, fast food chain restaurants, cafes and takeaway) found in the second most advantaged areas (Macintyre et al., 2005). However, a study in Melbourne found the lowest number of supermarkets (per head) in middle SES neighbourhoods (Ball et al., 2009).

Conclusion: The NFE can vary from place to place, with mixed associations with the neighbourhood SES. Further, the association between the NFE and neighbourhood SES appears to vary with type of food outlets. However, in general, the results suggest a higher number of retail food outlets in higher SES neighbourhoods, especially supermarkets.

2.6.1 Neighbourhood Racial Composition (Demography)

The demographic composition of the neighbourhood is associated with the NFE (Ford and Dzewaltowski, 2010a; Ford and Dzewaltowski, 2010b). For example, a study in the US found that neighbourhoods dominated by African–Americans often have more fast-food restaurants than neighbourhoods with fewer African–Americans (Block et al., 2004). Similarly, neighbourhoods dominated by Aboriginal populations had a higher availability of fast-food outlets in Canada (Smoyer-Tomic et al., 2008), while neighbourhoods dominated by other ethnicities such as Mexican–Americans had a higher availability of convenience stores (Lisabeth et al., 2010).

However, the availability of supermarkets is higher in neighbourhoods dominated by Caucasians (White) compared with African–American neighbourhoods (Bodor et al., 2010c; Morland et al., 2002b). One study indicated that the number of supermarkets in African–American neighbourhoods remained low even after controlling for the individual's income (Powell et al., 2007).

Research in the USA found that the location of the nearest supermarket was significantly further away in neighbourhoods with high proportions of African–Americans (Zenk et al., 2005b). Hosler and colleagues (2008) calculated the number of fruit and vegetable stores per 10,000 populations and compared the number of retail fruit and vegetable stores between different types of neighbourhoods. They found a lower availability of fresh fruit and vegetable stores in minority neighbourhoods compared with demographically mixed neighbourhoods (Hosler et al., 2008).

Similarly, in Canada, Daniel and colleagues (2009) found a positive association between the density of fast-food outlets and the proportion of households speaking neither French nor English. They also found a positive association between the density of fruit and vegetable stores and the proportion of households speaking neither French nor English (Daniel et al., 2009). That is, they observed a negative association between the density of fruit and vegetable stores and the proportion of French-speaking households (Daniel et al., 2009).

2.6.2 Land-use pattern and policy

Existing land use pattern can also influence the location of retail food outlets in the neighbourhood. For example, retail food outlets, particularly fast-food restaurants, are common around schools (Austin et al., 2005; Kipke et al., 2007). However, the availability of other types of retail food outlets, particularly those that sell fruit and vegetables, are found less often in and around the schools (Kipke et al., 2007).

Further, the number of retail food outlets available within the school may differ with the school type. For instance, researchers in the US have examined the proximity to fast-food outlets by school level (elementary, middle and high school). They found

that fast-food restaurants were located closer to high schools compared with other types of schools (Kwate and Loh, 2010; Simon et al., 2008). This association remained consistent across the US (Zenk et al., 2008). Another study in the US measured the NFE surrounding the school as the number of retail food outlets within a buffer zone (400m and 800m). However, this study did not find a significant difference in the number of convenience stores between middle and high schools within a 400m buffer zone (Sturm and Sturm, 2008).

The association between the school and the NFE can also vary by the neighbourhood's SES. For instance, children's exposure to food around schools has been shown to be inversely associated with neighbourhood income (Kestens and Daniel, 2010). Schools located in a low SES area may have easier access to food than schools from high SES neighbourhoods. Study in the USA found that schools in low-income neighbourhoods were three times more likely to have one fast-food outlet within a 400m buffer zone around the schools compared with schools located in high-income neighbourhoods (Simon et al., 2008). This study also found an inverse correlation between neighbourhood income and the distance to fast-food restaurants from the schools (Simon et al., 2008). However, a study in Canada that examined the retail food environment around schools (number of full-service restaurants, fast-food restaurants, subs/sandwiches, donut/coffee shops, convenience stores and grocery stores per 10,000 people and per buffer zone), found better access to all types of food outlets in schools located in higher SES areas (Seliske et al., 2009b).

The location of food outlets within the neighbourhood can also be influenced by the existing land-use policies of the government (Fraser et al., 2010), in addition to the existing land-use pattern of the neighbourhood. For example, study in the USA found the highest number of fast-food outlets in central business districts (CBD), transportation hubs and tourist areas (Kwate et al., 2009). A higher concentration of food outlets in the central areas of the city was also reported in New Zealand (Pearce et al., 2006) and Glasgow city in the UK (Macintyre et al., 2005).

The location of retail food outlets also correlates with other attributes of the built environment. For example, a recent study in Canada reported a direct association

between local road density and the density of fruit and vegetable outlets (Daniel et al., 2009). Greater access to food outlets along major arterial routes was also reported in the UK (Macintyre et al., 2005), New Zealand (Pearce et al., 2006) and Australia (Burns and Inglis, 2007). However, evidence from Canada shows a negative correlation between highway density and the density of fruit and vegetable outlets (Daniel et al., 2009).

Conclusion: The availability of food (quantity and types) in the neighbourhood is a contextual issue that may be affected by many factors associated with the neighbourhood, including its socio-demographic composition, land-use patterns, physical infrastructures and government land-use policies.

2.7 Neighbourhood Food Environment and Food Behaviours

It is believed that people's food systems can be defined by what is available in the market (Furst et al., 1996) or neighbourhood food outlet, as people tend to buy food—particularly staple food items—more frequently (Handy and Clifton, 2001; Horowitz et al., 2004) from the local shop. Hence, the NFE can play an important role in shaping the food habits of individuals residing within the neighbourhood (Edmonds et al., 2001; Gracia and Albisu, 2001; Jekanowski et al., 2001; Kamphuis et al., 2007; Liu et al., 2007; Molaison et al., 2005; Sallis and Glanz, 2006; Zenk et al., 2009a). However, the availability of retail food outlets (number and types) may vary from one neighbourhood to another, as discussed previously (Sections 2.5.1 and section 2.6). This variation can affect the NFE, which can in turn affect the food choice behaviours of many people who reside within a particular neighbourhood (Glanz et al., 1998; Glanz and Mullis, 1988).

It appears that the food habits of people in general are shifting. For example, more people are eating food that contains a higher proportion of animal and partially hydrogenated fats, and they are consuming fewer foods that contain fibre (Popkin, 2006). One theory that can partially explain this food dynamic is the higher

availability of food containing higher levels of fat compared with other types of food that have little or no fat. A review of literature on new trends in the global diet concluded that the higher consumption of fat resulted from a higher availability of food containing higher levels of fat in the neighbourhood (Drewnowski and Popkin, 1997; Popkin, 2001). People may choose these food items with higher fat levels more frequently as they are available in abundance within the neighbourhood, thereby making it easily accessible (Jekanowski et al., 2001). This is primarily because the availability of a particular type of food that is in abundance in the neighbourhood can increase its consumption among local residents (Ello-Martin et al., 2005; Jago et al., 2007). This is more pronounced when a higher quantity of food is coupled with a reduction in the price of the food, as this will provide easy access to that particular type of food for everyone in the community.

In contrast, the availability of a limited quantity of food in the neighbourhood can compromise its consumption (Treiman et al., 1996). For instance, the availability of a limited amount of healthy food in the neighbourhood can not only decrease its consumption (Franco et al., 2009), but it can also promote less healthy diets as an alternative among local residents (Sallis and Glanz, 2006), particularly among low SES individuals. A number of studies support this argument. For example, Cheadle and colleagues studied individuals' intake of food items such as red meat, reduced-fat milk and non-white bread, as well as the relative shelf space devoted to those food items in the neighbourhood food outlets (Cheadle et al., 1991).

The researchers found direct correlations between individuals' intake and the availability of a particular food type in the neighbourhood (measured as relative shelf space devoted to a selected type of food item in the local food store) (Cheadle et al., 1991). A similar finding was reported in New York with the availability of low-fat milk and the consumption of low-fat milk in the neighbourhood households (Fisher and Strogatz, 1999). Positive correlations between the consumption of food items (such as juice and vegetables) and their availability in local restaurants were also observed among 11–14-year-old African–American boy scouts (Edmonds et al., 2001). Past research in marketing has also shown a direct association between the sales of fruit and vegetables and the shelf length allocated for them in the local store (Curhan, 1974), including sugar-sweetened beverages and salty snacks (Curhan,

1972; Frank, 1970; Wilkinson, 1982). Positive correlations between the availability of fast food and its consumption among local residents were also reported recently (Li et al., 2009a; Li et al., 2009b).

However, the majority of researchers used food outlet type as a proxy to indicate the availability of certain food types in the neighbourhood (as discussed earlier in sub-section 2.5.1.1). Hence, they only provide indirect evidence to support the possible associations between the availability of food and its consumption among local residents. For example, evidence from the US shows a direct association between the presence of a grocery store in the neighbourhood and an increased intake of daily fruit and vegetables among local residents (Zenk et al., 2009a). A recent study on food acquisition habits among recently settled African refugees in Australia showed similar results (Pereira et al., 2010). The authors found a higher consumption of cereals, vegetables, fruits, legumes, meat and meat substitutes, particularly among participants residing closer to major retail food outlets such as Woolworths, Coles, Bi-lo and Aldi (Pereira et al., 2010). A recent study in the UK that examined the impact of the NFE on food consumption among children aged 9–10 years also found a direct association between supermarket availability and the consumption of fruit and vegetables among the study participants (Skidmore et al., 2010). Interestingly, the authors also observed a direct association between supermarket availability and the intake of unhealthy foods such as sweets, sugary soft drinks, breakfast cereals and white bread (Skidmore et al., 2010).

An early study in the USA observed an increased intake of fruit and vegetables among local residents and the availability of fruit and vegetables in small retail food outlets within 100m of the study participants' homes (Bodor et al., 2008). A higher consumption of fruit and vegetables was also noted among women who shopped at supermarkets and speciality stores compared with those who shopped at independent grocery stores (Zenk et al., 2005a), further indicating the possible influence of the availability of a particular type of food within the neighbourhood and its intake among local residents.

Similarly, Morland and her colleagues assessed the local food environment as the number and types of food stores and food service places per census tract (Morland et

al., 2002a). They found an increased consumption of fruit and vegetables among African–American and Caucasian participants when a supermarket was available in the neighbourhood (Morland et al., 2002a). This is consistent with the more recent study, which reported a higher consumption of vegetables among local participants when there was a higher density of supermarkets in the neighbourhood (Skidmore et al., 2010). A direct correlation between the density of fruit and vegetable outlets and the intake of fruit and vegetables was also reported in Melbourne (Ball et al., 2006a). Hence, the availability of retail food outlets, such as supermarkets (Laraia et al., 2004) and fruit and vegetable outlets, can improve the quality of the diet among local residents.

In contrast, a study conducted in Melbourne, Australia examined the possible associations between the availability of takeaway or fast-food outlets and the intake of takeaway or fast food among children in the neighbourhood (Timperio et al., 2009). The researcher determined access to the NFE from the participant's home as the distance, the number of food outlets within 800m and the number of food outlets along the route to school (Timperio et al., 2009). They found a direct association between the density of food stores closer to the home and the consumption of takeaway or fast food among children (Timperio et al., 2009). However, they reported that children with at least one fast-food outlet and convenience store within 800m of their homes were less likely to eat fruit and vegetables than those that did not have the outlets close to their homes (Timperio et al., 2008). Interestingly, the authors observed an increased consumption of vegetables (at least three times per day) when distance to the closest supermarket and fast-food outlet was increased (Timperio et al., 2008).

Conclusion: The evidence suggests that NFE or availability of food (quantity and types) within the local community may affect people's food choice behaviours.

2.8 Food Behaviours

Food habits can be defined as a function of the NFE, the frequency of food intake and portion sizes. Food habits can be dynamic (changes spatially as well as temporarily though the speed of change may vary from individuals to individuals), as they are primarily determined by the availability of food (both variety and quantity) in the neighbourhood. In recent times, people's food habits have been changing dramatically in almost all aspects of food, including types, frequency of intake, portion size and overall eating pattern.

2.8.1 Food Behaviours and Body Mass Index

Food habits can directly affect a person's health status (Joshipura et al., 2001; Rampersaud et al., 2005; Sarri et al., 2006). For example, healthy food habits (i.e., regular consumption of food consisting of high-fibre and nutrient-rich food products) (Rampersaud et al., 2005) particularly intake of fruit and vegetables (Schroder, 2010), can help in maintaining body weight (Hays et al., 2002) or body mass index. The importance of nutrient rich food like fruit has also been mentioned in the reviewed article (Alinia et al., 2009). In contrast, unhealthy food habits (i.e., regular consumption of energy-dense food or low-fibre and nutrient-poor food) can increase BMI.

A person's body weight (the result of extra energy accumulated in the body) can be directly affected by energy balance; that is, energy in versus energy out (Egger and Swinburn, 1997; French et al., 2001; Hill, 2006; Hill and Melanson, 1999; Hill and Peters, 1998; Hill et al., 2000; Hill et al., 2003; Phillips et al., 2004). However, energy intake, and therefore energy accumulation in the body, can be associated with dietary patterns (Birch and Fisher, 1998) such as frequency of food intake (Casey et al., 2008; Taveras et al., 2006). For example, a past study that assessed the frequency of food consumption from seven different restaurant types (fried chicken, burger, pizza, Chinese, Mexican, fried fish and 'other') among healthy men and women found a positive relationship between the frequency of consuming restaurant food and body fatness after controlling for age, sex and other items (McCrory et al.,

1999). That is, the higher the frequency of the intake of energy-dense food, the higher the likelihood of accumulating extra energy in the body, which increases the risk of becoming overweight or obese (Prentice and Jebb, 2003). For example, a study in Australia found a direct association between the frequency of takeaway meals and BMI among primary school children (Hesketh et al., 2009).

The amount of energy in the food can be associated with types of food or food habits. For example, intake of fruit, salad, cereals, and fish may positively correlate with intake of protein, fiber, β-carotene, folate, vitamin C, and potassium (McNaughton et al., 2008a). Conversely, food containing higher amount of fat and sugar may associate with higher amount of energy, saturated fat and sugar (McNaughton et al., 2008a). Hence, the association between the food habits and BMI of a person can also depend on the type of food. For example, an intervention trial which examined the relationship between initial body weight and weight loss found a reduction in body weight among those who consumed fat-reduced diets compared to their counterparts who consumed normal-fat diets (Astrup et al., 2000). The researchers also observed a direct association between the consumption of sugar-sweetened beverages and weight gain (Astrup et al., 2000).

Similarly, a diet consisting of sweets, snacks and carbohydrates can be positively associated with higher energy (body fatness), whereas foods such as vegetables can be negatively associated with the amount of energy (McCrory et al., 2000) or weight gain. Hence, the amount of weight gained over time may vary according to the energy density of individual food and beverages. For example, consumption of higher levels of energy-dense food, such as soda, white bread, potato chips, fruit punch, chowder, crackers, candy bars, doughnuts and bacon, can increase body weight faster compared with relatively low energy-dense food, such as oil and vinegar salad dressing, olive oil salad dressing and nuts (Bes-Rastrollo et al., 2008). Similarly, the consumption of energy-dense food, such as fast food (Prentice and Jebb, 2003), takeaway food (Hesketh et al., 2009) and sweets (Drewnowski and Specter, 2004), can increase body weight faster (Maskarinec et al., 2006; Newby et al., 2003; Yao et al., 2003).

A low energy-dense diet can include a relatively high proportion of foods that are high in micronutrients and water and low in fat, such as fruits and vegetables (Ello-Martin et al., 2005; Ledikwe et al., 2006a; Ledikwe et al., 2006b). A regular intake of these low energy-dense foods can reduce the risk of weight gain, even though people consume more in terms of quantity or frequency (Ledikwe et al., 2006b). For example, evidence from a recent literature review shows an inverse association between fruit intake and body weight (Alinia et al., 2009). An inverse association between weight gain and diets that are high in micronutrients and water and low in fat have been also recorded (Esmaillzadeh and Azadbakht, 2008; Esmaillzadeh et al., 2007). A record number of the Japanese population became obese when the traditional Japanese diet of rice and fish was replaced by fast food more often (McCurry, 2007). Obesity has become a problem in developing countries such as China (Ding and Malik, 2008) and India, where people have adopted western lifestyles regarding food (meat, dairy, oils and added sugar) (Popkin et al., 2001).

Further, portion size can also determine the amount of energy in the meal (Stender et al., 2007; Taveras et al., 2005). Unfortunately, portion sizes in general have been increasing, and this trend has been consistent in a variety of settings (Nielsen and Popkin, 2003; Young and Nestle, 2003). In most cases, the size of a meal exceeds the standard serving size. For example, the current portion size of fast food exceeds its original size by 2–5 times (Young and Nestle, 2003).

Conclusion: Individuals' food habits can influence their health status, including BMI. Individuals that eat healthy food as part of a regular diet can reduce their BMI, whereas people with unhealthy food habits can increase their BMI.

2.9 Neighbourhood Food Environment and Body Mass Index

The NFE can indicate the overall health status such as body weight of local residents (Lake et al., 2009). However, it may depend on the quality of the NFE. For example, higher availability of fast-food outlets in the neighbourhood may indicate a higher prevalence of obesity.

Li and colleagues examined the variation in obesity among older adults relative to the density of fast-food outlets and residents' behavioural, psychosocial and socio-demographic characteristics in Portland in the US (Li et al., 2009a; Li et al., 2009b). The authors observed a strong association between the density of fast-food outlets and the body weight of neighbourhood residents over a one-year period (Li et al., 2009a; Li et al., 2009b).

A study examining the association between the presence of food establishments and obesity among adults living in southern regions in the US also showed a higher prevalence of obesity in areas with a higher number of small grocery stores or fast-food outlets (Morland and Evenson, 2009).

Powell and colleagues examined the association between the availability of food store types (chain supermarkets and convenience stores) and the BMI of 8th and 10th-grade students in the US using a commercial source of food store data (Powell et al., 2007). The researchers found a positive correlation between the number of convenience stores per 10,000 persons and the BMI of school children (Powell et al., 2007).

Grafova conducted a national survey in the US that comprised 2,482 children and adolescents (Grafova, 2008). The author calculated the number of food outlets per 10,000 persons in the county of residence and examined the relationships between food access in the neighbourhood and the overweight status in children. The researcher observed a positive association between the density of convenience stores and the BMI of children and adolescents (Grafova, 2008).

Sturm and Datar derived the number of food stores comprising grocery stores, convenience stores, full-service restaurants and fast-food outlets for each residence (child home) and school zip code per 1,000 population (Sturm and Datar, 2005). The authors examined the association between the number of food stores and the BMI of elementary school children in the US (Sturm and Datar, 2005). They reported a significant association between BMI and the density of fast-food outlets (Sturm and Datar, 2005). The researchers also observed a positive association between restaurants and the BMI of children. Retail food outlets in the neighbourhood, such

as convenience stores (Morland et al., 2006) and small grocery stores (Wang et al., 2007) also showed a positive association with the prevalence of overweight and obesity among local residents (Morland et al., 2006).

Rundle and colleagues classified retail food outlets into three distinct categories: BMI-healthy (supermarkets, fruit and vegetable markets, natural food stores), BMI-intermediate (medium-sized grocery stores, fish markets, specialty food stores) and BMI-unhealthy (fast food, pizza, convenience stores, bodegas, bakeries, candy and nut stores, meat markets) (Rundle et al., 2009). The authors derived the density of each type of food store and examined the association of a selected type of NFE with BMI after adjusting for neighbourhood walkability. The researchers found an inverse association between the density of BMI-healthy food stores and the BMI of people residing within the neighbourhood (Rundle et al., 2009). Hence, the prevalence of obesity can be lower in areas with a higher number of supermarkets (Lopez, 2007; Morland et al., 2006; Morland and Evenson, 2009).

However, studies in the US (Wang et al., 2007) and Japan (Hanibuchi et al., 2011) indicated positive associations between the availability of supermarkets in the neighbourhood and the prevalence of overweight or obesity. One possible explanation for the inconsistency between the number of supermarkets and BMI could be the availability of a diverse range of food in the supermarket (Pettinger et al., 2008). In reality, supermarkets provide its consumers a wide range of options to choose food from, including healthy to unhealthy types. These options can be available even in other types of retail food outlets, such as convenience store, although the range of options may vary with the store type (Pettinger et al., 2008) (see section 2.5.1.2 for details on retail food outlet type and food types).

Hence, the presence of a particular type of retail food outlet in the neighbourhood can indicate a mixed association with the prevalence of overweight or obesity in the local population. For example, one study in New Zealand showed a positive association between the prevalence of overweight or obesity and the availability of multi-national fast-food chains (Pearce et al., 2009). However, the same study found no correlation between the availability of independent or locally owned fast-food

outlets and BMI (Pearce et al., 2009). A similar observation was made with density of BMI-unhealthy food stores and BMI in the US (Rundle et al., 2009).

More recently, Truong and colleagues derived the 'Physical Food Environment Index (PFEI)', and found that PFEI associated with the census-tract is a strong predictor of higher BMI and obesity (Truong et al., 2010). However, the authors did not find county-level PFEI to be an indicator of individual BMI or obesity (Truong et al., 2010). Similarly, Spence and his colleagues (2009) in Canada found direct association between the NFE (retail food environment index or RFEI) within 800m buffer zone around home and prevalence of overweight or obesity. However, they did not find strong association with the prevalence of overweight or obesity and RFEI within 1600m buffer zone (Spence et al., 2009), possibly suggesting that food available within the immediate surrounding is more important as people in general tend to buy food from the local shops as described earlier (section 2.7). Similarly, no association was reported between density of retail food outlets such as full service restaurants, limited service restaurants and snack shops, and weight status of children (Grafova, 2008). Crawford and colleagues analysed longitudinal data and found no correlation between the density of fast-food outlets in a 2 km buffer zone and body weight in a sample of children (aged 8–9 years and 13–15 years) and their parents (Crawford et al., 2008).

Conclusion: Access to retail food outlets show a mixed association with the BMI of local residents.

2.10 Neighbourhood Socioeconomic Status and Body Mass Index

Living in a low SES neighbourhood is associated with increased body weight (King et al., 2006), thereby increasing the risk of becoming overweight or obese (Grafova et al., 2008). This has been demonstrated consistently in past research (Ellaway et al., 1997; Smith et al., 1998). A past study conducted in Sweden and the Netherlands found a higher risk of becoming overweight or obese in areas with higher levels of

disadvantage (Reijneveld, 1998). Similar findings on the association between neighbourhood SES and the prevalence of overweight or obesity have been consistently reported among adults (Boardman et al., 2005; Booth et al., 2005a; Burdette et al., 2006; Cohen et al., 2006; Drewnowski, 2007; Drewnowski and Drewnowski, 2004; Ford and Dzewaltowski, 2008; Poortinga, 2006; Procter et al., 2008; Ross et al., 2007) and children (Hedley et al., 2004; Inglis et al., 2008; Jebb et al., 2004; Kinra et al., 2000; O'Dea, 2008; O'Dea and Dibley, 2010; O'Dea and Wilson, 2006; Ogden et al., 2006; Ogden et al., 2002; Rennie and Jebb, 2005; Stamatakis et al., 2005; Stamatakis et al., 2010; Wang and Zhang, 2006).

Despite growing evidence, the association between the neighbourhood SES and the prevalence of overweight or obesity is not always consistent. For example, no difference was observed in the risk of becoming overweight between adolescents residing in low and moderate SES neighbourhoods (Nelson et al., 2006). However, adolescents living in high SES areas are less likely to become overweight compared with their counterparts from moderate SES neighbourhoods (Nelson et al., 2006). Wang and Zhang also noted a mixed association between SES and the prevalence of overweight or obesity among children aged 2–18 years. They observed an inverse association between SES and the prevalence of obesity among white girls (Wang and Zhang, 2006). However, they reported a direct association between SES and the prevalence of obesity among African–American children (Wang and Zhang, 2006). Reviews of previous research also reported inconsistent evidence on the association between SES and the prevalence of obesity, particularly among girls (Hunt et al., 1995).

The inconsistency in the association between the prevalence of obesity and the neighbourhood SES suggests the possible involvement of other variables, including characteristics of the individual person (gender, age, ethnicity and individual SES) and attributes of his or her environment such as availability of food, physical infrastructures or resources including public open spaces (Papas et al., 2007; Wang and Beydoun, 2007). The combined effect of these variables can result in differences in the food habits and physical activity of the individual, which may in turn explain the higher prevalence of overweight or obesity among low SES groups (Wang and Beydoun, 2007).

Evidence shows that individuals from low SES groups eat more energy-dense food than their counterparts from high SES groups (Drewnowski and Specter, 2004; Lu et al., 2002). One possible reasons why the low SES groups of people often eat energy-dense food can be the higher availability of energy-dense food in low SES neighbourhoods (Lobstein et al., 2004; Moore et al., 2009). Many low SES individuals tend to live in neighbourhoods with higher access to convenience stores (Morland et al., 2002b) and fast-food outlets (Morland et al., 2002b; Reidpath et al., 2002). More importantly, as previously discussed many low SES neighbourhoods are more likely to have poor access to supermarkets (Moore et al., 2006; Morland and Filomena, 2007; Morland et al., 2002b; Powell et al., 2007). Hence, individuals from low SES neighbourhoods are more likely to be exposed to a poor food environment (mainly energy-dense food or less diverse food). Conversely, individuals from high SES areas are more likely to be exposed to a diverse range of food, including healthy foods, due to the higher number of supermarkets, which may stock a range of foods. The low availability of food in socially disadvantaged neighbourhoods can be further explained with the help of 'food deserts', which is a concept that describes areas where residents have poor access to affordable healthy foods (Beaulac et al., 2009; Wrigley, 2002).

The food desert is believed to be associated with the lack of shops, especially supermarkets, where fresh fruit, vegetables and other low energy-dense foods are readily available for an affordable price (Morland et al., 2002b). However, the availability of supermarkets can differ with the neighbourhood SES. For instance, low SES areas may have fewer supermarkets compared with affluent areas (Alwitt and Donley, 1997; Baker et al., 2006; Ball et al., 2009; Block and Kouba, 2006; Moore et al., 2006; Moore and Roux, 2006; Moore et al., 2008b; Morland et al., 2002b; Powell et al., 2007; Zenk et al., 2005b). Hence, the lack of supermarkets in low SES neighbourhoods (Ball et al., 2009; Morland et al., 2002b) may decrease the availability of fresh fruit and vegetables. A lack of supermarkets in the neighbourhood may also encourage other types of food stores to establish outlets in that particular neighbourhood as an alternative source of food for local residents.

However, these alternative sources of food, such as convenience stores and fast-food outlets, may stock only a limited quantity of healthy food (Ford and Dzewaltowski,

2008). This can in turn reduce the overall availability of healthy foods in poor areas. However, it can increase the availability of unhealthy foods. One possible consequence of the lack of supermarkets is that locals may be forced to choose other types of food (especially unhealthy foods) from alternative sources such as convenience stores and fast-food outlets (Ball et al., 2009; Morland et al., 2002b). Hence, individuals from low SES areas may eat higher energy-dense food more frequently than those from affluent areas, thereby increasing the risk of becoming overweight or obese in the long term (Lobstein et al., 2004).

The limited disposable income of low SES groups is another possible cause for the higher prevalence of overweight or obesity in low SES neighbourhoods (Mendoza et al., 2006). At an individual's level, limited disposable income can prevent people from eating healthy food (Ford and Dzewaltowski, 2008). Financial constraints can force people to overlook healthy food options in favour of less healthy options (Drewnowski and Specter, 2004; Giskes et al., 2002a; Giskes et al., 2002b; Mendoza et al., 2006) or high-fat food (Ball et al., 2004; Inglis et al., 2005; Mishra et al., 2005). This may be because healthy food in general costs more (Andrieu et al., 2006; Drewnowski, 2004; Drewnowski and Darmon, 2005b; Jetter and Cassady, 2006; McAllister et al., 1994) than unhealthy food. This can make the healthy food option less affordable, particularly for low-income groups.

Further, the availability of healthy food in low SES areas may be limited. This could be due to a lack of supermarkets (Alwitt and Donley, 1997; Baker et al., 2006; Ball et al., 2009; Block and Kouba, 2006; Moore et al., 2006; Moore and Roux, 2006; Moore et al., 2008b; Morland et al., 2002b; Powell et al., 2007; Zenk et al., 2005b), as evidence shows a direct association between supermarket access and healthier diets among many individuals (Glanz et al., 1998; Morland et al., 2002a). However, it is always possible to buy food from outside the neighbourhood. However, this process can add extra costs (indirectly) because it requires travel, which involves financial and human costs (e.g. time and effort). This added cost might discourage many people, especially low-income groups, from buying food outside their neighbourhood. This can subsequently result in the lower consumption of healthy food among low SES individuals, hence increasing the risk of becoming overweight or obese.

Furthermore, risk of being overweight or obese may also associate with physical activity. Many children, particularly from low SES areas, are less likely to participate in physical activity such as walking or playing outside their homes because of safety concerns (Catlin et al., 2003; Lobstein et al., 2004), which can be due to traffic, stranger danger (Greenwald and Boarnet, 2001) or other social crimes (Booth et al., 2000).

Less physical activity may be also partially due to a lack of physical facilities, such as footpaths (Booth et al., 2000), playgrounds or public open spaces (Saelens et al., 2003b), which may discourage many people particularly children, from walking or playing outside their homes (Catlin et al., 2003; Giles-Corti and Donovan, 2002). In other words, the availability of physical infrastructure such as footpaths, cycling paths and public open spaces can encourage local residents to walk or cycle within the neighbourhood (Booth et al., 2000; Saelens et al., 2003b). Similarly, other attributes of the neighbourhood, such as the availability of retail food outlets, can also encourage walking or cycling among local residents (Rundle et al., 2009; Saelens et al., 2003a; Saelens et al., 2003b).

The consequence of the lack of opportunities to engage in physical activity may encourage many children to spend a large amount of time in sedentary activities such as watching television (Lobstein et al., 2004). This can result in the accumulation of higher levels of energy in the body, thereby increasing the likelihood of becoming overweight or obese in the long term (Bowman, 2006; Davison et al., 2006; Gortmaker et al., 1996; Sisson et al., 2009).

Conclusion: Low SES areas in general are likely to have a higher prevalence of overweight or obesity, which may be due to poor food habits influenced by a poor food environment and lower levels of physical activity influenced by the built environment.

Chapter 3: Methods

3.1 Overview

This chapter describes the methods used for developing the neighbourhood food environment (NFE) for study participants in the Perth metropolitan area (see Figure 3.2). Next, the process involved in classifying food outlet types is described. Next, an approach used in estimating the weights for each type of retail food outlet for the availability of the selected type of food is discussed. Next, the process for creating the NFE by using geo-referenced food outlets and the weights of each type of food outlet obtained from the experts involved in the Delphi survey is outlined. Finally, this chapter concludes with a description of the techniques involved in analysing the association between the NFE and the physical health characteristics of the participants. Figure 3.1 outlines the process in detail.

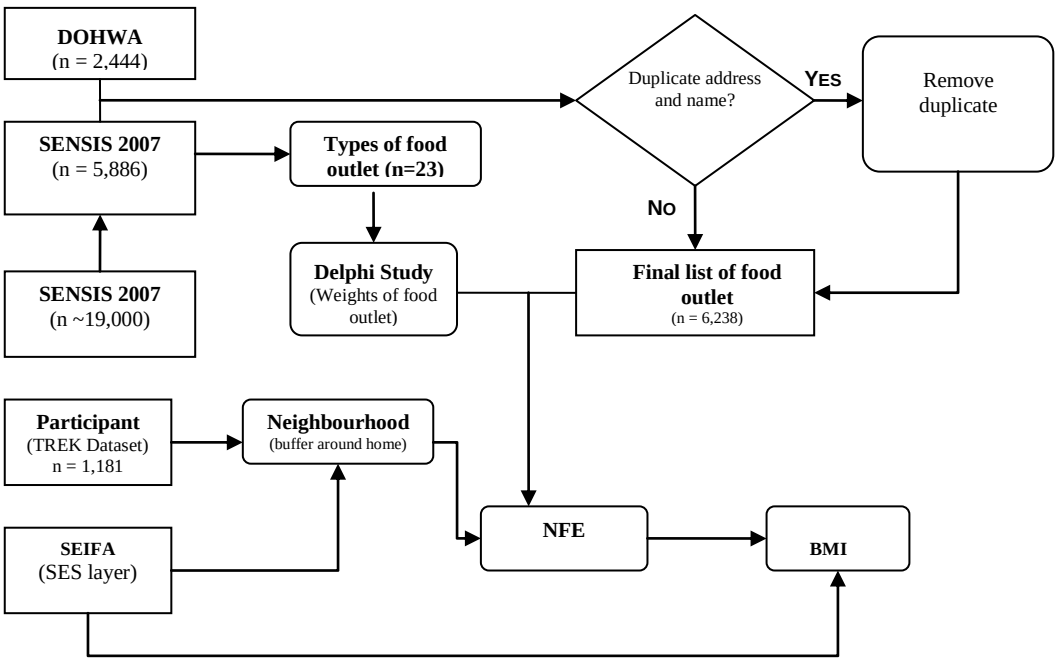

Figure 3.1: Overview of process and datasets involved in NFE development

Note: DOHWA = Department of Health, Western Australia; BMI = Body Mass Index; NFE = Neighbourhood Food Environment; SEIFA = Socio-economic Index for Areas

3.2 Study Area

Perth is the capital city of Western Australia (WA). Geographically, it is located 31 degrees, 57 minutes south and 115 degrees, 52 minutes east on the west coast of Australia. The Perth metropolitan region stretches approximately 150 kilometres down the coast from the northern suburbs of Quinns Rocks and Butler, in the City of Wanneroo, to the southern tip of the Peel Inlet in the Shire of Murray. The north-eastern part of the region comprises the inland settlements of Mount Helena and Mundaring, including several other residential developments in the Swan Valley, such as Ellenbrook and The Vines. Kalamunda, which is located in the foothills of the Darling Ranges, is an established centre in the region's south-east, while the southernmost part of the region includes the growing centres of Kwinana, Rockingham and Mandurah. Figure 3.2 presents a map of the study area.

Perth is known as 'the most isolated capital city in the world'. It has an estimated population of 1.7 million (ABS, 2009) and is the fourth most populous city in Australia. The population density of Perth is 310 people per square kilometre (ABS, 2009). Almost three-quarters (69 per cent) of Perth's population are aged between 15 and 64 years, with a median age of 36 years (ABS, 2009). Perth is ranked ninth Most Livable Cities in 2012, according to '*The Economist'*.

The study area (Figure 3.2) consisted of 2,906 Census collector's districts (CCD), which covered 30 Local Government Authorities, within the Perth metropolitan region (Appendix C-I).

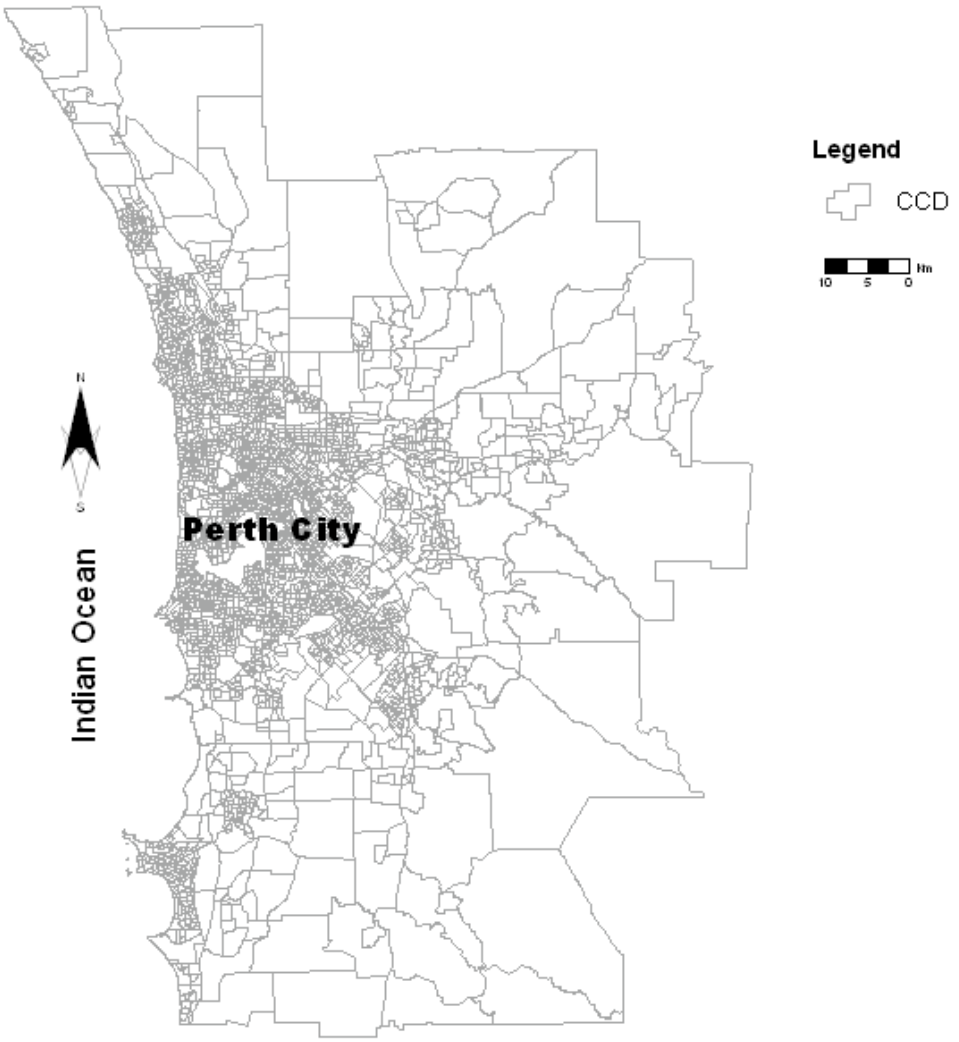

Figure 3.2: Study Area (Perth, Western Australia)

3.3 Secondary Dataset Used in the Project

Research based on primary data is expensive because it involves substantial amounts of time and resources. Therefore, the use of secondary data has become a cost-effective (Cowton, 1998) way of solving many empirical research problems (Atkinson and Brandolini, 2001), such as developing a new technique to measure the NFE. However, relying exclusively on a single source of secondary databases to characterise the NFE may introduce errors into epidemiological studies (Liese et al., 2010) because it may not be complete (i.e. true to the reality). However, this error can be minimised significantly by combining different sources of secondary food

outlet databases, which can be helpful in identifying the actual retail food outlets on the ground (Liese et al., 2010).

3.3.1 Secondary Sources of Food Outlet Data

Secondary data on food outlets can be obtained from commercial and government sources. Commercial sources of secondary food outlet data can include company websites (Apparicio et al., 2007; Baker et al., 2006; Ball et al., 2008; Block et al., 2004; Jones et al., 2009; Macdonald et al., 2007; Timperio et al., 2008), online business directories (Glanz et al., 2007) and telephone directories (Alwitt and Donley, 1997; Ball et al., 2008; Timperio et al., 2008; Zenk et al., 2005b), which include online telephone service directories (Ball et al., 2009; Reidpath et al., 2002; Zenk et al., 2005b) such as the White Pages and the Yellow Pages (Apparicio et al., 2007; Ball et al., 2009; Block et al., 2004; Burdette and Whitaker, 2004; Glanz et al., 2007; Reidpath et al., 2002).

Other sources of secondary data on food outlets can include government authorities (Bodor et al., 2010a; Bodor et al., 2010b; Bodor et al., 2008; Burns and Inglis, 2007; Glanz et al., 2007; Lewis et al., 2005; Liese et al., 2010; Liese et al., 2007; Morland et al., 2002a; Morland et al., 2002b; Pearce et al., 2009; Pearce et al., 2006; Simon et al., 2008; Smith et al., 2009; Timperio et al., 2008), such as local city councils (Ball et al., 2009; Burns and Inglis, 2007; Cummins et al., 2009a; Franco et al., 2009; Franco et al., 2008; Macdonald et al., 2009; Turrell and Giskes, 2008). Further, information on food outlets can also be obtained from state government authorities such as the Department of Environmental Health (Hemphill et al., 2008; Smoyer-Tomic et al., 2008), the State Department of Agriculture (Morland et al., 2002a; Zenk et al., 2005b) and the State Department of Health.

In general, secondary sources of food outlet data can represent fair to moderate levels of accuracy (Cummins et al., 2009a; Lake et al., 2010). It has been suggested that the secondary food establishment data maintained by government agencies, particularly local government authorities, might be more accurate, because local governments may need to regularly update all businesses operating within their jurisdiction (Simon et al., 2008), compared with commercial sources, such as the Yellow Pages

(Lake et al., 2010). Nevertheless, acquiring food outlet data from local governments may take a substantial amount of time and effort (Burgoine, 2010). Further, the data derived from multiple sources may provide a better representation of the actual food outlets data, as it may reduce errors in the identification of food stores (Larson et al., 2009).

In this study, we obtained food outlet data from two secondary sources: commercial (SENSIS obtained by the Residential Environments Study or the RESIDE project) and the government (i.e., the Department of Health Western Australia or DOHWA).

The SENSIS is Telstra's (Australian Telecommunications Company) advertising, information and local searchable business resource, which publishes the telephone directories for the White Pages and the Yellow Pages. The SENSIS also contains information on various types of destinations, including recreation facilities (such as parks, swimming pools and playgrounds), shops, place of worships, educational institutions and hospitals.

The DOHWA collected food outlet data from local government councils in the Perth metropolitan area and compiled them into a single dataset. The DOHWA agreed to provide its food outlets dataset, however prior to using these data, all local government authorities in Perth were contacted and permissions were obtained to comply with the DOHWA's requirements to access the food outlet dataset (Appendix C-II).

3.3.1.1 SENSIS 2007 Food Outlet Dataset

The SENSIS 2007 destination dataset was obtained from the RESIDE project (Centre for the Built Environment and Health, The University of Western Australia). A food outlet database was created in Microsoft Access. Then the SENSIS 2007 destination dataset was imported into this (food outlet) database as a separate table. A Structure Query Language (SQL) script was used to retrieve all food outlets (n = 5,886) from the SENSIS 2007 dataset.

3.3.1.2 Department of Health, Western Australia Food Outlet Dataset

The DOHWA's food outlets dataset was imported into the Microsoft Access food outlet database as a separate table.

3.3.1.3 Final Food Outlet Data

A final food outlet dataset was created by collating the SENSIS 2007 and DOHWA food outlet datasets. The datasets were compared and all duplicate food outlets were retrieved by matching addresses and names using SQL scripts in Microsoft Access. Duplicate food outlets were removed and the final food outlet (n = 6,238) dataset was obtained as a separate table in the food outlet database.

A separate layer (map) was produced for the food outlets as a point layer in ArcGIS v.9.3 (ESRI, Redlands, CA, 2010) (see Figure 4.1).

3.4 Classification of Food Outlets

Retail food outlets are defined as industries that sell food and beverages from fixed point-of-sale (POS) locations, including food service places that prepare meals, snacks and beverages for immediate on-premises and off-premises consumption (Morland et al., 2002a). Retail food stores can stock a diverse range of food. However, the quantity of each type of food available in the store may vary with the type of food outlet (Pettinger et al., 2008). For example, supermarkets may stock a higher proportion of healthy food (Farley et al., 2009; Sallis et al., 1986) whereas café, fast food restaurant, takeaway or convenience store may stock only a limited quantity of healthy type of food (Bader et al., 2010a; Cummins et al., 2010). Similarly, levels of fresh fruit and vegetables in a greengrocer are likely to be higher compared with other types of food. However, fresh fruit and vegetables are not expected in other types of food stores, such as butcher shops, although foods such as eggs, oils and butter may be available in fruit and vegetable shops.

Based on name recognition, 23 distinct types of retail food outlets were identified from the online Yellow Pages (http://www.yellowpages.com.au/). Table 3.1 provides detailed information, including food outlet types, definitions and examples.

Table 3.1: Classification of retail food outlets

Outlet type	Definition
Baker	A speciality food store primarily sells bread, rolls, croissants, muffins or other flour products with or without packaging. Example, Brumby's, Baker's Delight.
Butcher	Retail food store engages in sale of fresh meat, poultry, processed meat, fish (fresh and frozen) and other sea foods.
Café	Primarily provides ready-to-drink coffee, tea, meals, snacks and soft drinks for immediate consumption in the premises itself. The examples of the Café are Dome Coffee, The Wild Fig Café, Gloria Jeans, etc.
Cafeteria	A self-service restaurant usually attached to worksite including schools.
Cake & Pastries Shop	Food store primarily sells cakes, pies, doughnut and other sweets.
Convenience Store	Self-service grocery store, offers limited line of convenience foods such as snacks, chocolates, other sweets and soft drinks. The convenience store can attach to fuel station or stand alone. The typical examples of convenience store that attached to petrol station are FoodMart and StarMart.
Deli & Fine Food Store	Sells fine and imported, cooked or processed meats including sausage, pickled vegetables, cheese, etc.
Delicatessens	Small food outlet mainly engages in meal or light refreshment ready for immediate consumption without table service. The Delicatessen may have greater varieties of options than "traditional fast food restaurants".

Table 3.1 (cont.)

Ethnic Takeaway	Food store selling ready-to-eat food and meals with ethnic origin or name such as Chinese, Indian, Vietnamese, Thai, Indonesian, Italian, Lebanese, Turkish, Mexican, Greek.
Fast Food Outlet	Serves complete meals ordered without the assistance of wait person or table service, requires payment before eating, provide customers a place to consume their meals on-site or drive through. The fast food restaurant can be franchise or independently owned. The Fast food outlet's primary menu items may include pre-processed and prepared foods such as hamburgers, hot dogs, and fried chicken. McDonald's, Red Rooster, KFC, Hungry Jacks, Burger King and Nando's are the typical examples of fast food restaurants in Australia.
Food Hall	Mixed specialties which can have counters that are dependent in a department store or shopping centre or shopping mall and share the same dining area. International Food Court, Wembley; Carousel shopping Centre Food Hall are some typical examples of food hall.
Fresh Juice Bar	Small retail food outlet that offers fresh fruit juice.
Fruit and Vegetable Store	Specialty food store, primarily engages in retailing of fresh fruits and vegetables.
Full Service Restaurant	Restaurants included fine dining, sit-down (eat-in) with waiter or waitress available for service or carryout types.
General Takeaway	Retail food store selling a wide variety of ready-to-eat food and meals, often high in fat (example, meat pies, sausage rolls, fried fish, chips, etc) for consumption away from the premises on which it is prepared. The typical example of a general takeaway store is a Fish and Chips shop.
Health Food Store	Primarily oriented towards the sale of health foods, or natural foods. Alive Organics, Elementals Health Food & Eco Store, Manna whole foods, etc. can be the typical examples of some of the health food stores.
Ice Cream Shop	A retail food store specialising on ice-cream and candy, for examples, Crusty Kones, Wendy's and Gelateria.
Lolly Shop	Retail food store selling candy, chocolates and nuts.
Market	Represents farmers' or growers' market, provides mainly fresh fruit, vegetables, eggs, meat and fish.

Table 3.1 (cont.)

Pizza Shop	Mainly engages in selling pizza, for example, Eagle's Boys Pizza, Domino Pizza and Pizza Hut.
Sandwich Bar	Retail food store primarily sells fresh sandwich, salads and rolls for instance, Subway Sandwich bar.
Supermarket	Typical example of self-service retail food store, offers full range of grocery food items including fresh meat, meat products, bread, fresh fruits and vegetables, milk, dairy products, canned food and frozen food. The supermarket may likely to have on-site food preparation such as a butcher, baker and deli. IGA, Coles, Woolworths, Farmer's Jack, Bi-Lo are some examples of the supermarket in Australia. We have included grocery store and supermarket in the same category as they both sell similar types of foods, although grocery store may not affiliate with chain.
Sushi bar	Deals primarily with fresh Sushi for immediate consumption or takeaway.

3.5 Classification of Food Types

Food can be classified into different categories. For example, the Australian Guide to Healthy Eating categories food into five groups (cereals, vegetables, fruits, meat and dairy or alternatives or ''extra foods''). Similarly, the Food Guide Pyramid developed by the United States Department of Agriculture also classifies food into five groups (grains, vegetables, fruits, milk, and meat or meat alternatives) (Dixon et al., 2001).

Based on the taxonomy, food can be grouped into plant-based food (vegetables) or animal-based food (for example, meats) (Ross and Murphy, 1999). Nutrient profiling on the other hand, categorises food based on the nutrient content. It is widely used for labelling the food for its nutritional value (Drewnowski and Fulgoni, 2008). Based on the nutrient profiling, food can be broadly classified into nutrient-dense (i.e., healthy food) or energy-dense food or unhealthy food (Maillot et al., 2007).

In this research, we categorised food into the three groups, namely- 'Eat most', 'Eat moderate' and 'Eat least' as described in the Healthy Eating Pyramid (Australian Nutrition Foundation, Inc., 1999). We used the Healthy Eating Pyramid because it is a simple and easy to understand. It is promoted by Nutrition Society of Australia, Dietitians Association of Australia and Sports Dietitians Australia for the educational campaign.

The Healthy Eating Pyramid can accommodate all types of food. It can provide information on proportion of each type of food that we should eat as part of our regular meal. However, it may not be able to identify specific food or sometimes the nature of the foods included within a single category may vary. For example, 'Eat moderate' types of food may include fish, tofu and low-fat yoghurt along with pretzels and popcorn (Inglis et al., 2009).

Table 3.2 provides description of these food types.

Table 3.2: Classification of food types

Food Type	Description
Eat most	Eat most types of food is a base layer of food which includes fruit, vegetables, peas, beans, lentils, breads and cereals (preferably wholegrain). These foods contain different nutrients and should make up most of the food that we eat. Eating a variety of these foods each day should provide good amounts of carbohydrate, protein, minerals, vitamins and dietary fibre.
Eat moderate	Foods in the middle of the Healthy Eating Pyramid include fish, lean meat, eggs, chicken (no skin), milk, cheese and yoghurt. The "Eat moderate" types of food will provide protein, minerals (especially iron and calcium) and B vitamins.
Eat least	The "Eat least" types of food group consists of food containing higher proportion of sugars and fats. Regular consumption of larger amounts of these foods is not recommended because it can cause adverse impact on our health.

3.6 Estimating Food Available in Each Type of Food Outlet

We estimated availability of a particular type of food in the neighbourhood by integrating number of each type of retail food outlets located within a given neighbourhood and proportion of each type of food for each type of retail food outlets. This is important because a particular type of retail food outlets may stock

food belonging to ‘Eat most’, ‘Eat moderate’ and ‘Eat least’ types. This not only makes difficult to generalise the retail food outlets but it also makes difficult to assess the quantity of a particular type of food available in the neighbourhood. Therefore, a Delphi technique was used to rate all types of food outlet individually in terms of the quantity of each type of food available in a particular type of retail food store.

The Delphi technique is a research method based on the principle that group judgments are more valid than individual judgments (Rowe and Wright, 1999). It can be applied to almost any situation (Pill, 1971). However, it is well suited to complex situations where no accurate or definitive evidence is available regarding the research question (Pill, 1971; Taylor and Ryder, 2003), such as business forecasting (Green et al., 2007) or, in this case, the availability of food types in different types of retail food outlets**.**

The Delphi technique involves a Panel of experts in the field of study, where each Panel Member can provide his or her professional advice independently (Dalkey and Helmer, 1963; Landeta, 2006; Rowe and Wright, 1999), without any influence or pressure from other Panel Members. Hence, it avoids group dynamics that can occur when others influence individuals. Further, the Delphi technique can provide each Panel Member with an opportunity to review or reappraise his or her professional opinion based on the group’s overall view, such as the group median rating or score (Dalkey and Helmer, 1963). This review process increases the consensus of opinion among Panel Members, which is the main aim of the Delphi technique (de Villiers et al., 2005).

Theoretically, the Delphi technique can involve any number of iterations, depending on the nature of the research questions and the degree of accuracy required. However, two to three iterations are recommended to achieve a minimum level of consensus about the research question (Brooks, 1975; Custer et al., 1999; Ludlow, 1975).

3.6.1 Deployment of Delphi Survey

Websites of universities, government, semi-government, non-government institutions and professional organisations were searched, and 35 potential Delphi Panel Members were identified. These members were selected as experts based on their academic interests, research and practice in the field of food and nutrition. A letter was sent to each participant to introduce the study and the Delphi technique, along with an invitation to participate in the survey (Appendix D). Of the 35 experts invited, eight declined to be involved due to work commitments (n=4) or unavailability (n=4), and no response was received from eight experts. The final Panel Members included practitioners working in the field of food and nutrition (n=5), dietetics (n=4), academia (n=9) and industry (n=1). There were 14 local and five national experts.

Phase 1: The first round of the Delphi questionnaire was posted with invitation letter and background information about the study (Appendix D). Email responses were received from some participants (n=11) requesting an electronic version of the questionnaire, which was later sent to all participants as an email attachment.

The Panel Members were asked to return the first questionnaire within two weeks. One reminder letter (Appendix D-V) was sent to those who had not returned the questionnaire within this time. One follow-up phone call was made to those who had still not returned the questionnaire after an additional two weeks.

The first round of the Delphi technique assessed the availability of ‘eat most’, ‘eat moderate’ and ‘eat least’ types of food for each type of retail food outlet. The Delphi Panel Members were asked to allocate a total of 100 points to ‘eat most’, ‘eat moderate’ and ‘eat least’ types of food in terms of their availability in each type of food store. The group median score was calculated from the individual scores of all Panel Members indicating the proportions of each type of food available in each type of food store. The group median score was chosen because it is less sensitive to extreme values compared with the mean or average scores (Johnson and Bhattacharyya, 2001, p 48). Due to the use of the median score for each type of food and the potential for the score to total more than 100, all scores were normalised to

ensure that each contributed equally to the overall score. Using this method, the median score weights were assigned based on the proportions they contributed to the whole score. For example, original scores of 40, 50 and 16 were normalised to 38, 47 and 15, respectively.

Phase 2: The second round of the Delphi survey included only those that responded to the first questionnaire. The remaining Panel Members (n=19) were provided with the group median score along with his or her original score for each food outlet. They were asked whether they were satisfied with the response or wished to change their original score. The aim was to reach a group consensus among the participants.

Group median scores for each type of food outlet were re-calculated from the revised scores after collating all responses from the final Delphi round. The group median value obtained in the second round of the Delphi process was considered as proportions of the availability of a selected type of food from a particular type of food outlet (see Table 3.3). These scores were later used for calculating the NFE.

In the second (and final) round, some Panel Members changed their weightings. Most changes were made for ‘Bakery store’ (52.6 per cent), followed by ‘Deli and fine food store’ (47.4 per cent) and ‘Delicatessens’ (42.1 per cent). Few changes in scores were observed for retail food stores such as ‘Lolly’, ‘Pizza’, ‘Fruit and vegetable store’ and ‘Supermarket’ (5.3 per cent). The final food scores (weight of each type of retail food outlet) for each type of retail food outlet are presented in Table 3.3.

Table 3.3: Food outlet types and quantity of each type of food available

Food outlet type	Proportion (weight) of food		
	Eat most (%)	Eat moderate (%)	Eat least (%)
Baker	52	20	28
Butcher	0	80	20
Café	10	20	70
Cafeteria	20	30	50
Cake and Pastries Shop	0	0	100
Convenience Store	5	11	84
Deli and Fine Food Store	20	39	41
Delicatessens	15	25	60
Ethnic Takeaway	20	40	40
Fast Food Outlet	5	10	85
Food Hall	20	30	50
Fresh Juice Bar	50	30	20
Fruit and Vegetable Store	100	0	0
Full Service Restaurant	20	40	40
General Takeaway	0	10	90
Health Food Store	52	32	16
Ice Cream Shop	0	0	100
Lolly Shop	0	0	100
Market	60	30	10
Pizza Shop	0	5	95
Sandwich Bar	40	40	20
Supermarket	36	30	34
Sushi Bar	60	30	10

3.7 Study Participant Data

Participants' data (n=1,480) were obtained from the TRavel, Environment and Kids (TREK) project. The primary aim of the TREK project was to examine the extent to which the design of neighbourhoods influenced active transportation among children in grades 5–7 (9 to 13 years) who attended 25 government primary schools in Perth. Details of the methodology involved in the TREK project were published elsewhere (Giles-Corti et al., 2011; McCormack et al., 2011; Villanueva et al., 2012; Wood et al., 2010).

Data were collected in July–December 2007 using a child questionnaire and pedometers, in addition to objectively measured anthropometric data (height and weight) of children.

A student survey was administered during a classroom session. This included a 12-page questionnaire (completed by student) and mapping activity (in which the children marked destinations they used and routes they used to and from school) (see Appendix E). The anthropometric measurements (height and weight) were carried out by the trained personnel.

This section describes variables relevant to this research.

3.7.1 Demographics

The demographic characteristics of the participants (such as age and gender) were obtained from the TREK project's questionnaire for children.

The children were asked 'How old are you today?' with six options from which to choose (8, 9, 10, 11, 12 and 13). The participants were later categorised into two age groups for analysis (younger <= 11 and older > 11) as per previous definition (An and Sturm, 2012; Lobstein and Jackson-Leach, 2007).

3.7.2 Physical Activity

Children's objective physical activity was collected using pedometers. Children were asked to wear the pedometers (Accusplit AH120 M8) at all times for seven consecutive days except during activities such as swimming, taking a shower and sleeping. Each morning at school, under the instruction of the classroom teacher, children recorded whether they had worn the pedometer according to protocol. After seven days, the pedometers were collected and the number of steps was entered twice to minimise data entry errors.

To avoid overweight and obesity, primary school-aged girls are recommended to take a minimum of 12,000 steps per day, and boys are recommended to take a minimum of 15,000 steps per day (Tudor-Locke et al., 2004). Hence, the study participants were categorised into two groups: (1) those who achieved recommended or higher average daily steps and (2) those who did not achieve the recommended average daily steps.

3.7.3 Dietary Measures

3.7.3.1 Breakfast

Breakfast intake was measured by asking the participants how often they ate breakfast in a usual week (Monday–Sunday), with four responses: (1) Never; (2) 1–2 days; (3) 3–5 days; and (4) 6–7 days. Children were categorised into two groups based on the breakfast intake pattern. For example, occasional consumers of breakfast included those that responded never, 1–2 days and 3–5 days. Regular consumers of breakfast included those that ate breakfast 6–7 days per week.

3.7.3.2 Fruit

The study participants' fruit-eating behaviours were also derived from the children's TREK questionnaire. Participants were asked how many pieces of fruit they usually ate per day (where a serve of fruit was considered equal to one medium piece or two small pieces of fruit or one cup of diced fruit—approximately 150 grams). Participants were given four choices: (1) I don't know; (2) I don't eat fruit; (3) 1 piece or less; (4) 2–3 pieces; or (5) 4 or more pieces.

The Australian Guide to Healthy Eating guidelines recommend that children aged 8–11 eat at least one serve of fruit per day; whereas children aged 12–18 are recommended to eat at least three serves of fruit per day (NHMRC, 2010). Hence, study participants (children) were categorised into two groups to align with the age categories in the dietary recommendations. The higher fruit consumers comprised children who reported consuming recommended or higher serves of fruit every day, whereas children who reported consuming less than the recommendation were grouped into the lower consumers' category. The lower consumers of fruit group also included those children who reported not eating fruit along with others who reported that they did not know about the fruit (as this might be a proxy for not consuming fruit or eating less fruit).

3.7.3.2 Fast Food

Similarly, the unhealthy food behaviour (fast-food intake) of children was assessed by the frequency of the intake of pizza, burgers (such as McDonalds and Hungry Jacks) and soft drinks (such as Coke, Pepsi and Lemonade). Participants were asked how often they ate fast food (pizza, burgers and soft drinks).

Children were categorised again into four groups based on their unhealthy food behaviours (0 = no fast-food consumption; 2 = occasionally eat fast-food; 3 = moderately eat fast food; 4 = regularly eat fast food). These children were later categorised into two groups (0 = no fast food and 1 = consumes fast food).

3.7.4 Body Measurements

Data on height and body weight were objectively measured by trained research staff during the survey-administered session by using stadiometers and digital weighing scales respectively. All data on height were converted to metres, and body weight to kilograms. Body mass index (BMI) was calculated by dividing each participant's body weight by height squared as per the standard formula; that is, BMI = kg/m^2 (Cole et al., 2000; WHO, 2011).

The children were classified into normal, overweight or obese by using International age- and gender-specific child BMI cut points (Cole et al., 2000). Hence, for 10-year-old boys, a BMI of 19.84 or more ($\geq$ 19.84 and $<$ 24.00) was considered overweight and a BMI of 24.00 or more was considered obese. Similarly, for 10-year-old girls, a BMI of 19.86 or more ($\geq$ 19.86 and $<$ 24.11) was considered overweight and a BMI of 24.11 or more was considered obese.

Overweight and obese children were combined into a single category because of the smaller number of obese children, resulting in only two groups of children (1 = normal weight and 2 = overweight or obese).

3.8 Participant's Home Address

The parent provided each participant's home address (street address), which were geo-coded in ArcGIS 9.3 (ESRI, Redlands, CA, 2010) as a separate GIS point layer (Figure 3.3). As children were selected from 25 schools across the city, study participants were clustered, as can be seen from the Figure 3.3.

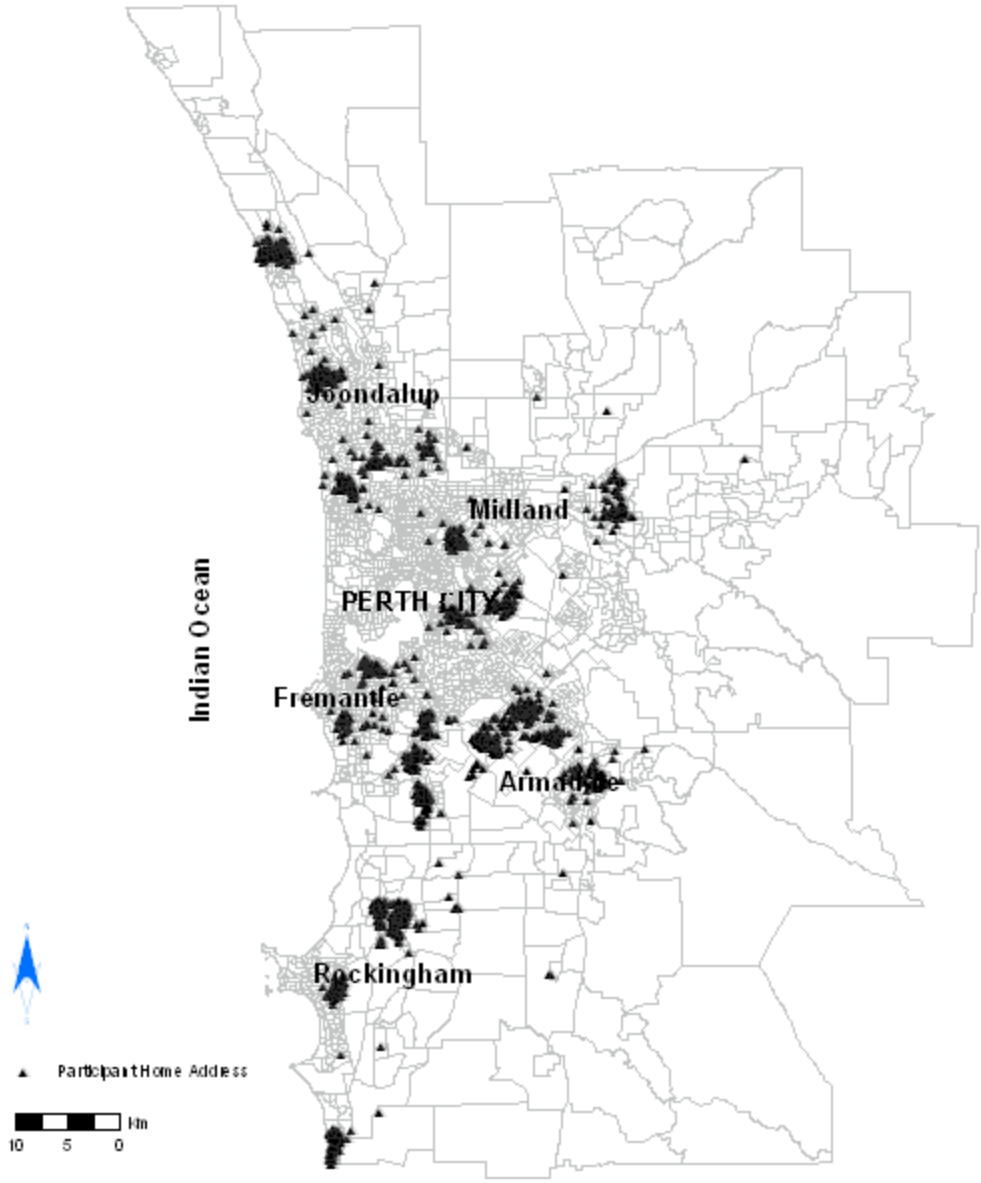

Figure 3.3: Locations of study participants

3.9 Participant's Neighbourhood

A neighbourhood is defined as a geographically localised community within a larger city, town or suburb. It can be measured as a political or administrative zone, such as the zip code area (Sturm and Datar, 2005), or as individual neighbourhood as perceived by individual people, such as buffer zones around the home or school (Ball et al., 2009; Ball et al., 2006b; Berke et al., 2007; Crawford et al., 2008; Frank et al., 2006; Liu et al., 2007; Rundle et al., 2009) as illustrated in Table 2.1 in chapter two.

One advantage of using the political or administrative neighbourhood is that data on many attributes of the neighbourhood are readily available (Ball et al., 2006b). However, an individual's neighbourhood may differ from the administratively defined neighbourhood. In a pilot study that compared neighbourhood maps drawn by residents with census-defined neighbourhoods (blocks), significant differences were observed (Coulton et al., 2001). On average, the perceived neighbourhood of the individual can be up to four times larger than a census-defined neighbourhood (Coulton et al., 2001). Further, perceptions of the neighbourhood can be highly individual (Hume et al., 2005; Veitch et al., 2006); therefore, the perceived neighbourhood can vary greatly from one individual to another, depending on the age (Ball et al., 2008; Matthews, 2008) and gender of study participants.

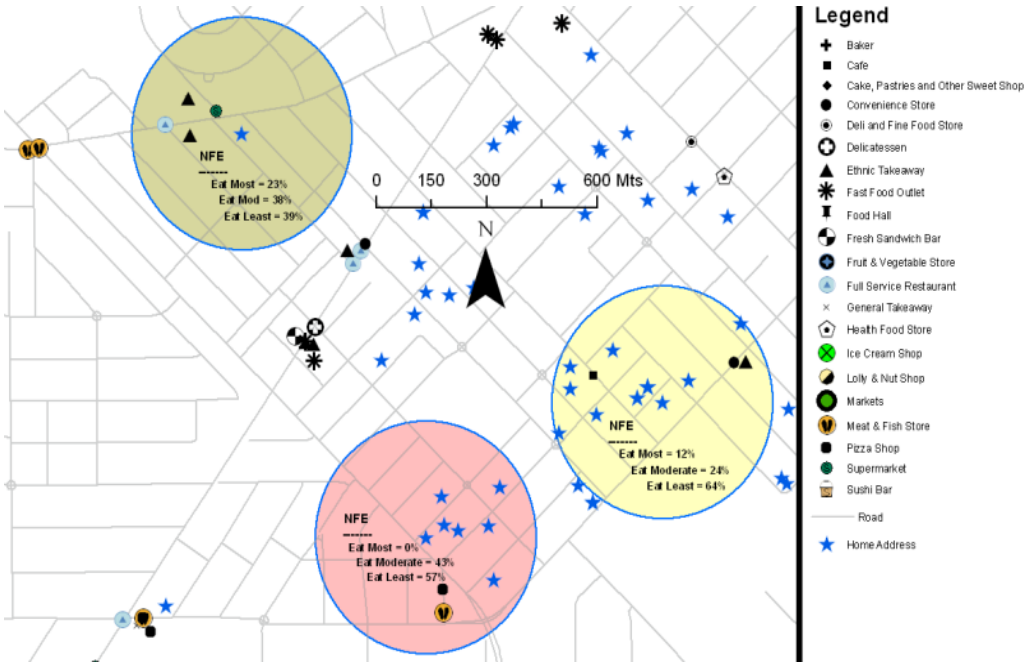

Figure 3.4: Example of neighbourhood (300m buffer around individual study participant's home) and food outlets within the neighbourhood.

The use of administrative boundaries (neighbourhoods) in studying the effect of neighbourhoods on food and physical activity may under- or over-estimate the effects of the neighbourhood on nutrition and physical activity behaviours. This is because the actual conditions affecting the resident's behaviours may not be adequately captured (Ball et al., 2006b). This prompts the importance of the individual neighbourhood in studying the influence of the NFE on people's food habits.

The individual neighborhood can provide increased specificity (Ball et al., 2006b). However, it can have some limitations. For instance, the individualised neighbourhood often may not align geographically with the existing administrative unit (Ball et al., 2006b). Therefore, the collection of neighbourhood attribute data for the individualized neighborhood can be resource intensive, as the data of interest may not exist at this level of specificity (Ball et al., 2006b). Furthermore, there is always a chance that some attributes of the neighborhood (for instance, retail food outlets) located just outside the boundary of an individual neighborhood (such as buffer zone) may be missed.

In this study, the individual participant's neighbourhood was defined as a specified buffer zone around his or her residential address (Figure 3.4). For the preliminary analysis, three different buffer zones (400, 800 and 1200m) were created around each participant's home address using ArcGIS (version 9.3, ESRI Inc., Redlands, California), consistent with the available literature (Rundle et al., 2009; Simon et al., 2008; Smoyer-Tomic et al., 2008; Sturm and Sturm, 2008). This exercise was carried out as a part of preliminary study with an aim of identifying the most appropriate buffer size for the main study (i.e., to study influence of the NFE on prevalence of obesity in children in Perth metropolitan region). The final analysis was focused on neighbourhood food environment within the 300m buffer zone.

We assumed that all participants were familiar with their respective neighbourhoods. However, the degree (magnitude) of familiarity of each participant may differ with the size of the neighbourhood. This in turn can make a difference in the magnitude of exposure to his or her neighbourhood (buffer). For example, if the size of a neighbourhood increases, it can decrease the individual's familiarity with its attributes, such as the availability of food (Moore et al., 2008a). That is, food environments within a 400m buffer zone may be more familiar to the participant than the food environment further away. Hence, the food environment closer to home (400m buffer) may affect the person's food choice behaviour more compared with the food environment further away (e.g. 800m or 1200m buffer). This is particularly relevant for young people (children and adolescents) who often have limited independent mobility (Timperio et al., 2004). This was confirmed from the preliminary analyses of the data, which agrees with the more recent observation (Spence et al., 2009; Truong et al., 2010). For instance, compared with 800m and 1200m buffer zones, the NFE associated with the 400m buffer zone had more effect on the prevalence of overweight or obesity among study participants, although the results did not reach a statistically significant level (see Appendix B).

3.9.1 Neighbourhood Socioeconomic Status

Neighbourhood socioeconomic status (SES) was defined as a composite measure of the overall economic and social position of a given neighbourhood derived from

CCD [1] level Socioeconomic Index For Areas (SEIFA) Index of Relative Socioeconomic Advantage and Disadvantage. The SEIFA score is a spatial (areal level) index (Adhikari, 2006). It is a summary measure of the SES of an area based on a component analysis of relevant variables (Adhikari, 2006) such as economic resources, education, occupation, family structure and ethnicity of households. A CCD with a low SEIFA score indicates that the area has a higher proportion of households with characteristics related to disadvantage, such as low income, low education, unskilled jobs and lone person or single-parent households. A low SEIFA score also indicates that the area has a low incidence of people with characteristics associated with advantage, such as higher incomes, skilled and professional jobs, tertiary education and internet access (Baker and Adhikari, 2007). Hence, the SEIFA index aims to identify and rank small areas that are relatively more, or less, disadvantaged. For individual and household level analyses, SEIFA can provide contextual information concerning the area in which a person lives (Baker and Adhikari, 2007).

In this project, the spatial SES for each participant's neighbourhood was defined as the mean SEIFA of all CCDs that fall under each participant's neighbourhood (i.e. buffer), stratified into tertiles (Timperio et al., 2009); that is, low SES (SEIFA < 831), medium SES (SEIFA 831–957) and high SES (SEIFA 1,083–1,209).

A separate GIS layer (polygon) of neighbourhood SES was created using ArcGIS 9.3 software.

3.9.2 Neighbourhood Food Environment

The neighbourhood food environment (NFE) is a critical component of the built environment (Ford and Dzewaltowski, 2008) that can represent the overall status of food available (quantity and quality) in a given neighbourhood. Numerically, the NFE (the availability of food in the neighbourhood) can be estimated as the sum of all the types of retail food outlets available in the neighbourhood (O'Dwyer and Coveney, 2006). However, it can provide only a crude estimates for the availability

[1] CCD is the smallest geographic area defined in the Australian Standard Geographical Classification, and is used for the aggregation of statistics to larger census geographic areas.

of food in the neighbourhood (Morland et al., 2006). Furthermore, the NFE derived by using the food store type as a proxy to represent the availability of a selected type of food may provide only one aspect of the NFE. When only one aspect of the NFE is studied, the results can become difficult to interpret, since a neighbourhood with greater access to unhealthy food options may also have greater access to healthy food options (Larson et al., 2009). This is because, as noted previously, a particular type of retail food outlet may stock a diverse range of food, ranging from healthy to unhealthy types. For example, in supermarkets, fresh fruit and vegetables are sold alongside pizza, cake, chips, ice-cream and chocolate (Farley et al., 2009). Furthermore, healthy types of food such as fruit and vegetables can also be available in smaller retail food outlets, where major supermarkets are not available in the neighbourhood (Moore et al., 2008a).

This prompted a comprehensive approach to be undertaken to measure the NFE (Larson et al., 2009). One possible alternative was to define the NFE by taking into account all possible types of retail food outlets available in a given neighbourhood, along with all possible types of food available in each type of retail food store. However, it is difficult to develop a single measure of the NFE by taking into account all possible types of food outlets and quantity of each type of food available. In this study, a comprehensive approach to developing an neighbourhood food index (NFE)[2] was attempted by modifying the Shannon's Diversity Index.

The Shannon's Diversity Index (Beisel and Moreteau, 1997; Kricher, 1972; Spellerberg and Fedor, 2003; Tramer, 1969) is a mathematical measure used for calculating the species diversity of a given community. It is a simple but powerful measurement that is widely used in the ecology, as it can provide information on the composition of a neighbourhood by taking into account the relative abundance of different species that are available within the neighbourhood or community.

The Shannon's Diversity Index was used as it could easily accommodate all possible types of retail food outlets (i.e. species) present in a given neighbourhood. Furthermore, the NFI that was developed based on the Shannon's Diversity Index

[2] The terms NFI and NFE are used interchangeably throughout this thesis.

could accommodate the quantity of each type of food available in a given neighbourhood. This is important, since it may help to measure both the quantitative and qualitative aspects of the NFE in a single measure, which was not attempted previously. The steps involved in determining the NFE are shown below and also illustrated in Figure 3.5.

1. Each individual participant's neighbourhood (buffer zone around each participant's home) was created;
2. The NFE was calculated as follows:
   a. the total number of each type of food outlet for each neighbourhood was counted
   b. the estimated quantity (proportion) of each type of food for each type of food outlet was obtained (see Table 3.3)
   c. the total quantity of each type of food ('eat most', 'eat moderate' and 'eat least') available for a given neighbourhood was determined.

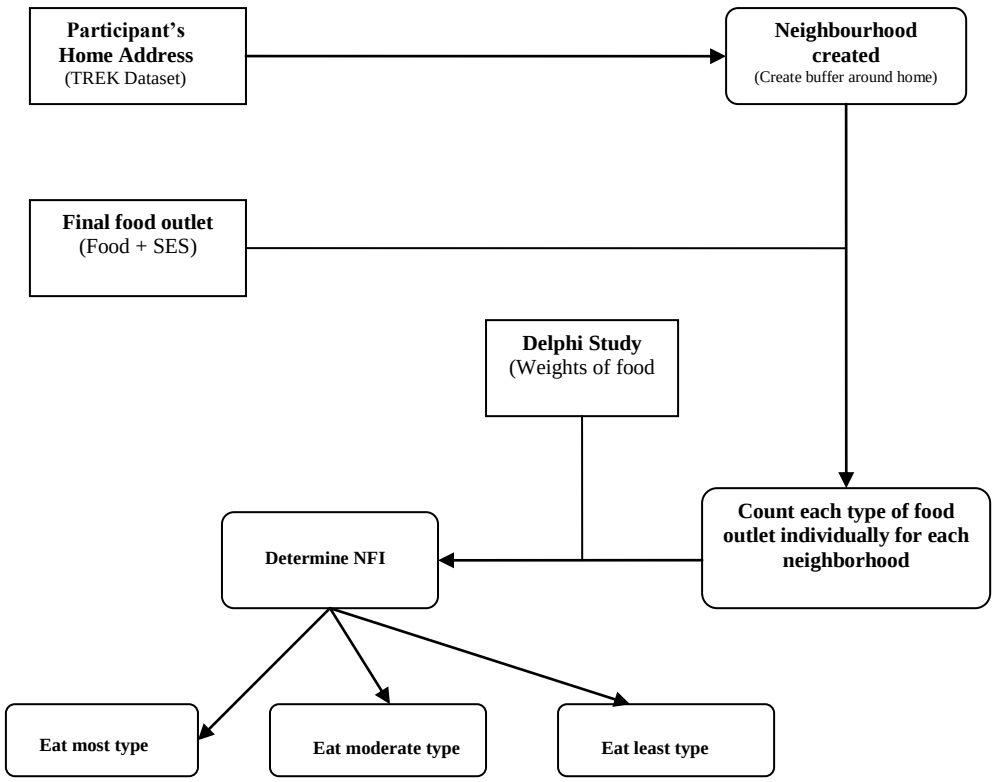

Figure 3.5: Overview of steps involved in determining the NFE

Mathematically, the NFE was derived using the following formula:

$NFE\ (i) = \Sigma(n_i * q_i + \ldots + n_j * q_{ij})/T_{f,,}$

where, T_f = total amount of food available in a neighbourhood, i.e.,

$$T_f = (n_i * q_i + \ldots + n_j * q_{ij} + \ldots + n_j * q_j + \ldots + n_i * q_{ji})$$

and,

n_i = number of i^{th} type of outlet

n_j = number of j^{th} type of outlet

q_i = quantity of i^{th} type of food in i^{th} type of outlet

q_j = quantity of j^{th} type of food in j^{th} type of outlet

q_{ij} = quantity of i^{th} type of food in j^{th} type of outlet

q_{ji} = quantity of j^{th} type of food in i^{th} type of outlet.

For example, consider a neighbourhood with two supermarkets, three bakery stores and five fast-food outlets. The NFE can be estimated by combining the number and weight of each type of retail food outlet. Table 3.3 provides the median scores used for the weights.

The weight of supermarkets for ‘eat most’ type of food = 36, the weight of bakery stores for ‘eat most’ type of food = 52 and the weight of fast-food outlets for ‘eat most’ type of food = 5. Similarly, the weight of supermarkets for ‘eat moderate’ type of food = 30, the weight of bakery stores for ‘eat moderate’ type of food = 20 and the weight of fast-food outlets for ‘eat moderate’ type of food = 10. In addition, the weight of supermarkets for ‘eat least’ type of food = 34, the weight of bakery stores for ‘eat least’ type of food = 28 and the weight of fast-food outlets for ‘eat least’ type of food = 85.

Using $\mathbf{NFE = \Sigma(_i * q_{msti} + \ldots + _j * q_{mstj})/T_f}$, results in:

(A) ‘Eat most’ type of food available in the neighbourhood:
= [(2*36) + (3*52) + (5*5)] / [(2*36) + (3*52) + (5*5)] + (2*30) + (3*20) + (5*10) + (2*34) + (3*28) + (5*85)] = 0.253

Similarly,

(B) ‘eat moderate’ type of food available in the neighbourhood = 0.17

and (C) ‘eat least’ type of food available in the same neighbourhood = 0.577.

Hence, the given neighbourhood with two supermarkets, three bakery stores and five fast-food outlets may have approximately 25 per cent ‘eat most’, 17 per cent ‘eat moderate’ and 58 per cent ‘eat least’ types of food.

3.10 Data Analysis (Treatment of the Data)

To handle outliers, NFEs with a value of 1.0 were removed from the analyses (NFE was considered valid if it was less than one, and NFE values with a value of 1.0 were recorded as missing). All analyses were conducted using SAS 9.2 (SAS Institute Inc., Cary, USA).

Means, standard deviations and correlations were used for the descriptive statistics.

3.10.1 Neighbourhood Socioeconomic Status and Neighbourhood Food Environment

The association between the neighbourhood SES and NFE was examined using a linear regression model (bi-variate), where the NFE was considered a continuous (outcome) variable and neighbourhood SES a categorical (explanatory) variable, as shown in models A, B and C below.

Model A:

$$\text{NFE (total number of food outlets)} = \alpha + \beta_1*[\text{SES = high}] + \beta_2*[\text{SES = medium}] + \beta_3*[\text{SES = low}].$$

Model B:

$$\text{NFE (eat most)} = \alpha + \beta_1*[\text{SES = high}] + \beta_2*[\text{SES = medium}] + \beta_3*[\text{SES = low}].$$

Model C:

NFE (eat moderate) = $\alpha + \beta_1$*[SES = high] + β_2*[SES = medium] + β_3*[SES = low].

Model D:

NFE (eat least) = $\alpha + \beta_1$*[SES = high] + β_2*[SES = medium] + β_3*[SES = low].

3.10.2 Neighbourhood Food Environment and the Prevalence of Obesity

The influence of the NFE on the prevalence of overweight or obesity was examined in three steps. First, it was examined using bi-variate logistic regression models (models I, II, III and IV). Next, it was examined using multivariate logistic regression models (models VI, VII, VIII and IX), where variables such as age, gender, food behaviours, physical activity and neighbourhood SES were adjusted. Finally, the association was examined by adjusting the age, gender, food behaviours, physical activity, neighbourhood SES and NFE (other types of food available in the neighbourhood) (model X).

Model I:

$\ln(p/1-p) = \alpha + \beta_1$*[total number of food outlets].

Model II:

$\ln(p/1-p) = \alpha + \beta_1$*[eat most].

Model III:

$\ln(p/1-p) = \alpha + \beta_1$*[eat moderate].

Model IV:

$\ln(p/1-p) = \alpha + \beta_1$*[eat least].

Model VI (total number of food outlets):

$$\ln(p/1-p) = \alpha + \beta_1*[\text{total number of food outlets}] + \beta_2*[\text{SES = high}] + \beta_3*[\text{SES = medium}] + \beta_4*[\text{SES = low}] + \beta_5*[\text{age = older}] + B_6*[\text{age = younger}] + \beta_7*[\text{sex = boy}] + \beta_8*[\text{sex = girl}] + \beta_9*[\text{physical activity = high}] + \beta_{10}*[\text{physical activity = low}] + \beta_{11}*[\text{breakfast = regular}] + \beta_{11}*[\text{breakfast = occasional}] + \beta_{12}*[\text{fruit = high}] + \beta_{13}*[\text{fruit = low}] + \beta_{15}*[\text{fast food = no}] + \beta_{16}*[\text{fast food = yes}].$$

Model VII (eat most):

$$\ln(p/1-p) = \alpha + \beta_1*[\text{eat most}] + \beta_2*[\text{SES = high}] + \beta_3*[\text{SES = medium}] + \beta_4*[\text{SES = low}] + \beta_5*[\text{age = older}] + B_6*[\text{age = younger}] + \beta_7*[\text{sex = boy}] + \beta_8*[\text{sex = girl}] + \beta_9*[\text{physical activity = high}] + \beta_{10}*[\text{physical activity = low}] + \beta_{11}*[\text{breakfast = regular}] + \beta_{11}*[\text{breakfast = occasional}] + \beta_{12}*[\text{fruit = high}] + \beta_{13}*[\text{fruit = low}] + \beta_{15}*[\text{fast food = no}] + \beta_{16}*[\text{fast food = yes}].$$

Model VIII (eat moderate):

$$\ln(p/1-p) = \alpha + \beta_1*[\text{eat moderate}] + \beta_2*[\text{SES = high}] + \beta_3*[\text{SES = medium}] + \beta_4*[\text{SES = low}] + \beta_5*[\text{age = older}] + B_6*[\text{age = younger}] + \beta_7*[\text{sex = boy}] + \beta_8*[\text{sex = girl}] + \beta_9*[\text{physical activity = high}] + \beta_{10}*[\text{physical activity = low}] + \beta_{11}*[\text{breakfast = regular}] + \beta_{11}*[\text{breakfast = occasional}] + \beta_{12}*[\text{fruit = high}] + \beta_{13}*[\text{fruit = low}] + \beta_{15}*[\text{fast food = no}] + \beta_{16}*[\text{fast food = yes}].$$

Model IX (eat least):

$$\ln(p/1-p) = \alpha + \beta_1*[\text{eat least}] + \beta_2*[\text{SES = high}] + \beta_3*[\text{SES = medium}] + \beta_4*[\text{SES = low}] + \beta_5*[\text{age = older}] + B_6*[\text{age = younger}] + \beta_7*[\text{sex = boy}] + \beta_8*[\text{sex = girl}] + \beta_9*[\text{physical activity = high}] + \beta_{10}*[\text{physical activity = low}] + \beta_{11}*[\text{breakfast = regular}] + \beta_{11}*[\text{breakfast = occasional}] + \beta_{12}*[\text{fruit = high}] + \beta_{13}*[\text{fruit = low}] + \beta_{15}*[\text{fast food = no}] + \beta_{16}*[\text{fast food = yes}].$$

3.10.3 Neighbourhood Socioeconomic Status and the Prevalence of Obesity

The influence of neighbourhood SES on the prevalence of overweight or obesity was initially examined using a bi-variate model, where neighbourhood SES was considered an independent variable and the prevalence of overweight or obesity a binary outcome variable (model V). This analysis was repeated using a multivariate model (model X), where the influence of the neighbourhood SES on the prevalence of overweight or obesity was examined by adjusting for other variables such as age, gender, physical activity, food behaviours and NFE.

Model V (SES):

$$\ln(p/1-p) = \alpha + \beta_1*[\text{SES = high}] + \beta_2*[\text{SES = medium}] + \beta_3*[\text{SES = low}].$$

Model X (fully adjusted):

$$\ln(p/1-p) = \alpha + \beta_1*[\text{eat most}] + \beta_2*[\text{eat moderate}] + \beta_3*[\text{eat least}] + \beta_2*[\text{SES = high}] + \beta_3*[\text{SES = medium}] + \beta_4*[\text{SES = low}] + \beta_5*[\text{age = older}] + B_6*[\text{age = younger}] + \beta_7*[\text{sex = boy}] + \beta_8*[\text{sex = girl}] + \beta_9*[\text{physical activity = high}] + \beta_{10}*[\text{physical activity = low}] + \beta_{11}*[\text{breakfast = regular}] + \beta_{11}*[\text{breakfast = occasional}] + \beta_{12}*[\text{fruit = high}] + \beta_{13}*[\text{fruit = low}] + \beta_{15}*[\text{fast food = no}] + \beta_{16}*[\text{fast food = yes}].$$

where p = proportion of overweight or obese.

3.11 Conclusion

The measurement of food available in the neighbourhood is a complex issue, not only due to the types of retail food outlets available, but also due to the diversity of food available in specific type of outlets.

Many researchers have used the food store type as a proxy to represent the availability of particular type of food in the neighbourhood. However, this approach does not represent the overall picture of the NFE, particularly the quality of the food available.

This study undertook a comprehensive approach to measuring the NFE by accommodating the number of all possible types of retail food outlets that exist in a given neighbourhood. Further, it attempted to accommodate the quantity of all possible types of food available in each type of outlet using the Delphi method. This appears to be the first research to attempt to include qualitative and quantitative aspects of the NFE. This may help to redefine the NFE and further explore the effect of the NFE on food behaviours, which in turn may help us predict health outcomes, such as BMI, more accurately.

Chapter 4: Results

4.1 Overview

This chapter is divided into two sections. Section 4.2 describes the overall status of food available across the Perth metropolitan area (total number of retail food outlets, number of individual type of retail food outlets and amount of 'eat most', 'eat moderate' and 'eat least' types of food). Section 4.3 examines the association between neighbourhood characteristics (e.g. availability of 'eat most', 'eat moderate' and 'eat least' types of food, and neighbourhood SES) and BMI. More specifically, the general characteristics of the study participants and their neighbourhoods (SES and NFE) are presented, followed by associations between the NFE and neighbourhood SES. Relationships between the study participants' NFE and BMI are analysed, as well as relationships between neighbourhood SES and the BMI of individual participants. Finally, the effect of neighbourhood characteristics (SES and NFE) on the prevalence of overweight or obesity among participants is presented.

4.2 Retail Food Outlets in the Perth Metropolitan Area

A total of 6,238 retail food outlets were identified in the Perth metropolitan area. These outlets were categorised into 21 types. Figure 4.1 shows the distribution of the retail food outlets across the Perth metropolitan region.

On average, each CCD in the Perth metropolitan area had 2.15 (SD = 6.34) retail food outlets (Table 4.1). 'General takeaway' (n = 1,249) dominated, contributing over 20 per cent of the overall retail food outlets across the Perth metropolitan region. 'Full-service restaurants' (n = 732) and 'ethnic takeaway' (n = 707) occupied second and third positions, contributing 12 per cent and 11 per cent of the overall retail food outlets respectively (Table 4.1). As seen in Table 4.1, the Perth metropolitan area was dominated by 'eat least' type of food (63 per cent) followed by 'eat moderate' (21 per cent) and 'eat most' (16 per cent).

Table 4.1: Food outlets (number and types) and food types available in each CCD in the Perth metropolitan area

Food Outlet Type	Number	Percent	Mean±SD
Baker	184	2.95	0.06±0.30
Butcher	196	3.14	0.07±0.30
Cafe	532	8.53	0.18±0.91
Cake and Pastries Shop	222	3.56	0.08±0.44
Convenience Store	252	4.04	0.09±0.39
Deli and Fine Food Store	182	2.92	0.06±0.26
Delicatessens	78	1.25	0.03±0.16
Ethnic Takeaway	707	11.33	0.24±0.96
Fast Food Outlet	394	6.32	0.14±0.70
Food Hall	40	0.64	0.01±0.13
Fruit and Vegetable Store	73	1.17	0.03±0.16
Full Service Restaurant	732	11.73	0.25±1.24
General Takeaway	1249	20.02	0.43±1.50
Health Food Store	141	2.26	0.05±0.27
Ice Cream Shop	143	2.29	0.05±0.38
Lolly Shop	36	0.58	0.01±0.17
Market	7	0.10	0.002±0.06
Pizza Shop	345	5.53	0.12±0.48
Sandwich Bar	285	4.57	0.10±0.49
Supermarket	376	6.03	0.13±0.51
Sushi Bar	64	1.03	0.02±0.21
Total	**6238**	**100.00**	**2.15±6.34**
NFE*			
Eat least		63.00	0.24±0.34
Eat moderate		21.00	0.08±0.13
Eat most		16.00	0.06±0.11

*NFE as neighbourhood food index (NFI)
SD = Standard deviation

Figure 4.1 shows the clustering of retail food outlets in and around Perth's CBD including North Bridge, Subiaco, Victoria Park and Nedlands, in addition to major town centres (Joondalup, Fremantle, Midlands, Armadale and Rockingham). Geographically, retail food outlets (see Figure 4.1), are also located along major road networks (including railway) and residential areas (built areas). Figures 4.2, 4.3 and 4.4 show the maps of food availability scores in Perth metropolitan region. As seen in the Figure 4.2, availability of 'eat most' type of food was higher in and around the older suburbs (around the Perth CBD) and some beachside suburbs. Distribution of

'eat moderate' type of food did not show any clear pattern (Figure 4.3). However, 'eat least' type of food was common away from the Perth CBD (Figure 4.4).

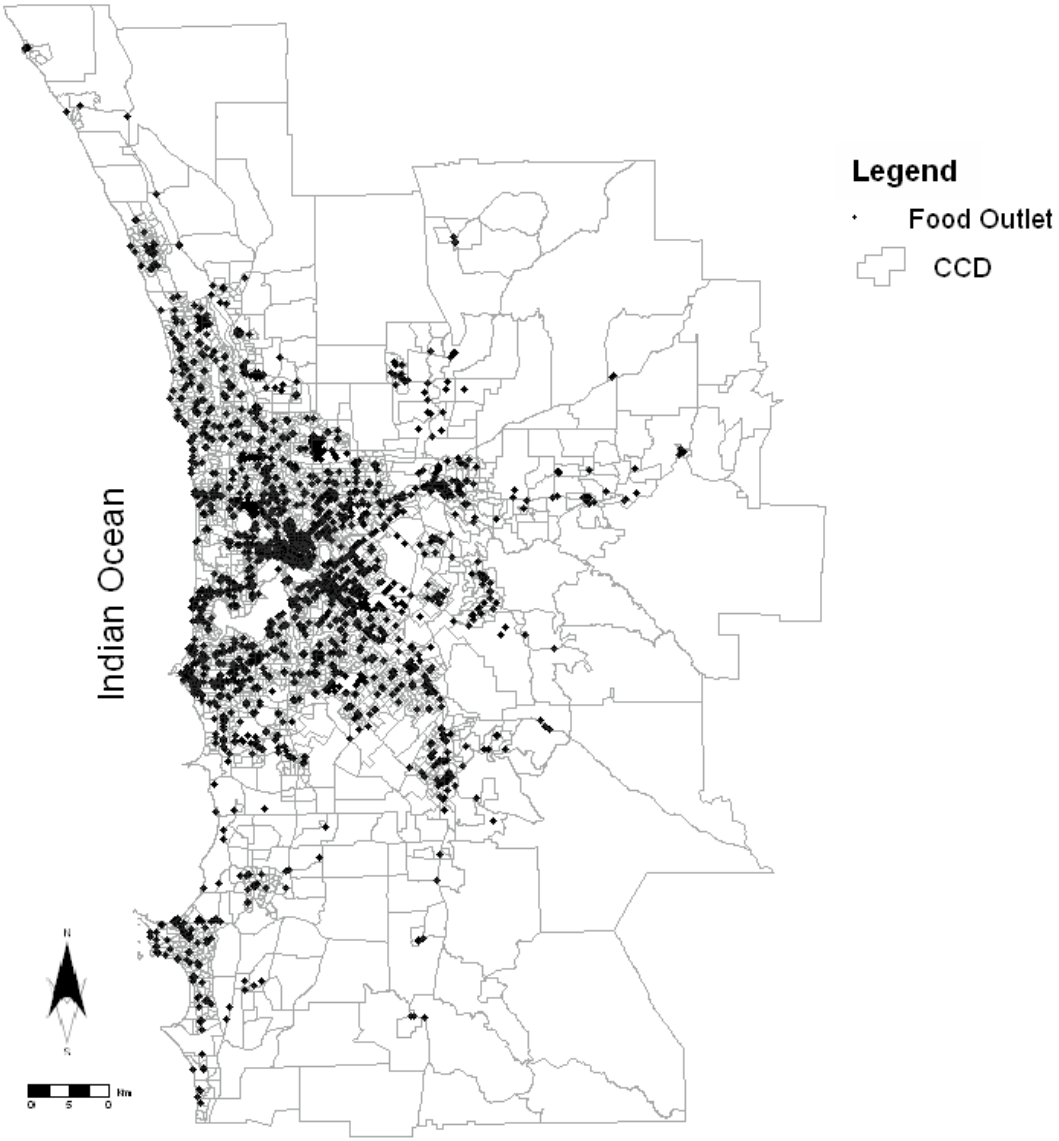

Figure 4.1: Distribution of retail food outlets across the Perth metropolitan area

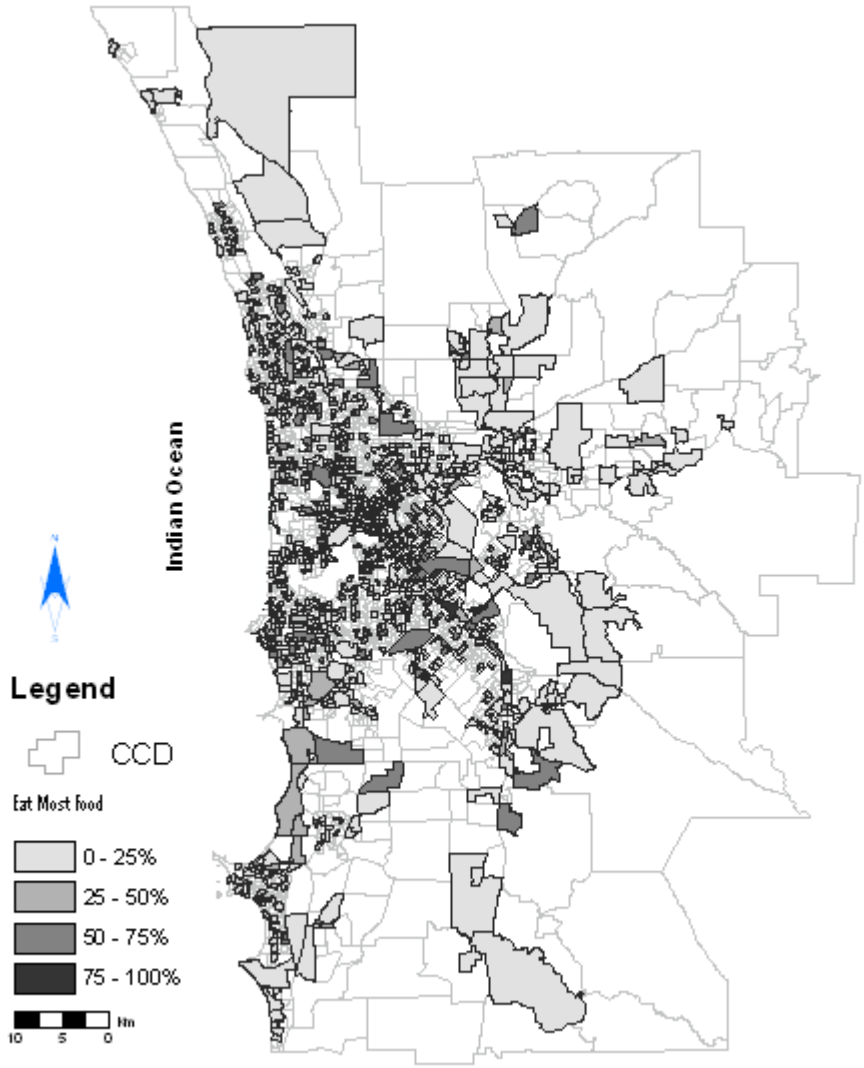

Figure 4.2: Distribution (proportion) of 'eat most' type of food across the Perth metropolitan area

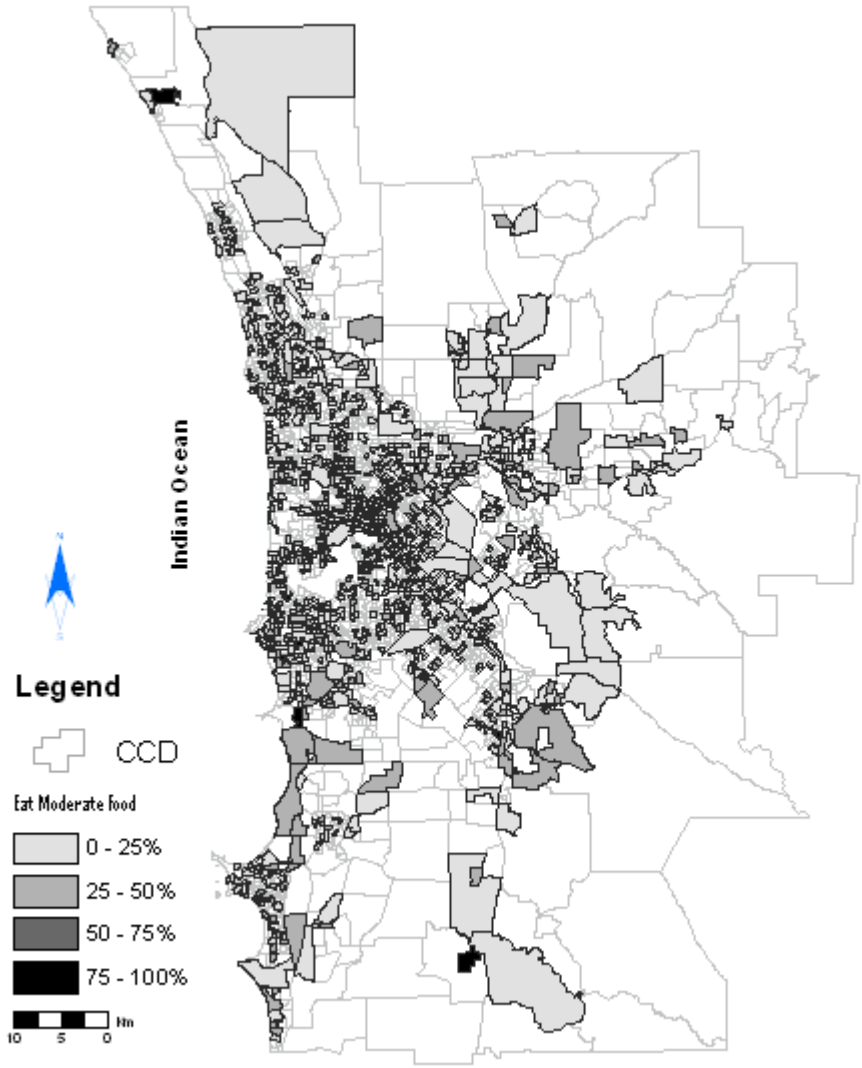

Figure 4.3: Distribution (proportion) of 'eat moderate' type of food across the Perth metropolitan area

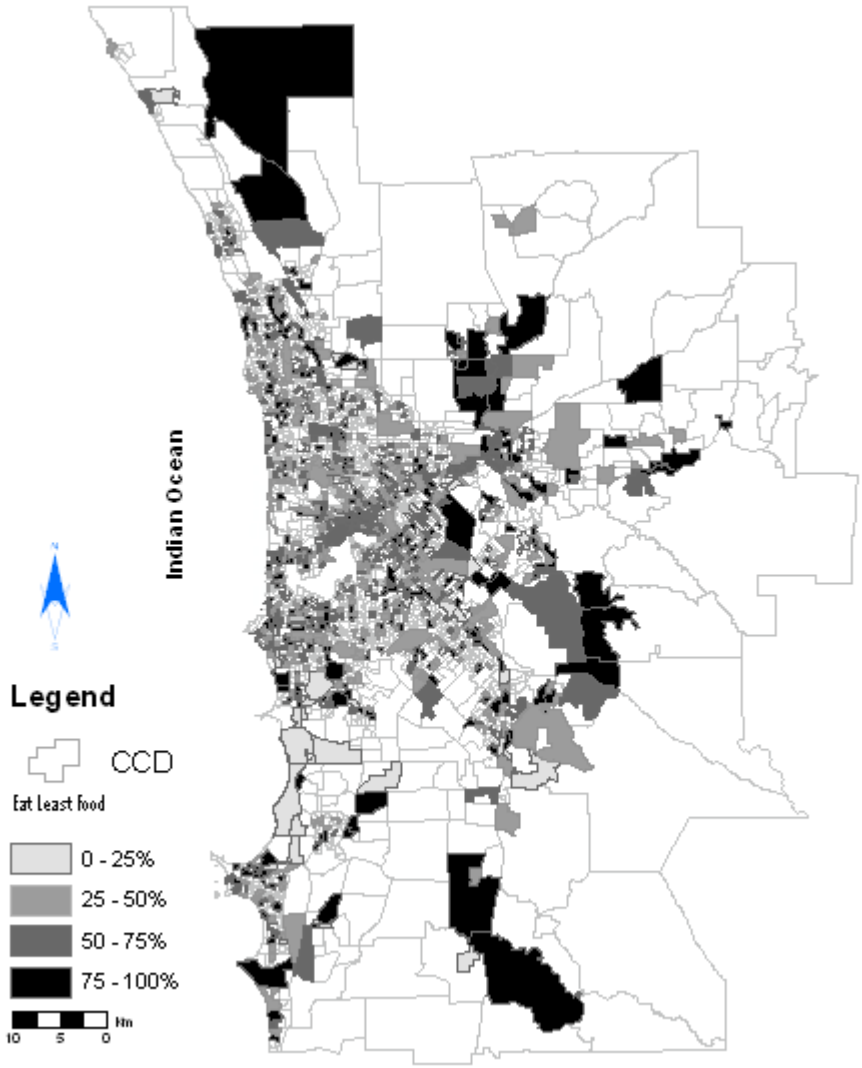

Figure 4.4: Distribution (proportion) of 'eat least' type of food across the Perth metropolitan area

4.3 Characteristics of Study Participants and Their Neighbourhoods

4.3.1 Body Mass Index

The children's BMI ranged from 12.39 to 33.26, with an average of 18.89 (SD = 2.93). Overall, 24 per cent of children were overweight or obese (Table 4.2).

4.3.2 Age

The age of the children included in the study ranged from 9 to 13 years, with an average age of 11 years. Sixty-nine per cent comprised younger children (≤ 11 years)

with an average age of 11 years and 31 per cent were older children (> 11 years) with an average age of 12 years (see Table 4.2).

Table 4.2 shows that the mean BMI of the older children was significantly higher (mean = 19.39, SD = 2.78, range = 13.21–33.26) than the mean BMI of the younger children (mean = 18.67, SD = 2.97, range = 12.39–31.44) ($p < 0.0001$). The prevalence of overweight or obesity was 25 per cent for the younger children and 23 per cent for the older children (see Table 4.2).

4.3.3 Gender

The study participants comprised 52 per cent boys and 48 per cent girls. The boys had a slightly lower BMI (mean = 18.87, SD = 2.91, range 13.89–33.26) than the girls (mean = 18.92, SD = 2.95, range = 12.39–31.44). However, the results (difference in mean BMI between the boys and girls) did not reach a statistically significant level (see Table 4.2). Overall, 24 per cent of boys and 25 per cent of girls were overweight or obese.

4.3.4 Pedometer-assessed Physical Activity

On average, the children took 11,278 steps per day (SD = 3,441, range = 1,000–22,878). Only 26 per cent of the children achieved the recommended daily steps or higher. The children that achieved recommended steps had a slightly lower BMI (mean = 18.59, SD = 2.59) compared with those that did not achieve the recommended daily steps (mean = 18.91, SD = 3.00). However, the prevalence of overweight or obesity was found to be the same (23 per cent) in both groups (Table 4.2).

4.3.5 Food Behaviours

4.3.5.1 Breakfast

Approximately 77 per cent of the children consumed breakfast regularly. The average BMI of the children who ate breakfast regularly was significantly lower (mean = 18.73, SD = 2.86) than those who did not eat breakfast regularly (mean = 19.42, SD = 3.09) ($p = 0.0007$).

Consequently, the odds of being overweight or obese was significantly higher among those children who did not consume breakfast regularly compared with those children who ate breakfast regularly (OR = 1.37, 95% CI = 1.007 – 1.854, p = 0.0451).

4.3.5.2 Fruit

Overall, 56 per cent of the children participated in the study consumed the recommended, or higher daily serves of fruit, and had a significantly lower BMI than those who did not eat the recommended daily serves of fruit (p = 0.0028). However, the prevalence of overweight or obesity was almost the same between the two groups (Table 4.2).

4.3.5.3 Fast Food

Overall, 70 per cent of the children consumed fast food. The mean BMI of these children was moderately higher (mean = 19.00, SD = 3.02) than those who did not eat fast food (mean = 18.65, SD = 2.68) (p = 0.0667). Moreover, there was a slightly higher prevalence of overweight or obesity among children that reported consuming fast food but this did not reach statistical significance (p > 0.1520) (Table 4.2).

4.3.6 Neighbourhood Characteristics

4.3.6.1 Neighbourhood Socioeconomic Status

The SEIFA score for the neighbourhoods (300m buffer zone) ranged from 826.87 to 1,196.40, with a mean score of 995.14 (SD = 61.12). The mean SEIFA score for low SES neighbourhoods was 907.58 (SD = 23.36, range = 826.87–927.70). Similarly, the mean SEIFA scores for medium and high SES neighbourhoods were 988.85 (SD = 34.98, range = 927.94–1,061.65) and 1,108.24 (SD = 32.34, range = 1,062.57–1,196.40) respectively.

The majority (75 per cent) of the children who took part in this study resided in medium SES areas. Only 12 per cent resided in low SES areas and the remaining 13 per cent resided in high SES areas (Table 4.2).

Table 4.2: Characteristics of study participants (n=1,181) and their environments

Variable	Total				Overweight/obese		
	N	%	BMI±SD	p-value	N	%	p-value
Demography							
Age							
Older (> 11 yrs)	364	31	19.39±2.78	<0.0001	82	23	0.3898
Younger (≤ 11 yrs)	817	69	18.67±2.97		203	25	
Gender							
Boy	616	52	18.87±2.91	0.7525	145	24	0.6189
Girl	565	48	18.92±2.95		140	25	
Physical Activity[1]							
Recommendation/higher level	264	26	18.59±2.59	0.1238	62	23	0.9909
Below recommendation level	742	74	18.91±3.00		174	23	
Food Behaviour							
Breakfast[2]							
Regular	906	77	18.73±2.86	0.0007	206	23	0.0451
Occasional	272	23	19.42±3.09		78	29	
Fruit[3]							
Recommendation/higher level	605	56	18.69±3.04	0.0028	154	25	0.7414
Below recommendation level	468	44	19.23±2.79		115	25	
Fast food							
No	355	30	18.65±2.68	0.0667	76	21	0.1520
Yes	826	70	19.00±3.02		209	25	
Neighbourhood characteristics							
Neighbourhood SES[4]							
High	154	13	18.52±2.87	0.1622	31	20	0.4150
Medium	876	75	18.97±2.96		213	24	
Low	136	12	18.72±2.75		36	26	

[1,2,3,4]Some values missing
SD = Standard deviation

4.3.6.2 Neighbourhood Food Environment

Overall, children's neighbourhoods had 1,309 retail food outlets that were grouped into 19 categories (see Table 4.3). Nevertheless, the majority of the children did not have any retail food outlets in their neighbourhoods (over 74 per cent). Approximately 22 per cent of the children had 1–10 outlets in their neighbourhoods, three per cent had 11–20 outlets and less than one per cent had 20–31 outlets (data not shown). The study participants' neighbourhoods were dominated by retail food outlets like 'general takeaway' (22 per cent), 'ethnic takeaway' (12 per cent) and 'full-service restaurant' (11 per cent). On average, these outlets contributed almost half (45 per cent) of the total number of retail food outlets available.

Table 4.3 also shows the overall NFE (total number of retail food outlets and quantity of 'eat most' 'eat moderate' and 'eat least' types of food) of the study participants' neighbourhoods. On average, each child's neighbourhood had 1.11 (SD = 3.18, range = 0.00–31.00) retail food outlets. The mean quantity of 'eat most' type of food was 0.03 (SD = 0.09, range = 0.00–0.52). Similarly, the mean quantities of 'eat moderate' and 'eat least' types of food were 0.06 (SD = 0.11, range = 0.00–0.80) and 0.15 (SD = 0.28, range = 0.00–0.95) respectively. On average, 'eat least' type of food contributed 62 per cent of the overall quantity of food available. Conversely, the overall contribution of 'eat moderate' and 'eat most' types of food were only 25 and 13 per cent respectively (Table 4.3).

Table 4.3: Description of study participants' NFE (food outlet types, number and food types)

Variable	Number	Percent	Mean±SD
Baker	52	3.97	0.04±0.23
Butcher	42	3.21	0.04±0.20
Cafe	76	5.81	0.07±0.29
Cake and Pastries Shop	30	2.29	0.03±0.17
Convenience Store	68	5.19	0.06±0.33
Deli	48	3.67	0.04±0.20
Delicatessens	15	1.15	0.01±0.11
Ethnic Takeaway	159	12.15	0.14±0.52
Fast Food Outlet	91	6.95	0.08±0.49
Food Hall	1	0.08	0.001±0.03
Fruit and Vegetable Store	15	1.15	0.01±0.11
Full Service Restaurant	141	10.77	0.12±0.56
General Takeaway	282	21.54	0.24±0.80
Health Food Store	35	2.67	0.03±0.19
Ice cream Shop	12	0.92	0.01±0.11
Pizza Shop	95	7.26	0.08±0.37
Sandwich Bar	46	3.51	0.04±0.26
Supermarket	96	7.33	0.08±0.43
Sushi Bar	5	0.38	0.004±0.07
Total	**1309**	**100.00**	**1.11±3.18**
NFE*			
Eat most		13.00	0.03±0.09
Eat moderate		25.00	0.06±0.11
Eat least		62.00	0.15±0.28

*NFE as neighbourhood food index (NFI)

SD = Standard deviation

4.4 Relationship between the Neighbourhood Food Environment and Neighbourhood Socioeconomic Status

4.4.1 Total Number of Retail Food Outlets and Neighbourhood Socioeconomic Status

The total number of retail food outlets available in the child's neighbourhood was positively correlated ($p = 0.0021$) with the neighbourhood SES, although the Pearson's Correlation Coefficient was not high ($r = 0.09$) (see Table 4.4). Results from the linear regression model also showed that the total number of retail food outlets available in the neighbourhoods positively correlated with the neighbourhood SES ($p = 0.0031$). Table 4.5 shows the highest number of retail food outlets were in high SES areas (mean = 1.52, SD = 3.24, range = 0.00–16.00) followed by medium SES areas (mean = 1.18, SD = 3.39, range = 0.00–31.00) and low SES areas (mean = 0.31, SD = 0.94, range = 0.00–6.00).

Table 4.4: Correlation between neighbourhood SES and retail food outlets (types and number) available in study participants' neighbourhoods

Food Outlet Type	r	p-value
Baker	0.06	0.0441
Butcher	0.05	0.0654
Cafe	0.02	0.4923
Cake and Pastries Shop	0.03	0.2960
Convenience Store	0.06	0.0501
Deli and Fine Food Store	0.10	0.0005
Delicatessens	0.04	0.1282
Ethnic Takeaway	0.04	0.1491
Fast Food Outlets	0.01	0.8065
Food Hall	0.02	0.4635
Fruit and Vegetable Store	0.08	0.0056
Full Service Restaurant	0.07	0.0156
General Takeaway	0.08	0.0086
Health Food Store	0.04	0.1713
Ice Cream Shop	-0.02	0.5944
Pizza Shop	0.12	<.0001
Sandwich Bar	0.00	0.9259
Supermarket	0.05	0.0665
Sushi Bar	0.01	0.7429
Total	**0.09**	**0.0021**

$p<0.05$

[r]Pearson's correlation coefficient

Pairwise comparisons of means further revealed that the mean number of retail food outlets in high SES areas significantly varied with the mean number of outlets available in low SES areas (mean difference = 1.22, 95% CI = 0.4766–1.9447, p = 0.0012). Similarly, the mean number of outlets available in medium SES areas also significantly varied from the mean number in low SES areas (mean difference = 0.87, 95% CI = 0.2955–1.4453, p = 0.0030). However, the mean number of outlets in high SES areas was not significantly different from medium SES areas (mean difference = 0.34; 95% CI = -0.2048–0.8853, p = 0.2209) (data not shown).

Table 4.5: Availability of retail food outlets (types and number) in low, medium and high SES neighbourhoods

	Neighbourhood SES			
	Low	Medium	High	
Food Outlet Type	Mean±SD	Mean±SD	Mean±SD	p-value
Baker	0.01±0.17	0.05±0.23	0.06±0.26	0.2312
Butcher	0.01±0.09	0.04±0.21	0.04±0.18	0.1763
Cafe	0.03±0.17	0.07±0.32	0.04±0.20	0.1422
Cake and Pastries Shop	0.02±0.15	0.02±0.14	0.06±0.32	0.0230
Convenience Store	0.00±0.00	0.06±0.34	0.09±0.41	0.0507
Deli and Fine Food Store	0.01±0.09	0.04±0.20	0.08±0.29	0.0154
Delicatessens	0.01±0.09	0.01±0.11	0.03±0.17	0.2119
Ethnic Takeaway	0.04±0.24	0.15±0.56	0.17±0.48	0.0771
Fast Food Outlet	0.00±0.00	0.09±0.54	0.06±0.45	0.1147
Food Hall	0.00±0.00	0.001±0.03	0.00±0.00	0.8541
Fruit and Vegetable Store	0.02±0.15	0.01±0.08	0.04±0.20	0.0014
Full Service Restaurant	0.00±0.00	0.13±0.59	0.18±0.61	0.0143
General Takeaway	0.12±0.46	0.24±0.82	0.35±0.88	0.0677
Health Food Store	0.00±0.00	0.03±0.21	0.04±0.18	0.1551
Ice Cream Shop	0.00±0.00	0.01±0.12	0.01±0.08	0.4308
Pizza Shop	0.01±0.09	0.09±0.38	0.12±0.48	0.0294
Sandwich Bar	0.00±0.00	0.05±0.28	0.04±0.22	0.1464
Supermarket	0.02±0.26	0.09±0.47	0.07±0.31	0.1761
Sushi bar	0.00±0.00	0.01±0.08	0.00±0.00	0.4530
Total	**0.31±0.94**	**1.18±3.39**	**1.52±3.24**	**0.0031**

$p<0.05$
SD = Standard deviation

4.4.2 'Eat Most' Type of Food and Neighbourhood Socioeconomic Status

The quantity of 'eat most' type of food available in the child's neighbourhood was significantly associated with neighbourhood SES ($p = 0.0099$) (see Table 4.6).

The highest quantity of 'eat most' type of food was available in high SES areas (mean = 0.05, SD = 0.10, range = 0.00–0.52) followed by medium SES areas (mean = 0.04, SD = 0.09, range = 0.00–0.52) (see Table 4.7). On average, the lowest quantity of 'eat most' type of food was associated with low SES areas (mean = 0.01, SD = 0.04, range = 0.00–0.21). Results from the linear regression models (pairwise comparison of means) further showed that the mean quantity of 'eat most' type of

food in low SES areas was significantly lower than the mean quantity of 'eat most' type of food in high SES areas (mean difference = 0.04, 95% CI = 0.0153–0.0559, p = 0.0006) and medium SES areas (mean difference = 0.03, CI = 0.0097–0.0415, p = 0.0016). However, there was no evidence that the quantity of 'eat most' type of food in medium SES areas differed significantly from high SES areas (mean difference = 0.01, 95% CI = -0.0050–0.0251, p = 0.1905) (data not shown).

4.4.3 'Eat Moderate' Type of Food and Neighbourhood Socioeconomic Status

The quantity of 'eat moderate' type of food was significantly associated with the neighbourhood SES (p = 0.0030) (see Table 4.6). Overall, the highest quantity of 'eat moderate' type of food was found in high SES areas (mean = 0.07, SD = 0.12, range = 0.00–0.50) followed by medium SES areas (mean = 0.06, SD = 0.11, range = 0.00–0.80), then low SES areas (mean = 0.03, SD = 0.09, range = 0.00–0.80) (Table 4.7). The availability of 'eat moderate' type of food in low SES areas was significantly lower than in high SES areas (mean difference = 0.04, 95% CI = 0.0157–0.0687, p = 0.0018) and medium SES areas (mean difference = 0.03; CI = 0.0087–0.0501, p = 0.0055). However, the difference in the mean quantity of 'eat moderate' type of food between high and medium SES areas was not significantly different (mean difference = 0.01, 95% CI = -0.0068–0.032, p = 0.2016) (data not shown).

4.4.4 'Eat Least' Type of Food and Neighbourhood Socioeconomic Status

The quantity of 'eat least' type of food associated moderately with the neighbourhood SES (p = 0.0106) (see Table 4.6). As shown in Table 4.7, the highest quantity of 'eat least' type of food was found in high SES areas (mean = 0.19, SD = 0.31, range = 0.00–0.90) followed by medium SES areas (mean = 0.15, SD = 0.29, range = 0.0 –0.95) and low SES areas (mean = 0.09, SD = 0.24, range = 0.00–0.93) respectively.

Table 4.6: Correlation between NFE and neighbourhood SES

NFE*	Mean±SD	%	r	p-value
Eat most	0.03±0.09	13	0.08	0.0099
Eat moderate	0.06±0.11	25	0.09	0.0030
Eat least	0.15±0.28	62	0.08	0.0106

$p<0.05$

[r]Pearson's correlation coefficient

SD = Standard deviation

NA = Not applicable

NFE* as neighbourhood food index (NFI)

Table 4.7: NFE associated with low, medium and high SES areas

	Neighbourhood SES			
	Low	Medium	High	
NFE*	Mean±SD	Mean±SD	Mean±SD	p-value
Eat most	0.01±0.04	0.04±0.09	0.05±0.10	0.0015
Eat moderate	0.03±0.09	0.06±0.11	0.07±0.12	0.0052
Eat least	0.09±0.24	0.15±0.29	0.19±0.31	0.0108

$p<0.05$

SD = Standard deviation

*NFE as neighbourhood food index (NFI)

Results from the linear regression models further confirmed that the mean quantity of 'eat least' type of food available in low SES areas was significantly lower than the mean quantity in high SES areas (mean difference = 0.10, 95% CI = 0.0337–0.1669, p = 0.0032) (data not shown).

Similarly, the availability of 'eat least' type of food in low SES areas was also significantly lower than in medium SES areas (mean difference = 0.07, CI = 0.0129–0.1170, p = 0.0144). However, the mean quantity of 'eat least' type of food available in medium SES areas was not significantly different from high SES areas (mean difference = 0.04, 95% CI = -0.0142–0.0847, p = 0.1617) (data not shown).

4.5 Influence of the Neighbourhood Food Environment and Neighbourhood Socioeconomic Status on the Prevalence of Overweight and Obesity

4.5.1 Neighbourhood Food Environments

4.5.1.1 Total Number of Retail Food Outlets

Overweight or obese children had fewer retail food outlets (mean = 0.95, SD = 2.81, range = 0–19) in their neighbourhoods than normal-BMI children (mean = 1.16, SD = 3.28, range = 0–31), although this difference did not reach statistical significance (see Table 4.8). Interestingly, overweight or obese children had significantly lower amounts of 'eat most' and 'eat moderate' types of food in their neighbourhoods compared with the normal BMI children (Table 4.8). They also had lower amount of 'eat least' type of food in their neighbourhoods but the mean difference did not quite reach statistical significance (p = 0.0575).

Table 4.8: NFE associated with overweight or obese and normal-BMI participants

	BMI		
	Normal BMI	Overweight or obese	
Variable	Mean±SD	Mean±SD	p-value
Total number of food outlet	1.16±3.28	0.95±2.81	0.3204
NFE*			
Eat most	0.04±0.09	0.02±0.07	0.0157
Eat moderate	0.06±0.12	0.04±0.09	0.0054
Eat least	0.16±0.29	0.12±0.27	0.0575

p<0.05
SD = Standard deviation
NFE* as neighbourhood food index (NFI)

Results from the logistic regression models (see Table 4.9) showed that the addition of one retail food outlet to the individual's neighbourhood was likely to reduce the risk of becoming overweight or obese by almost two per cent (OR = 0.98; 95% CI = 0.933–1.023), although the results did not reach a statistically significant level (p = 0.3226). However, as seen in Table 4.9, the effect of the total number of retail food

outlets on the prevalence of overweight or obesity among children was attenuated after adjusting for individual characteristics (age, gender, physical activity and food behaviours) and the SES of the child's neighbourhood (OR = 0.99, 95% CI = 0.937–1.037).

4.5.1.2 'Eat Most' Type of Food

The results from the unadjusted logistic regression model (Model 2) showed that the risk of becoming overweight or obese was significantly lower for children residing in neighbourhoods with a higher availability of 'eat most' type of food (OR = 0.10, 95% CI = 0.016–0.670, p = 0.0174) (see Table 4.9). It continued to influence negatively even after adjusting for the individual characteristics of the children (age, gender, physical activity and food behaviours) and the neighbourhood SES (OR = 0.06, 95% CI = 0.007–0.531, p = 0.0115). However, the fully adjusted model (Model 10) did not show significant association between the availability of 'eat most' type of food and prevalence of overweight or obesity among children (p = 0.4126). However, it continued to remain negatively associated with the prevalence of overweight or obesity (OR = 0.22, 95% CI = 0.005–8.472) (see Table 4.9).

4.5.1.3 'Eat Moderate' Type of Food

The results from the unadjusted logistic regression model (Model 3) showed that the risk of becoming overweight or obese was significantly lower for children residing in neighbourhoods with a higher availability of 'eat moderate' type of food (OR = 0.15, 95% CI = 0.037–0.576, p = 0.0059) (see Table 4.9). Similarly, the results from the partially adjusted logistic regression model (Model 8) showed that the availability of 'eat moderate' type of food was negatively associated with the risk of children becoming overweight or obese after adjusting for individual characteristics along with the neighbourhood SES (OR = 0.12, 95% CI = 0.026–0.593, p = 0.0089). However, the availability of 'eat moderate' type of food in the neighbourhood was not significantly associated with the prevalence of overweight or obesity after adjusting for other types of food available in the same neighbourhood (i.e. 'eat most' and 'eat least') along with individual characteristics of the children and the neighbourhood SES (OR = 0.30, CI = 0.011–8.104, p = 0.4733).

4.5.1.4 'Eat Least' Type of Food

Further, the amount of 'eat least' type of food available in the children's neighbourhoods was negatively associated with the prevalence of overweight or obesity (OR = 0.62, 95% CI = 0.373–1.017), although it did not reach statistical significance in the unadjusted (p = 0.0584) or adjusted models (p = 0.9666) (see Table 4.9). Although it remained non-significant, the association between the availability of 'eat least' type of food and the prevalence of overweight or obesity changed direction (i.e. became slightly positive) after adjusting for other neighbourhood characteristics (such as availability of 'eat most' and 'eat moderate' types of food, and the neighbourhood SES) and individual-level variables (age, gender, food and physical activity) (OR = 1.02, 95% CI = 0.462–2.238).

Table 4.9: Odds ratios from logistic regression models associating environmental variables on the prevalence of overweight or obesity among primary school children in the Perth metropolitan area

	Unadjusted										Partially adjusted								Fully adjusted	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Neighbourhood Food Environment																				
Total number of food outlets	0.98	0.933 – 1.023									0.99	0.937 – 1.037								
Eat Most			0.10*	0.016 – 0.670									0.06*	0.007 – 0.531					0.22	0.005 – 8.472
Eat Moderate					0.15*	0.037 – 0.576									0.12*	0.026 – 0.593			0.30	0.011 – 8.104
Eat Least							0.62	0.373 – 1.017									0.60	0.339 – 1.066	1.02	0.462 – 2.238
Neighbourhood SES																				
High									1.00		1.00		1.00		1.00		1.00		1.00	
Medium									1.28	0.835 – 1.946	1.35	0.843 – 2.146	1.31	0.819 – 2.098	1.31	0.820 – 2.100	1.32	0.825 – 2.109	1.31	0.818 – 2.097
Low									1.43	0.826 – 2.471	1.33	0.705 – 2.523	1.15	0.597 – 2.198	1.14	0.594 – 2.190	1.18	0.612 – 2.253	1.12	0.585 – 2.156
Demography																				
Age																				
Older (> 11 yrs)											1.00		1.00		1.00		1.00		1.00	
Younger (≤ 11 yrs)											1.31	0.874 – 1.974	1.26	0.840 – 1.902	1.27	0.846 – 1.917	1.29	0.857 – 1.937	1.26	0.836 – 1.894
Gender																				
Boy											1.00		1.00		1.00		1.00		1.00	
Girl											1.12	0.815 – 1.535	1.12	0.811 – 1.535	1.11	0.803 – 1.521	1.12	0.812 – 1.536	1.11	0.806 – 1.531
Physical Activity																				
Recommendation/higher level											1.00		1.00		1.00		1.00		1.00	
Below recommendation level											1.10	0.768 – 1.562	1.11	0.775 – 1.592	1.11	0.772 – 1.586	1.12	0.784 – 1.610	1.11	0.774 – 1.593
Food Behaviour																				
Breakfast																				
Regular											1.00		1.00		1.00		1.00		1.00	
Occasional											1.26	0.876 – 1.810	1.25	0.869 – 1.802	1.25	0.870 – 1.804	1.26	0.872 – 1.806	1.24	0.858 – 1.780
Fruit																				
High											1.00		1.00		1.00		1.00		1.00	
Low											1.11	0.765 – 1.598	1.11	0.766 – 1.604	1.11	0.764 – 1.600	1.10	0.760 – 1.591	1.10	0.759 – 1.589
Fast food																				
No											1.00		1.00		1.00		1.00		1.00	
Yes											1.35	0.947 – 1.919	1.42	0.995 – 2.034	1.41	0.984 – 2.012	1.39	0.971 – 1.984	1.41	0.983 – 2.014

Partially adjusted odds raios (adjusted for age, gender, physical activity, food behaviours and neighbourhood SES)

Fully adjusted odds ratios (adjusted for age, gender, physical activity, food behaviours, NFE and neighbourhood SES)

*Significant at < 0.05

4.6 Influence of Socioeconomic Status on the Prevalence of Overweight or Obesity

On average, children residing in medium SES areas had the highest BMI (mean = 18.97, SD = 2.96, range = 12.39–33.26) compared with children from low SES areas (mean = 18.72, SD = 2.75, range = 13.94–26.08) and high SES areas (mean = 18.52, SD = 2.87, range = 13.36–27.30) (see Table 4.2). However, the prevalence of overweight or obesity was higher among those residing in low SES area (26 per cent) compared with medium (24 per cent) and high SES areas (20 per cent) (see Table 4.2).

Prior to adjustment, compared with children from high SES areas, those from the low SES areas were 43 per cent more likely to become overweight or obese (95% CI = 0.826–2.471), whereas children from medium SES areas had 28 per cent higher risk of becoming overweight or obese (95% CI = 0.835–1.946) (see Table 4.9). However, the association between neighbourhood SES and the odds of children being overweight or obese showed no clear pattern after adjusting for individual characteristics (such as age, gender, eating behaviours and physical activity) and the NFE (‘eat most’, ‘eat moderate’ and ‘eat least’ types of food). Nor were clear patterns observed between the neighbourhood SES and the odds of children being overweight or obese when we adjusted for the total number of retail food outlets (Model 6) and the amount of ‘eat most’ (Model 7), ‘eat moderate’ (Model 8) and ‘eat least’ (Model 9) types of food (Table 4.9).

4.7 Summary

There were 6,238 retail food outlets distributed across the Perth metropolitan area. These were dominated by ‘general takeaway’, ‘full-service restaurants’ and ‘ethnic takeaway’ retail food outlets. The children’s neighbourhoods (i.e., from the TREK project) were also dominated by the similar types of retail food outlets as the general Perth metropolitan area.

On average, ‘eat least’ type of food contributed 63 per cent of the overall food available in the metropolitan Perth area, while ‘eat moderate’ and ‘eat most’ contributed approximately 21 per cent and 16 per cent respectively. Similarly, among the TREK study (children’s) neighbourhoods, ‘eat least’ contributed the highest proportion (62 per cent) of the overall amount of food available, followed by ‘eat moderate’ (25 per cent) and ‘eat most’ (13 per cent).

The ‘eat most’ and ‘eat moderate’ types of food were strongly correlated with neighbourhood SES. However, the availability of ‘eat least’ type of food in the neighbourhood was only moderately associated with the neighbourhood SES. While the availability of ‘eat most’ and ‘eat moderate’ types of food were significantly associated with prevalence of overweight or obesity in children, the presence of ‘eat least’ type of food in the neighbourhood was not significantly associated with the prevalence of overweight or obesity in children.

Furthermore, the study also demonstrated a social gradient in overweight or obesity suggesting children from the low SES areas had higher risk of becoming overweight or obese although the differences did not reach statistically significant level.

Chapter 5: Discussion

5.1 Overview

This chapter discusses the findings of the research. First, the key findings are summarised and then examined in relation to the available literature. Next, the strengths and limitations of the study are discussed and the conclusion of the research is presented.

5.2 Overview of Research Findings

This study included 6,238 retail food outlets distributed across the Perth metropolitan area. These outlets were grouped into 21 different types. Overall, the area was dominated by 'general takeaway', 'full-service restaurants' and 'ethnic takeaway' types of retail food outlets. Furthermore, study participants' neighbourhoods were also dominated by similar types of outlets.

Overall, the Perth metropolitan area was dominated by 'eat least' type of food (63 per cent) followed by 'eat moderate' (21 per cent) and 'eat most' (16 per cent) types. Study participants' neighbourhoods were also dominated by 'eat least' type of food (62 per cent) followed by 'eat moderate' (25 per cent) and 'eat most' (13 per cent) types of food.

The availability of 'eat most' and 'eat moderate' types of food were significantly associated with the SES of the corresponding neighbourhood. However, availability of 'eat least' type of food in the neighbourhood was only moderately associated with the neighbourhood SES. Furthermore, amounts of 'eat most' and 'eat moderate' types of food in the neighbourhood showed significant inverse association with the prevalence of overweight or obesity in children, whereas 'eat least' type of food was not significantly associated with the prevalence of overweight or obesity among children. Furthermore, the study also demonstrated a social gradient in overweight or obesity among children in Perth.

5.3 Socioeconomic Status and Neighbourhood Food Environment

We found the highest number of retail food outlets in high SES areas followed by medium SES areas. The lowest number of retail food outlets was associated with low SES areas. Similar patterns were observed when we examined the associations between amount of each type of food (particularly 'eat most' and 'eat moderate') and neighbourhood SES. This possibly suggests that the NFE (amount of each type of food available within the individual study participant's neighbourhood) is a reflection of the total number of outlets available in the given neighbourhood. However, there is no direct evidence to support this argument.

In general, we found a direct association between neighbourhood SES and the NFE. However, contrary to our hypothesis, the availability of 'eat least' type of food was not associated strongly with the neighbourhood SES. This confirms the previous findings (Ball et al., 2009; Bodor et al., 2010b; Franco et al., 2009; Franco et al., 2008). This is also consistent with other (store-based) studies (Baker et al., 2006; Timperio et al., 2009). However, this finding contradicts previous studies in Australia (Reidpath et al., 2002; Turrell and Giskes, 2008) and elsewhere (Block et al., 2004; Cummins et al., 2005b; Hemphill et al., 2008; Larson et al., 2009; Macdonald et al., 2007; Smoyer-Tomic et al., 2008), as they suggested higher availability of 'eat least' type of food in low SES areas. Others have indicated higher amounts of 'eat least' type of food in middle SES areas (Wang et al., 2007; Winkler et al., 2006). However, it is not possible to compare results directly.

5.3.1 Methodology

First plausible explanation for this inconsistency in results could be differences in the methodology used to estimate the NFE. Most studies estimated the NFE only by considering a particular type of retail food outlet as a proxy for a given type of food. For example, the supermarket as a proxy for the healthy food (i.e. 'eat most') and fast-food outlet as a proxy for the unhealthy food (i.e. 'eat least'). The underlying hypothesis behind these store based studies is that retail food outlets, such as supermarkets, sell healthy food, whereas convenience stores or fast-food outlets sell

unhealthy food although, in reality, retail food outlets in general sell all the possible types of food (i.e., healthy or unhealthy).

Hence, in this study we estimated the NFE by combining all possible types of retail food outlets and all possible types of food that might be available in each type of outlet. This is important because, theoretically, a given neighbourhood can have not only any number (0 to n) but also any types (0 to n) of retail food outlets. Further, a given type of retail food outlets can stock any type of food or food products belonging to 'eat most', 'eat moderate' or 'eat least', although the quantity of an individual type of food may vary from one type of store to another. For example, a supermarket can stock a large volume of healthy food, whereas convenience stores may stock only a limited quantity of healthy food (Block and Kouba, 2006; Farley et al., 2009; Franco et al., 2008). Furthermore, supermarkets may provide a wide range of options in terms of fresh produce (Farley et al., 2009; Latham and Moffat, 2007; Liese et al., 2007; Morland and Filomena, 2007; Skidmore et al., 2010), whereas convenience stores may provide only limited options (Bodor et al., 2010b; Farley et al., 2009; Liese et al., 2007; Morland and Filomena, 2007). However, convenience stores can often act as alternative sources for the healthy food, particularly in areas where supermarkets are absent (Bowyer et al., 2009; Short et al., 2007).

Neighbourhoods in Perth metropolitan region were dominated by 'eat least' type of food, irrespective of the neighbourhood SES. The primary reason for the higher availability of 'eat least' type of food in the study area could be due to widespread availability of 'ethnic takeaway', 'fast food outlet', 'café' and 'convenience store' since these retail food outlets primarily stock 'eat least' type of food. Further, 'eat least' type of food (such as salty snacks, cookies, crackers, pastries, candies, or carbonated beverages) can also be purchased from other types of retail outlets, including supermarkets, full-service restaurants and bakeries which further suggests the widespread availability of 'eat least' type of food in the study area.

Furthermore, we found direct correlation between the total number of retail food outlets and neighbourhood SES consistent with previous studies (Alwitt and Donley, 1997; Larson et al., 2009; Moore et al., 2006; Morland et al., 2002a). However, our findings on the association between neighbourhood SES and the total number of

retail food outlets contradicts an earlier study in Glasgow city, which indicated the highest number of outlets (comprising bakery, butcher, fish market, fruit and vegetable store, supermarket, convenience store and delicatessen) in the economically most disadvantaged neighbourhoods (Macdonald et al., 2009). This possibly suggests that the NFE is a contextual issue (Ball et al., 2009; Cummins and Macintyre, 2006). Hence, it can vary spatially and temporarily depending on the number of variables associated with the particular neighbourhood, such as existing business climate (physical infrastructures: road access, parking access, policy of the government such as zoning restriction) and demand for a particular type of food in the neighbourhood.

Although we found low SES areas with fewer outlets than high SES areas, the overall number of outlets in high SES neighbourhoods did not vary significantly (mean difference) with medium SES neighbourhoods. We observed similar patterns with the availability of 'eat most', 'eat moderate' and 'eat least' types of food. This could be possibly because the medium and high SES areas in Perth metropolitan region might have similar attributes in terms of 'business climate', socio-demographic composition, population densities, government land use regulations and land prices.

5.3.2 Neighbourhood Type/Size

Part of the inconsistency may be related to variations in definitions or geographical scales of the neighbourhood. We used a 300m circular buffer zone around children's homes. A similar buffer size was used previously to examine the exposure to fast food for different population groups (Kwate et al., 2009), however, others have used administrative zones (for example, Census Collector's District, Census Tract, Zip code area, Postal district, etc.) to define the NFE. Please refer Table 2.1 for the possible types of neighbourhood and their scales. Unfortunately, no specific information is available in the literature to date regarding the definition of the neighbourhood or spatial scale.

5.4 Neighbourhood Food Environment and the Prevalence of Overweight and Obesity

We found no association between the total number of retail food outlets and prevalence of overweight or obesity in children in Perth metropolitan region. This contradicts with the previous study (Seliske et al., 2009a) .

However, availability of 'eat most' type of food in the neighbourhood showed inverse association with the prevalence of overweight or obesity in children, as expected. This is indirectly supported by several studies (Jago et al., 2007; Morland et al., 2006; Powell et al., 2007; Zenk et al., 2009a; Zenk et al., 2005a). The argument behind the inverse association is that a higher availability (therefore higher access to) of 'eat most' type of food within the local community may encourage residents to consume 'eat most' type of food more frequently, thereby helpful in maintaining a better weight status. However, this may not always be the case (Casagrande et al., 2011).

The results also indicated higher availability of 'eat least' type of food in the neighbourhood (irrespective of the neighbourhood SES) compared with other types of food, as suggested previously (Bodor et al., 2010a; Bodor et al., 2010b; Rundle et al., 2009). The higher availability of 'eat least' type of food in the neighbourhood could be due to dominance of retail food outlets like 'general takeaway', 'ethnic takeaway', 'fast-food outlet', 'café' and 'convenience store', in the study area. However, we found no association between 'eat least' type of food and the prevalence of overweight or obesity. This agrees with previous studies to an extent (Burdette and Whitaker, 2004; Crawford et al., 2008; Sturm and Datar, 2005; Truong et al., 2010). This lack of association between availability of 'eat least' type of food in the neighbourhoods and prevalence of overweight or obesity in children may possibly reflect the ubiquity of unhealthy or 'eat least' type of food across the whole study area.

We found no difference in the availability of 'eat least' type of food for the normal-BMI and overweight or obese children, further suggesting the widespread availability of 'eat least' type of food across the whole study area. Moreover, unlike

‘eat most’ and ‘eat moderate’ types of food, ‘eat least’ type of food was available almost everywhere and in a range of food outlets, including supermarkets, full-service restaurants, vending machines, petrol (service) stations, fast-food outlets, pizza shops, ice-cream shops and lolly shops. This can further increase the chances of widespread availability of ‘eat least’ type of food across the whole study area.

There may be many factors responsible for the widespread availability of ‘eat least’ type of food in the neighbourhood. One hypothesis could be the response of food industries to meeting demand for ‘eat least’ type of food in the society. However, we may be able to explain this by considering other factors such as the socio-demographic composition of the neighbourhood (Truong et al., 2010), government policy, land-use pattern or the overall business climate as discuss previously.

5.4.1 Other reasons

Relationships between the availability of food in the neighbourhood and the prevalence of overweight or obesity among our study participants might have been mediated through food behaviours of individual children. It is also possible that exposure to a particular type of food in the neighbourhood may not relate to its increased consumption among children, since children’s food habits can be influenced by other factors such as parents, friends or home food environment (Arcan et al., 2007; Hesketh et al., 2005; McGee et al., 2008; Patrick and Nicklas, 2005). Parents decide what children eat and thus, can influence whether or not they become overweight or obese (Birch and Davison, 2001; Birch and Fisher, 1998; Carper et al., 2000). This might be one reason why more children, particularly the ‘younger group’ in our study, ate the recommended daily serves of fruit (i.e., higher) than their ‘older group’ counterparts.

Furthermore, other issues, such as the price and range of choices available in the neighbourhood, may well be more important than the simple measures of the availability of a particular type of food in the neighbourhood (although the price of food may not directly affect children). However, price can indirectly affect children’s food choices through their parents or home food environment.

It may also be possible that the 300m buffer zone around the child's home address was not suitable measure of the NFE to examine its effect on food behaviours and therefore the BMI of children, because many participants may not have any food outlet within this buffer zone and/or children travel further to access food. In fact, almost three-quarters of the study participants had no retail food outlet in their neighbourhoods. However, there was very little in the literature to guide decision-making regarding the size of the buffer, although it has been the subject of interest in physical activity research because it may produce contradictory results (Giles-Corti et al., 2005).

We chose a 300m buffer for this study considering the age of our study participants and the possible effect of distance to destination for the independent mobility of primary school children, particularly in relation to food. Moreover, results from the preliminary analysis of data suggested that the NFE within the smaller sized buffer (400m) showed more influence than the NFE of a bigger sized buffers (800m and 1200m) although many children may visit up to 800m from their home (Timperio et al., 2004). However, it may vary with age and gender of children therefore the perception (or definition) of neighbourhood (or boundary) (Evenson et al., 2006) and their activities (Timperio et al., 2006) or degree of familiarity with the different attributes of the neighbourhood such as NFE. Furthermore, the measurement of children's exposure to the NFE based on the buffer zone around home may not be appropriate, since retail food outlets, particularly fast-food outlets, can cluster around schools (Austin et al., 2005; Kwate and Loh, 2010; Simon et al., 2008; Sturm and Sturm, 2008; Zenk et al., 2008) or along roads.

We found majority children (70 per cent) in this study ate fast food. Popularity of fast food among children was also demonstrated earlier in Melbourne (Timperio et al., 2009). One possible hypothesis for the widespread consumption of 'eat least' type of food among children in this study is perhaps due to time constraints with parents as a result of longer work hours particularly mothers in the workforce. This can force many dual-earner households to depend on 'eat least' type of food, such as convenience food (Turrell and Giskes, 2008), because it saves time and effort in food activities (meal preparation, cooking, consumption and post-meal activities) (Buckley et al., 2007). Furthermore, the participation of females in the workforce has

been increasing over time (Evans and Kelley, 2008; Mabry et al., 2010), in addition to longer working hours, which not only increases the demand for convenience food (Buckley et al., 2007; Wycherley et al., 2008), but also widespread consumption. In addition, 'eat least' type of food (fast food and convenience foods) may also be available in schools, hospitals and recreational venues such as cinemas and sports centres, including swimming pools and playgrounds. Further, home delivery service (online/telephone ordering systems) or convenience of buying 'eat least' type of food such as takeaway and pizza on the way home might have also made the availability of 'eat least' type of food in the neighbourhood less relevant with the prevalence of overweight or obesity in children. The null findings may also be due to the underestimation of 'eat least' type of food (or under counting/over counting retail food outlets that sell 'eat least' type of food). This can also be due to error in estimating the overall NFE since similar type of retail food stores can stock different amounts of a particular type of food depending upon the local context (Cummins et al., 2010) or demand within the catchment area.

It is also possible that the influence of the NFE on the prevalence of overweight or obesity in children was confounded by the availability of other types of food in the same neighbourhood, thereby reducing the BMI and, therefore, the risk of becoming overweight or obese (Zick et al., 2009). It is also possible that neighbourhoods with a higher amount of 'eat least' type of food have a higher availability of 'eat most' and 'eat moderate' types of food, hence diluting the influence of 'eat least' type of food as suggested earlier (Crawford et al., 2008). The children's BMI might also be indirectly influenced by other attributes of the neighbourhood, thereby changing behaviours such as physical activity, because the characteristics of the neighbourhood, such as residential density, street connectivity and a variety of walking destinations including retail food outlets in the neighbourhood, can positively influence physical activity, particularly walking (Owen et al., 2004). For example, the higher availability of retail food outlets (including fast-food outlets) can encourage people to walk (Rundle et al., 2009), although it may increase the individual's exposure to NFE and, presumably, increase the intake of fast food or 'eat least' type of food. However, it can result in no significant change in weight gain among those in a neighbourhood with a higher availability of fast-food outlets or 'eat

least' type of food. This could be because walking possibly reduces the accumulation of energy in the body and therefore the risk of becoming overweight or obese.

It is also likely that the relationship between the NFE and prevalence of overweight or obesity in children may be confounded by individual-level variables such as age, sex, knowledge, taste preference and physical activity, in addition to the SES of parents, such as income or education (O'Dea and Wilson, 2006; Wrigley et al., 2002). It is also possible that girls may less likely to eat breakfast regularly than boys (Meland et al., 2007). This is probably because the girls are more concerned about their body image (Knauss et al., 2008; McCabe and Ricciardelli, 2004; Meland et al., 2007). Hence, the girls are less likely to eat fast food than boys. However, they are more likely to eat fruit than boys.

Similarly, younger children are more likely to eat higher fruit and breakfast than older children. This could be one possible influence of their parents as family members (Benton, 2004) particularly parents can create environments for children that may foster the development of healthy or unhealthy eating behaviours (Scaglioni et al., 2008). Family food habits, such as eating meals together (McGee et al., 2008), can change the food choice behaviours of children and adolescents (Patrick and Nicklas, 2005), such as encouraging them to eat more fruit (Befort et al., 2006; Larson et al., 2007) and vegetables (Ball and Crawford, 2006; Larson et al., 2007). This has also been shown with a longitudinal study (Arcan et al., 2007). However, parents' influence on food habits may also differ according to the child's gender. For example, girls are more likely to follow their mothers and boys are more likely to follow their fathers (Loureiro et al., 2010).

However, when the analyses were repeated, adjusting for individual factors (age, sex, food behaviours and physical activity) and neighbourhood characteristics (such as SES), the overall pattern of findings remained largely unchanged. Further findings revealed that the influence of the NFE on the prevalence of overweight or obesity among the study participants attenuated and became non-significant after adjusting for other types of food available in the same neighbourhood. However, the amounts of 'eat most' and 'eat moderate' types of food available in the neighbourhood continued to affect negatively with the prevalence of overweight or obesity. In

addition, the influence of ‘eat least’ type of food changed its direction (showed a slight positive association with the prevalence of overweight or obesity). This is possibly due to the confounding effect of the availability of other types of food within the given neighbourhood.

In summary, individuals learn and understand many things from their immediate surroundings (Bandura, 2001a; Bandura, 2001b), including food and physical activity. However, long-term influences of a particular lifestyle (food and physical activity) of the individual can affect his or her health status, such as BMI (i.e. phenotype, expression of genes in a given environment). For example, some children may eat fast food more frequently because it is readily available at home and in their neighbourhoods. However, at the same time, they may engage in more physical activity, since past evidence suggests that people residing in neighbourhoods with a higher availability of retail shops (including fast-food outlets) are more likely to walk to the food outlets (Rundle et al., 2009). This can be helpful in spending the energy gained through the consumption of food (Pettinger et al., 2008), including energy-dense food. Moreover, this in turn helps to maintain the body weight, thereby reducing the risk of becoming overweight or obese among those who consume fast food but are also physically active. However, others may eat more fruit, vegetables and breakfast but do not engage in physical activity (such as walking or cycling), because their neighbourhoods may not have retail food outlets or there may be physical barriers such as a lack of footpaths or playgrounds, or security concerns such as stranger danger and traffic. Whatever the reasons, the lack of physical activity can reduce energy expenditure, thereby increasing the risk of becoming overweight or obese.

5.5 Neighbourhood Socioeconomic Status and the Prevalence of Overweight or Obesity

Our data showed an inverse association between neighbourhood SES and the prevalence of overweight or obesity in children. For example, compared with children in high SES areas, the children in low SES areas were 43 per cent more likely to become overweight or obese whereas children in medium SES areas were 28 per cent more likely to become overweight or obese.

Our findings on the prevalence of overweight or obesity in low SES areas are consistent with previous studies that demonstrated a higher prevalence of overweight or obesity among children from socio-economically disadvantaged groups (Fraser and Edwards, 2010; Grafova, 2008; Khanam et al., 2009; O'Dea, 2008; O'Dea and Dibley, 2010; O'Dea and Wilson, 2006). Similar association between the neighbourhood SES and the prevalence of overweight or obesity have been reported by other researchers among different groups of populations (Booth et al., 2005a; Drewnowski, 2007; Drewnowski and Drewnowski, 2004; Ford and Dzewaltowski, 2008; Procter et al., 2008). King and colleagues also demonstrated area-level disadvantage as an important predictor of BMI among adults (King et al., 2006).

There are a number of explanations for the inverse association between the prevalence of overweight or obesity in low SES areas among our study participants.

5.5.1 Disparity in Availability of Food in the Neighbourhood

One theory is that low SES (low income, less educated) individuals are more likely to live in low SES neighbourhoods (Dubois and Girard, 2001) characterised by the lower availability of healthy food (Franco et al., 2009; Franco et al., 2008) or 'eat most' type of food. Our data showed that the availability of 'eat most' type of food was significantly lower in low SES areas. This is consistent with several studies (Cummins et al., 2010; Franco et al., 2009; Franco et al., 2008; Larson et al., 2009). The lower availability of 'eat most' type of food in low SES neighbourhoods might make it difficult to access the healthy or 'eat most' type of food (Larson et al., 2009), such as fruit and vegetables, for many local residents, which might have discouraged them from consumption. This in turn might contribute to the increased body weight or BMI. Furthermore, the data used in this study showed a lower availability of 'eat most' type of food in the neighbourhoods that were associated with overweight or obese children. Furthermore, our data demonstrated higher BMI among those children who did not consume 'eat most' type of food (e.g., fruit) as per recommendations.

That is, the higher prevalence of overweight or obesity in low SES neighbourhoods is explained partially by the 'food desert' concept, which describes areas where

residents have poor access to affordable and healthy food (Beaulac et al., 2009; Wrigley, 2002) which is believed to be associated with the lack of particular type of retail food outlets such as supermarkets and green grocers which are likely to stock 'eat most' type of food (healthy food). The lack of these outlets, may force many local residents to purchase their food from alternative sources, such as small grocery stores or convenience stores, which are common in poor neighbourhoods. These small retail food outlets may only stock a limited amount of healthy food such as fruit and vegetables (Cummins et al., 2010). This may consequently reduce the options to choose healthy food although, this may not be solely due to the disparity in the availability of supermarkets and green grocers rather, the total number of retail food outlets, as suggested by our data.

5.5.2 Disposable Income/Higher Price of Healthy Food

The intake of 'eat least' type of food is more likely to be spontaneous or unplanned, whereas the intake of 'eat most' and 'eat moderate' types of food will be planned, as they often require preparation or cooking. Hence, the intake of 'eat most' and 'eat moderate' types of food among the study participants (children in general) is more likely to be mediated by the home food environment (Utter et al., 2008).

However, the home food environment, or parents' food habits, may depend on parents' SES; for example, household income (Giskes et al., 2006; Turrell et al., 2004), education (Wrigley et al., 2002), type of profession (Hunter and Worsley, 2009), knowledge of food (Brown and Landry-Meyer, 2007), skills and time available for shopping, preparation (Eikenberry and Smith, 2004; Inglis et al., 2005) and cooking (Devine, 2005; Inglis et al., 2005). A person's level of education, for instance, can help in understanding the importance of healthy food (Wrigley et al., 2002). Hence, people with higher education may find value in healthy food and are willing to pay the extra cost. However, nutrition may not drive most food choices, especially among low SES groups.

It is believed that healthy food in general costs more (Darmon et al., 2002; Drewnowski and Darmon, 2005a; Drewnowski and Specter, 2004; Ford and Dzewaltowski, 2008; Giskes et al., 2007b; Waterlander et al., 2010). It can create a

barrier for many low-income (low SES) people from buying (Eikenberry and Smith, 2004; Inglis et al., 2005; Turrell et al., 2003; Turrell et al., 2002) or eating healthy food (Inglis et al., 2005). For example, studies in Australia suggested that low-income people like to purchase healthy food (Inglis et al., 2009; Turrell et al., 2004), however, they do not choose healthy type of food, primarily because of higher prices (Inglis et al., 2009; Kettings et al., 2009). It would cost low-income families almost 40 per cent of their disposable income if they ate food according to the HEP guidelines (Kettings et al., 2009).

Economic constraints (low income combined with the high price of healthy food) can play a major role in not eating healthy food. That is, a limited amount of disposable income can force low-income groups to restrict their food choices within the unhealthy type of food group (Dibsdall et al., 2003; Giskes et al., 2006), such as fast food (Darmon et al., 2003; French et al., 2001), biscuits, sweets and soft drinks (Roux et al., 2000), thereby resulting in a narrower (less diverse) food band. High SES groups on the other hand, may not have economic (financial) constraints. The high SES groups may also have enough time require for shopping and preparing meals (Inglis et al., 2005). Hence, the high SES groups of people can have a wider (i.e., more diverse) range of food choices. For instance, the high SES groups can consume healthy or 'eat most' type of food (Drewnowski and Specter, 2004; Dubowitz et al., 2008; Inglis et al., 2009; James et al., 1997) as well as 'eat least' or unhealthy type of food. In other words, the food habits of high SES groups are likely to be more diverse than low SES groups (Arimond and Ruel, 2004; Thiele and Weiss, 2003) thus the high SES groups are more likely to get all the essential nutrients since the food habits comprising of diverse range of food may provide more nutrients including protein, carbohydrate, fiber, calcium, iron, vitamin A, vitamin C, folate, phosphorous, magnesium, zinc, and iodine, and a higher poly unsaturated (Golley et al., 2011). Conversely, it may associate with lower intake of fat, sugars, and sodium (Golley et al., 2011) which in turn may reduce the risk of being overweight or obese among the high SES people.

Furthermore, 'eat most' type of food, such as fruit and vegetable, are perishable in nature and bulky in volume. With food where spoilage and volume are issues, large storage spaces (fridges) are required. Unfortunately, many poor families may not be

able to afford a fridge or may not have enough space in the fridge (Wiig and Smith, 2009). Limited food storage space or lack of a storage facility can force many low SES people to purchase only a limited amount of healthy food (Wiig and Smith, 2009). This not only increases the frequency of shopping but also the cost of food indirectly (for example, travel-related costs and time). Furthermore, smaller-sized packaged food may cost more, whereas buying in bulk can reduce the unit price (economy of scale). The increased cost of healthy food due to insufficient storage space can subsequently reduce the consumption of healthy food among low SES families. In addition, limited storage space can also encourage poor families to buy non-perishable food items more often, including snacks and chips, thereby increasing the consumption of 'eat least' type of food (Wiig and Smith, 2009).

5.5.3 Physical Activity is Expensive in Low SES Areas

It is believed that residents from low SES areas generally engage in low levels of physical activity (Leslie et al., 2010). This can lead to accumulation of extra energy in the body, thereby increasing the risk of becoming overweight or obese. There are various reasons for lower levels of physical activity among residents in low SES areas. One reason is associated with the characteristics of low SES areas, such as traffic density, social crime, stranger danger and neighbourhood design, which can influence activities such as walking, cycling or playing outside the home. Unsafe, busy streets and the absence of cycle paths make children reluctant to walk or ride to school. Conversely, in safer neighbourhoods with availability of sidewalks, many people including children may engage in physical activities such as walking or riding bi-cycle (Villanueva et al., 2012).

Another reason for the lower levels of physical activity in low SES areas is the lower number of retail food outlets in the neighbourhood. The results showed that low SES neighbourhoods were associated with a lower number of outlets. The results of this study further highlighted that normal weight (BMI) children had a higher number of outlets in their neighbourhoods compared with overweight or obese children. It also showed a positive association between number of daily steps taken by individual children and number of retail food outlets in the neighbourhood. This is consistent with previous evidence which suggested that people residing in neighbourhoods with

a higher number of retail food outlets are likely to walk more than their counterparts from neighbourhoods with fewer outlets (Cerin et al., 2011; Rundle et al., 2009). This is probably because food outlets add some vibrancy in the local community thereby encouraged children (and adults) to engage in walking or cycling. Hence, it is highly likely that participants from low SES areas walk less than those from high SES areas, thereby spending less energy (or accumulating more energy), leading to a higher prevalence of overweight or obesity among low SES groups.

People may use facilities (destinations) if available. This has been shown with bike and walking paths, trails and with facilities in schools. However, barriers to use must also be considered. Many parents residing in low SES areas may believe that their neighbourhoods are not suitable for children to play especially outside the home. For instance, children may like to ride or walk to school, but if parents have safety concerns (e.g., crime, stranger danger or traffic density), then participation will be hampered. Further, many parents may believe that their children are already doing enough sports during school time; hence, they do not want their children to roam outside. This may create an atmosphere where children engage in sedentary activities such as watching television and playing computer games, which may in turn lead to an accumulation of energy in the body, thereby increasing the risk of becoming overweight or obese.

However, our data did not show a clear association between the neighbourhood SES and average daily steps taken by children. However, in general, children in low SES areas took fewer steps than their counterparts in high SES areas. Further, there was no significant influence of the total number of steps on the BMI of children, although the BMI was slightly higher among children who took fewer steps. Hence, the higher prevalence of overweight or obesity among study participants from low SES areas is not solely due to physical activity; rather, it is possibly the combined effect of food and physical activity, which in turn is associated with neighbourhood characteristics, including NFE and neighbourhood SES.

In addition, we did not find a clear association between neighbourhood SES and the prevalence of overweight or obesity among study participants when we adjusted for individual level variables (such as age, gender, physical activity, food) along with the

neighbourhood level variable (i.e., NFE). For instance, we found that the odds of becoming overweight or obese increased among those residing in medium SES areas compared with those in high SES areas. However, the risk of becoming overweight or obese was lower among children residing in the low SES areas after adjusting for individual characteristics and the NFE. This suggests the involvement of other factors or complexity in the development of overweight or obesity in children.

5.6 Study Limitations

There are a number of limitations in this study. First, there may be a discrepancy in the food outlet datasets regarding currency; that is, some food outlets might have closed or moved elsewhere, or new outlets might have opened. Second, as SENSIS is designed for commercial purposes, it is highly unlikely that it represents the complete set of retail food outlets (Liese et al., 2010), as many businesses may not advertise in the SENSIS. Similarly, City Council food outlets databases may also have some limitations thus may not represent the actual food premises on the ground (Cummins et al., 2009a). Hence, for this study SENSIS and Department of Health databases were combined which might have certainly increased the accuracy (Liese et al., 2010). However, it may be still unable to represent the actual food premises on the ground (Cummins et al., 2009a) possibly due to classification bias in commercial business lists for the retail food outlets (Han et al., 2012).

Third, the proportion or weight values for ‘eat most’, ‘eat moderate’ and ‘eat least’ types of food for each type of retail food outlet was obtained from experts (Delphi technique). This might have created some bias (errors) in estimating the NFE. Hence, it requires validating by objectively measuring the availability of each type of food, such as total shelf space allocated for a specific type of food in each type of outlet, or opinions (interview) from the store manager. Furthermore, given the characteristic of the composite index, the NFE derived in this study may lead to misinterpretation of the results.

Similarly, this study did not examine the possible associations between the availability of retail food outlets against other neighbourhood attributes such as demography (lifestyles, income, education and ethnicity), population density and

physical infrastructure such as road types, parking facilities and policies of the local government authorities regarding retail food businesses in the neighbourhood.

Next, we considered that 300m buffer zone around home as an appropriate size for the child's neighbourhood. One possible limitation with smaller-sized neighbourhoods is that many of these neighbourhoods may not have any retail food outlet within their boundaries. Moreover, the individualised neighbourhood such as buffer zone around home may not align geographically with the existing administrative unit (Ball et al., 2006b). Hence, the retail food outlets located just outside the boundary of the individual neighborhood might not have captured. However, there is very little in the literature to guide our decision regarding the size of the neighbourhood.

Moreover, given the cross-sectional nature of the study, it is not possible to prove causality. Hence, while a child might live near by a fast-food outlet or in an area with a higher availability of 'eat least' type of food, it does not necessarily mean that the child eats fast food (i.e., 'eat least' type of food). This is simply because the children's food habits are influenced by a number of other variables, including individual characteristics, parents or home food environment, exposure to television advertisements, school canteens or vending machines. However, we did not conduct any analysis to confirm whether the association was mediated or moderated by food behaviours, home food environment or parent's food habits. Next, the effect of food and physical activity on body weight (hence, development of overweight or obesity) is a long-term consequence. Therefore, the duration of exposure in a particular environment is important. Unfortunately, length of exposure (length of stay in the current neighbourhood) was not included in this study. Furthermore, the effect of a particular type of food on the prevalence of overweight or obesity (particularly in a fully adjusted model) might be confounded by the possible co-linearity that exists in the NFE ('eat most', 'eat moderate' and 'eat least' types of food), although this might be reduced to some extent by the methods applied in calculating the NFE. In addition, our analyses did not adjust for clustering according to school attended or did not conduct spatial statistics to verify potential correlations between participants who share similar attributes of the neighbourhood such as design of the built environment.

5.7 Strengths of the Study

This project developed a comprehensive, yet simple and flexible method useful for assessing the NFE by taking into account all types of retail food outlets and the amount of each type of food available in each type of outlet. To the best of Author's knowledge, this has not been attempted previously. Hence, this research fills the gap that existed in the literature, particularly in measuring the NFE therefore to provide a complete picture of the NFE. This is an important first step in studying the influence of the NFE on health-related behaviours. Moreover, the approach used here is easily modifiable depending on the local context. For instance, it can easily accommodate an objectively measured value of different types of food available in each type of outlet, such as shelf space, or opinions from others, such as store managers or perceptions of consumers. Furthermore, this study combined government and commercial sources of food outlet databases, which might have increased the accuracy rate compared with many other studies, particularly those which used only one source.

Next, the BMI of the study participants was calculated by objectively measuring their height and weight. This might have increased the accuracy of the BMI, and therefore the prevalence of overweight or obesity among our study participants compared with previous studies.

5.8 Conclusion

Neighbourhood characteristics such as SES are associated with NFE. For instance, in this study the availability of 'eat most' and 'eat moderate' types of food varied significantly by neighbourhood SES. However, the availability of 'eat least' type of food may not be strongly associated with neighbourhood SES. Nevertheless, the NFE and neighbourhood SES were both associated with BMI of children, and therefore contribute to an increased risk of children becoming overweight or obese in Perth metropolitan region.

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7 APPENDICES

Appendix A: Conference Paper Presentations/manuscripts

1. We are what we eat: Influence of neighbourhood food environment on prevalence of obesity among the primary school children in the Perth metropolitan region. Paper presented in 7th International Symposium on Digital Earth incorporating WALIS Forum 2011 and The State NRM conference. 23-25 August 2011, Perth Convention and Exhibition Centre, Western Australia.

Appendix B-I: 400m buffer zone (Odds ratios from logistic regression models associating environmental variables on prevalence of overweight or obesity among the primary school children in Perth metropolitan region)

	Unadjusted								Partially adjusted						Fully adjusted	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Neighbourhood Food Environment																
Eat Most	0.32	0.074 – 1.382							0.35	0.067 – 1.824					0.23	0.016 – 3.254
Eat Moderate			0.44	0.146 – 1.309							0.59	0.175 – 2.013			1.49	0.161 – 13.751
Eat Least					0.78	0.509 – 1.185							0.87	0.537 – 1.393	0.95	0.516 – 1.746
Neighbourhood SES																
High							1.00		1.00		1.00		1.00		1.00	
Medium							1.31	0.835 – 2.041	1.26	0.769 – 2.065	1.28	0.784 – 2.100	1.28	0.783 – 2.098	1.26	0.770 – 2.073
Low							1.54	0.842 – 2.823	1.28	0.634 – 2.568	1.36	0.683 – 2.714	1.34	0.670 – 2.672	1.25	0.621 – 2.531
Demography																
Age																
Older (> 11 yrs)									1.00		1.00		1.00		1.00	
Younger (≤ 11 yrs)									1.31	0.869 – 1.968	1.33	0.881 – 1.993	1.30	0.864 – 1.953	1.28	0.850 – 1.924
Gender																
Boy									1.00		1.00		1.00		1.00	
Girl									1.11	0.808 – 1.528	1.13	0.822 – 1.549	1.14	0.831 – 1.568	1.12	0.817 – 1.546
Physical Activity																
Recommendation/higher level									1.00		1.00		1.00		1.00	
Below recommendation level									1.13	0.788 – 1.614	1.09	0.767 – 1.559	1.10	0.770 – 1.566	1.13	0.790 – 1.619
Food Behaviour																
Breakfast																
Regular									1.00		1.00		1.00		1.00	
Occasional									1.27	0.884 – 1.833	1.27	0.883 – 1.828	1.28	0.886 – 1.835	1.27	0.880 – 1.828
Fruit																
High									1.00		1.00		1.00		1.00	
Low									1.13	0.778 – 1.629	1.12	0.775 – 1.622	1.12	0.776 – 1.622	1.13	0.778 – 1.628
Fast food																
No									1.00		1.00		1.00		1.00	
Yes									1.38	0.964 – 1.968	1.33	0.930 – 1.886	1.31	0.921 – 1.869	1.36	0.952 – 1.948

Partially adjusted odds raios (adjusted for age, gender, physical activity, food behaviours and neighbourhood SES)

Fully adjusted odds ratios (adjusted for age, gender, physical activity, food behaviours, NFE and neighbourhood SES)

*Significant at < 0.05

Appendix B-II: 800m buffer zone (Odds ratios from logistic regression models associating environmental variables on prevalence of overweight or obesity among the primary school children in Perth metropolitan region)

	Unadjusted								Partially adjusted						Fully adjusted	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Neighbourhood Food Environment																
Eat Most	0.75	0.199 – 2.842							0.53	0.114 – 2.477					4.83	0.404 – 57.715
Eat Moderate			0.30	0.090 – 0.971							0.20	0.049 – 0.777			0.08	0.006 – 1.071
Eat Least					0.73	0.457 – 1.176							0.59	0.341 – 1.013	0.82	0.436 – 1.541
Neighbourhood SES																
High							1.00		1.00		1.00		1.00		1.00	
Medium							0.96	0.647 – 1.470	0.86	0.548 – 1.356	0.81	0.510 – 1.270	0.88	0.560 – 1.376	0.81	0.515 – 1.288
Low							0.73	0.378 – 1.393	0.52	0.233 – 1.174	0.46	0.203 – 1.041	0.52	0.231 – 1.168	0.47	0.208 – 1.071
Demography																
Age																
Older (> 11 yrs)									1.00		1.00		1.00		1.00	
Younger (≤ 11 yrs)									1.28	0.851 – 1.926	1.30	0.859 – 1.952	1.22	0.811 – 1.849	1.25	0.827 – 1.899
Gender																
Boy									1.00		1.00		1.00		1.00	
Girl									1.12	0.812 – 1.530	1.12	0.814 – 1.535	1.12	0.814 – 1.538	1.12	0.813 – 1.540
Physical Activity																
Recommendation/higher level									1.00		1.00		1.00		1.00	
Below recommendation level									1.11	0.778 – 1.579	1.11	0.776 – 1.579	1.11	0.777 – 1.585	1.11	0.774 – 1.585
Food Behaviour																
Breakfast																
Regular									1.00		1.00		1.00		1.00	
Occasional									1.28	0.890 – 1.835	1.26	0.878 – 1.815	1.26	0.873 – 1.813	1.25	0.863 – 1.795
Fruit																
High									1.00		1.00		1.00		1.00	
Low									1.13	0.777 – 1.628	1.14	0.788 – 1.658	1.12	0.769 – 1.626	1.14	0.780 – 1.658
Fast food																
No									1.00		1.00		1.00		1.00	
Yes									1.37	0.962 – 1.949	1.38	0.965 – 1.959	1.42	0.993 – 2.029	1.43	1.002 – 2.052

Partially adjusted odds raios (adjusted for age, gender, physical activity, food behaviours and neighbourhood SES)

Fully adjusted odds ratios (adjusted for age, gender, physical activity, food behaviours, NFE and neighbourhood SES)

*Significant at < 0.05

Appendix B-III: 1200m buffer zone (Odds ratios from logistic regression models associating environmental variables on prevalence of overweight or obesity among the primary school children in Perth metropolitan region)

	Unadjusted								Partially adjusted						Fully adjusted	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Neighbourhood Food Environment																
Eat Most	1.79	0.265 – 12.021							2.34	0.270 – 20.247					0.74	0.038 – 14.492
Eat Moderate			3.88	0.726 – 20.682							3.89	0.533 – 28.445			4.93	0.293 – 82.802
Eat Least					1.06	0.525 – 2.154							1.00	0.418 – 2.389	0.89	0.370 – 2.156
Neighbourhood SES																
High							1.00		1.00							
Medium							0.93	0.607 – 1.409	1.08	0.693 – 1.670	1.11	0.714 – 1.733	1.06	0.682 – 1.644	1.12	0.717 – 1.754
Low							1.35	0.699 – 2.618	1.86	0.877 – 3.941	1.93	0.907 – 4.089	1.79	0.848 – 3.761	1.93	0.907 – 4.096
Demography																
Age																
Older (> 11 yrs)									1.00		1.00		1.00		1.00	
Younger (≤ 11 yrs)									0.90	0.617 – 1.317	0.90	0.616 – 1.316	0.90	0.614 – 1.309	0.90	0.615 – 1.314
Gender																
Boy									1.00		1.00		1.00		1.00	
Girl									0.87	0.646 – 1.184	0.88	0.648 – 1.187	0.88	0.649 – 1.189	0.88	0.648 – 1.188
Physical Activity																
Recommendation/higher level									1.00		1.00		1.00		1.00	
Below recommendation level									0.92	0.656 – 1.303	0.93	0.661 – 1.313	0.92	0.656 – 1.302	0.93	0.660 – 1.313
Food Behaviour																
Breakfast																
Regular									1.00		1.00		1.00		1.00	
Occasional									0.84	0.594 – 1.189	0.84	0.595 – 1.190	0.84	0.596 – 1.193	0.84	0.595 – 1.193
Fruit																
High									1.00		1.00		1.00		1.00	
Low									1.08	0.764 – 1.527	1.08	0.764 – 1.526	1.07	0.760 – 1.517	1.08	0.763 – 1.526
Fast food																
No									1.00		1.00		1.00		1.00	
Yes									0.72	0.512 – 1.016	0.73	0.516 – 1.024	0.72	0.513 – 1.017	0.73	0.517 – 1.027

Partially adjusted odds raios (adjusted for age, gender, physical activity, food behaviours and neighbourhood SES)

Fully adjusted odds ratios (adjusted for age, gender, physical activity, food behaviours, NFE and neighbourhood SES)

*Significant at < 0.05

Appendix C-I: Local Government Authority in Perth metropolitan region

Armadale, City Of
Bayswater, City Of
Belmont, City Of
Cambridge, Town Of
Canning, City Of
Claremont, Town Of
Cockburn, City Of
Cottesloe, Town Of
East Fremantle, Town Of
Fremantle, City Of
Joondalup, City Of
Kalamunda, Shire Of
Kwinana, Town Of
Mandurah, City Of
Melville, City Of
Mosman Park, Town Of
Mundaring, Shire Of
Murray, Shire Of
Nedlands, City Of
Peppermint Grove, Shire Of
Perth, City Of
Rockingham, City Of
Serpentine-Jarrahdale, Shire Of
South Perth, City Of
Stirling, City Of
Subiaco, City Of
Swan, City Of
Victoria Park, Town Of
Vincent, Town Of
Wanneroo, City Of

Appendix C-II: Letter (E-mail) seeking permission to access the Food outlets dataset

Attention to: Environment and Health Services Department

Ps: On behalf of Professor Billie Giles-Corti.

Dear Sir/Madam,

Your contact details have been provided to me, by the Epidemiology Section of Department of Health, Western Australia. The Centre for the Built Environment and Health is currently examining the correlates of obesity as a part of "Life Course Project," a study being undertaken in collaboration with the Department of Health. This study will examine the impact of the neighborhood food environment on eating behaviors and weight status along with physical activity and sedentary behavior.

In the first instance, one of our postgraduate students (Damber Shrestha) who is working on a sub-study of the "Life Course Project" will be developing a neighborhood food index that will represent the types of food available in the local neighborhoods. This approach is not only new but also fundamental to understanding the impact of the food environment on eating behaviors of local residents.

I have contacted Department of Health WA requesting access to a food outlet dataset held by the Epidemiology Section. As our group is a collaborator of the Department, it is willing to provide these data to our group for our research, however, the officers have requested we seek the permission of each of the proprietors of the datasets (i.e., each LGA involved), before being willing to do so. Therefore, I am writing to formally request permission to use your LGA's food outlets dataset currently held by the Health Department.

We would be very happy to share the results with your council once the study is finalised, and if of interest, to provide you a copy of the results for your own LGA.

Thank you in anticipation of your assistance. I look forward to hearing from you.

Sincerely,

Billie Giles-Corti DIRECTOR |
Centre for the Built Environment and Health | School of Population Health | Mailbag M707 | University of Western Australia | 35 Stirling Highway Crawley WESTERN AUSTRALIA 6009

T (+61 8) 6488 1257 | F (+61 8) 6488 1199 | E Billie.Giles-Corti@uwa.edu.au | W www.sph.uwa.edu.au/research/cbeh | UWA CRICOS Provider No. 00126

Courier Address: 10 Stirling Highway Nedlands WA 6009

Appendix D-I: Invitation Letter

THE UNIVERSITY OF WESTERN AUSTRALIA
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Centre for the Built Environment & Health
The University of Western Australia
M707, 35 Stirling Highway
CRAWLEY WA 6009
T +61 8 6488 1259
F +61 8 6488 1199
E dshrestha@meddent.uwa.edu.au
http://www.sph.uwa.edu.au/research/cbeh
CRICOS Provider Code: 00126B
Courier Address: 10 Stirling Hwy, Nedlands

Date: DD/MM/2010

Dear Sir/Madam,

I am inviting you to participate in a study on the availability of (opportunity to purchase) different types of food sold in various types of retail food outlets in the Perth Metropolitan region.

I am a postgraduate research student undertaking a study examining the relationship between neighborhood food environment, food behavior and the weight status of children in metropolitan Perth. This study forms part of the "Life Course Project", a study being undertaken in collaboration with the Department of Health, Western Australia (DOHWA) through the use of the DOHWA's "Health and Wellbeing Survey and Surveillance System (HWSS)" data.

This study involves a Delphi method which seeks opinions from experts in the field on food sold by different types of food outlets, with the aim of attempting to reach group consensus. **Please find enclosed information about the study and the Delphi method.**

This study involves two phases. In the first phase, you are asked to: (a) rate 23 types of food outlets in terms of the availability of types of foods in accordance with the 'Healthy Food Pyramid'; and to (b) provide brief details about yourself. In the second phase, you will be asked to compare the ratings that you assigned to the various food groups with the group median score of all experts participating in the study. If appropriate, you will have an opportunity to make adjustments to each of your scores.

Your response will be completely confidential. All information will be aggregated, and no individual data will be published.

Please find enclosed the consent form and first questionnaire. If you would prefer the questionnaire to be sent via e-mail, please let me know via email or phone provided below.

Please complete and return the consent form and first questionnaire via email (dshrestha@meddent.uwa.edu.au), fax (61 8 6488 1199) or reply paid envelope by DD/MM/2010.

If you have any questions, please contact me on (08) 6488 1259, or my supervisor, Professor Billie Giles-Corti on (08) 6488 1257.

Yours sincerely,

Damber Shrestha

OUR MISSION *To undertake policy-relevant research that builds capacity and influences planning and urban design policy and practice to create healthy and sustainable communities*

MinterEllison
Foundation Corporate Partner:

[1]The Human Research Ethics Committee at The University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the Chief Investigator (Winthrop Professor Billie Giles-Corti 6488 1257) or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, The University of Western Australia, Nedlands, 6907 (telephone number 6488 3703). All study participants must be provided with a copy of the Information Sheet for their personal records.

Appendix D-II: Information Sheet

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

Centre for the Built Environment & Health
The University of Western Australia
M707, 35 Stirling Highway
CRAWLEY WA 6009
T +61 8 6488 1259
F +61 8 6488 1199
E dshrestha@meddent.uwa.edu.au
http://www.sph.uwa.edu.au/research/cbeh
CRICOS Provider Code: 00126G
Courier Address: 10 Stirling Hwy, Nedlands

INFORMATION SHEET

What is a Delphi Study?

The Delphi technique is a research method that aims to formulate group judgment on a subject. It is based on the principle that group judgments are more valid than individual judgments. The Delphi is a very flexible method and has been widely used in establishing a consensus on complex problems, in circumstances where accurate information does not exist. It can be used in almost any situation for a collective opinion from a Panel of Experts about a particular research question. The Delphi technique allows all Panel Members to freely express their views. In addition, it also gives every (individual) Panel Member the opportunity to revise his or her opinion based on the group's overall view.

Who are the Panel members?

The Panel involves approximately 20 professional experts (academics and industry) working in the field of food, nutrition and marketing.

What you will do as a member of the Expert Panel?

Based on your knowledge and experience, you will be asked to provide your professional opinion about how much of the food sold by different types of food outlets is in the 'eat most'; 'eat moderate' or 'eat small' categories of the Healthy Eating Pyramid.

How many Phases does this Delphi study involve?

It involves two phases.

Phase 1: In the first phase, you will be asked to allocate a total of 100 points for each food outlet in terms of the availability of three categories of foods in the Healthy Eating Pyramid i.e., 'eat most'; 'eat moderate' or 'eat small'. The allocation of points should be based on your professional knowledge and experience. This information will be collected using a self-completion questionnaire.

Phase 2: You will be provided a self-completion questionnaire with the group median score along with your original scores for each food outlet. You will be asked whether you are satisfied with your response or whether you wish to change your view. Here, you are

Appendix D-III: Consent Form

THE UNIVERSITY OF WESTERN AUSTRALIA
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School of Population Health (M707)
The University of Western Australia
35 Stirling Highway
CRAWLEY. 6009
Tel: 6488 1259
Fax: 6488 1199
Email: dshrestha@meddent.uwa.edu.au

LCP COPY

!1!

Life Course Project

CONSENT FORM

I _____ (your full name) have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in the Delphi survey for the Life Course Project and understand that it involves completion of two questionnaires. I understand that I may withdraw at any time without reason and without prejudice.

I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required to by law. I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.

I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

Name: _____

Signature: _____ Date: _____

The Human Research Ethics Committee at The University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the Chief Investigator (Winthrop Professor Billie Giles-Corti 6488 1257) or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, The University of Western Australia, Crawley, 6009 (telephone number 6488 3703). All study participants must be provided with a copy of the Information Sheet and Consent Form for their personal records.

THE UNIVERSITY OF WESTERN AUSTRALIA
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School of Population Health (M707)
The University of Western Australia
35 Stirling Highway
CRAWLEY. 6009
Tel: 6488 1259
Fax: 6488 1199
Email: dshrestha@meddent. uwa.edu.au

YOUR COPY

!1!

Life Course Project

CONSENT FORM

I _____ (your full name) have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in the Delphi survey for the Life Course Project and understand that it involves completion of two questionnaires. I understand that I may withdraw at any time without reason and without prejudice.

I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required to by law. I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.

I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

Name: _____

Signature: _____ Date: _____

The Human Research Ethics Committee at The University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner in which a research project is conducted, it may be given to the Chief Investigator (Winthrop Professor Billie Giles-Corti 6488 1257) or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, The University of Western Australia, Crawley, 6009 (telephone number 6488 3703). All study participants must be provided with a copy of the Information Sheet and Consent Form for their personal records.

Appendix D-IV: First Delphi Questionnaire

THE UNIVERSITY OF WESTERN AUSTRALIA

healthway

Government of Western Australia Department of Health Public Health

LIFE COURSE PROJECT

This survey is about the different types of food available in a particular type of food store. The information you provide will be used for categorising the food outlets into different types which will be used for developing a neighbourhood food index to examine the influences of the overall availability of food in a neighbourhood on food behaviour and health status of children and adolescents.

The questionnaire will take you about 20 - 30 minutes to complete. Your professional knowledge and experience are important for making this vital study a success.

When you have completed the questionnaire, **please return it within 7 days either by reply paid envelop** or **by e-mail**.

If you have any questions or need help with the survey, please call **Damber Shrestha on (08) 6488 1259** or **email** dshrestha@meddent.uwa.edu.au.

My Neighborhood Food Environment

First Delphi Questionnaire: Completion Instructions

In the first phase, we would be grateful if you would:

1. Rate 23 different types of food outlets in terms of proportion of 'eat most', 'eat moderate' and 'eat least' types of food that could be stocked by each individual type of food outlet; and
2. Provide brief details about yourself.

Please:

- Read through the questionnaire completely before rating any food outlet, to get an overall picture of how it is structured and how we have grouped the various types of food that may be available in the local food outlet;
- Refer to the definition of each type of food outlet and example provided as a guideline;
- Complete the survey based on your current **knowledge and professional judgement.**

Section I: Rating Food Outlets for Availability of Various Food Types

When thinking of the types of food sold by each food outlet, the focus is on the **availability or opportunity** to purchase different types of food. The food types are based on the three levels Healthy Eating Pyramid (HEP) (Figure 1). The HEP gives an idea of the balance of food required for a healthful diet.

As you will be aware, each level of the food pyramid is comprised of food classified by the amount of food from each level that a person should consume i.e.: (a) Eat Most (b) Eat Moderate and (c) Eat Small. When rating a food outlet, you should consider the opportunity to purchase different types of food (i.e., eat most, eat moderate and eat small or least) from that particular food outlet. This will differ from one type of food outlet to another. Some food outlets may stock predominantly 'Eat Most' type of food (e.g., a

green grocer store) while another food outlet will stock mainly 'Eat Moderate' (e.g., a butcher shop) or 'Eat small' (e.g., an ice-cream shop) types of food.

'Eat Most' Type of Food

This is the base layer of the HEP. It contains food with high levels of carbohydrate, fibre, minerals and vitamins. For example, breads, cereals (preferably wholegrain), other grains (beans, peas, lentils, etc), fruit and vegetables.

'Eat Moderate' Type of Food

Food in the middle layer of the HEP consists mainly of animal-based food. These foods are the main source of protein and some minerals (e.g., iron, calcium and vitamins B). The 'Eat Moderate' type of food includes fish, lean meat, eggs, milk, cheese and yoghurt.

'Eat Small' Type of Food

Food in the top layer of the HEP consists of food containing sugars, salt and fats. The 'Eat Small' type of food includes butter, ghee, lard, cream, animal fat, savory snacks, sweets, chocolates, cakes, pastries, etc.

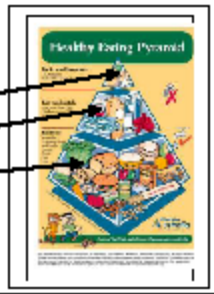
What You Do?

In this section of the questionnaire, for each type of food outlet, you:

- distribute 100 point across the thee different types of food for the availability or opportunity to purchase from each individual **TYPE** of outlet
- ensure that the total sum of the points of three types of food for each outlet exactly equals 100.

For example: My scores for Meat and Fish Shop (meat, fish and sea foods) are:

Store Type	Definition	Example	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
3. Meat, Fish & Seafood Store	• Mainly engaged in sale of fresh meat, poultry, processed meat, fish (fresh and frozen) and other sea foods.	Dalkeith Butcher De Jong Seafood	0	70	30	100	



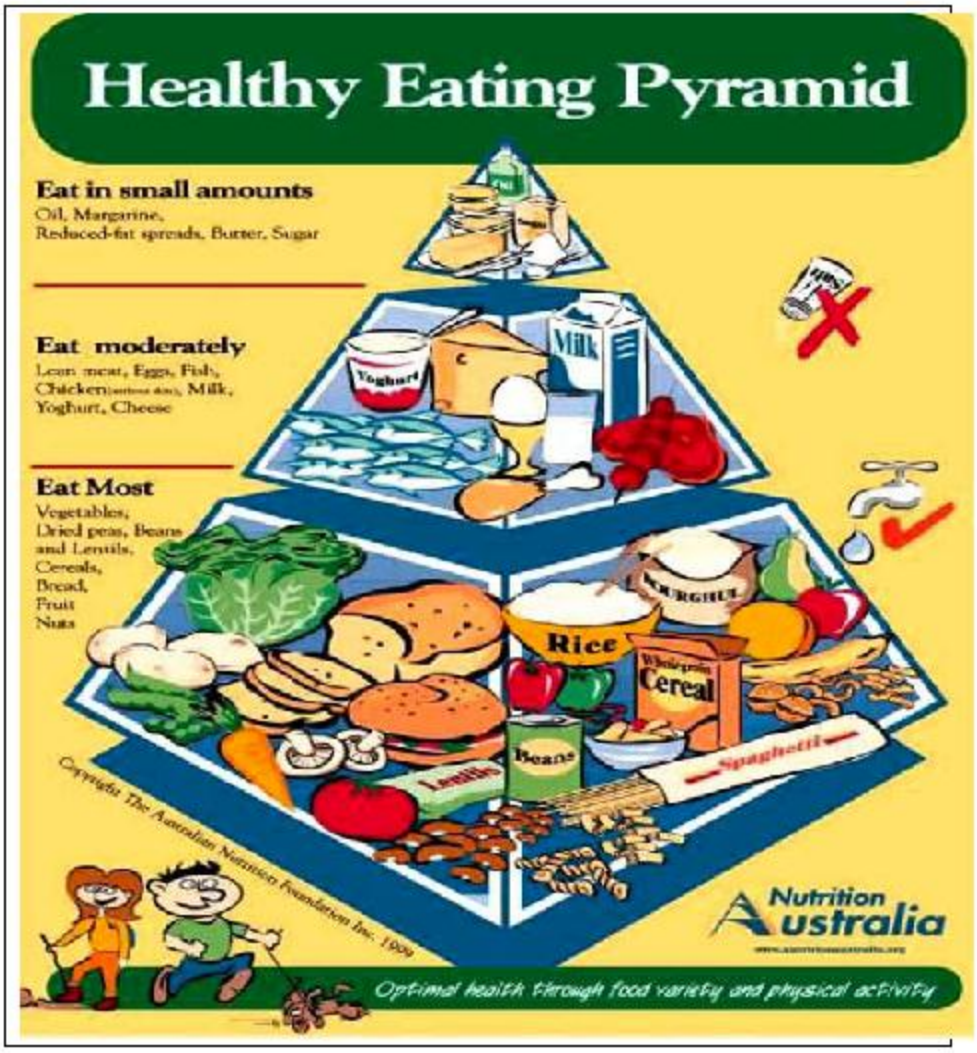


Figure 1: Healthy Eating Pyramid adopted from Nutrition Australia (1999).

Please allocate a total of 100 points for each food store listed (page 5 - 7) for the likelihood of availability of 'Eat Most', 'Eat Moderate' and 'Eat Small' types of food as illustrated in the HEP (Figure 1). Please also refer to definition of food store and example as a guideline.

Store Type	Definition	Example	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
1. Baker	• Mainly engaged in the sale of bread, biscuits, rolls, croissants, muffins or other flour products with or without packaging.	Baker's Delight Brumby's Belmont Bakery				100	
2. Cake, Pastries and Other Sweet Shop	• Primarily sell cakes, pies, pastry and other sweets such as doughnut.	Corica Pastries Donut King Muffin Break Jesters				100	
3. Lolly/Candy, nut and Confectionary Shop	• Primarily sells candy, nut and chocolates.	Chokeby Road				100	
4. Ice Cream shop	• Primarily sell ice cream and candy.	Crusty Kones Wendy's Gelare				100	
5. Meat & Fish Store	• Mainly engaged in sale of fresh meat, poultry, processed meat, fish (fresh and frozen) and other sea foods.	Dalkeith Butcher De Jong Seafood				100	
6. Cafe/Coffee Shop	• Primary provide ready-to-drink coffee/tea • Also sells meals and snacks and soft drinks • Provide facility to consume on the premises.	Dome Coffee The Wild Fig Café Gloria Jeans				100	
7. Cafeteria	• Self-service restaurant usually attached to worksite.					100	
8. Convenience Store	• A small store selling a limited variety of foods mostly snacks (e.g., crisps, chocolate and sweets), soft-drinks, etc • may attach to fuel station.	Gas station with food items (food marts – star mart) Seven-Eleven				100	
9. Delicatessen	• Small food outlets mainly engaged in the preparation and sale of meals or light refreshment that are ready for immediate consumption • Serve food without table service • Tend to have greater varieties of options than "traditional fast food restaurants".	Bryan's Delicatessen				100	

Store Type	Definition	Example	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
10. Deli and Fine Food Store	• Sells ready-to-eat, fine and imported cooked or processed foods.	Arkana Road Deli				100	
11. Fast Food Restaurant	• Served complete meals ordered without the assistance of wait person or table service • Require payment before eating • Provide customers a place to consume their meals on-site/drive through • Can be franchise or independently owned • Serve predominately pre-processed and prepare to order in a highly standardised, mechanised fashion.	McDonald's Red Rooster KFC Hungry Jacks Burger King Nando's				100	
12. Pizza Shop	Primarily sells pizza.	Pizza Hut Eagle Boys Pizza Domino Pizza				100	
13. Fruit & Vegetable Store	• A retail seller of fresh fruit and vegetables.	Apple Fresh Bella Fruit & Veg				100	
14. Full Service Restaurant	• Food outlets which served complete meals ordered with the assistance of waiters or waitresses available for service • Provides facilities for customers to consume their meals on site.	Jo Jos, Matilda Bay Maharaja Indian Restaurant Seaview Restaurant				100	
15. Health Food Store	• Primarily oriented towards the sale of health foods, for example, natural food store.	Alive Organics Elementals Health Food and Eco Store Manna Wholefoods				100	

Store Type	Definition	Example	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
16. Supermarket	• Self-service grocery store typically belonged to a large chain/locally owned • Offered a full range of consumer foods/full-line of groceries, meat, fish, vegetables (fresh and frozen), fruit (fresh and canned), bread, dairy, etc. • Also includes ethnic grocery stores (store selling specialized ethnic food lines, may carry ethnic foods).	Woolworths Coles IGA Farmer Jack Kongs Oriental Supermarket				100	
17. General Takeaway	• Food store selling a wide variety of ready-to-eat food and meals, often high in fat (meat pies, sausage rolls, fried fish, chips, etc)	Fish and Chips shops				100	
18. Ethnic Takeaway	• Food store selling ready-to-eat food and meals with Ethnic origin/name.	Chinese, Indian, Thai, Indonesian, and other Ethnic (Italian, Lebanese, Turkish, Mexican, Greek, etc)				100	
19. Food Hall	• Mixed specialties, have counters that are dependent in a department store/shopping centre/mall • Share same dinning area.	International Food Court, Wembley Carousel Shopping Centre Food Hall				100	
20. Fresh Sandwich Bar	• Mainly sells fresh sandwich, salads, rolls, etc	Subway				100	
21. Sushi Bar	• Primarily sells fresh Sushi.	Pink Rice ZushiBento Nagano Sushi				100	
22. Fresh Juice Bar	• Small outlets that offer fresh fruit juice.	Java Juice				100	
23. Markets	• Provides mainly fresh fruit, vegetables, eggs, meat and fish, etc.	Station street market, Subiaco				100	

Comments:_____

_____

_____

_____

_____

_____

Would you like to be sent the second Delphi questionnaire via e-mail?

- ☐ Yes, my e-mail address: _____
- ☐ No, please send by post.

Section II: Personal Details

1. What is your job title? _____

2. What type of work are you currently involved in? (Please tick applicable options)

- ☐ Research
- ☐ Practice
- ☐ Policy
- ☐ Other (please describe) _____

Please return your questionnaire by *DD/MM/2010* either in the reply paid envelop enclosed or via email (dshrestha@meddent.uwa.edu.au). Thank you for completing and returning the first Delphi questionnaire for the "Life Course Project".

Appendix D-V: Reminding Letter

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

Centre for the Built Environment & Health
The University of Western Australia
M707, 35 Stirling Highway
CRAWLEY WA 6009
T +61 8 6488 1259
F +61 8 6488 1199
E dshrestha@meddent.uwa.edu.au
http://www.sph.uwa.edu.au/research/cbeh
CRICOS Provider Code: 00126G
Courier Address: 10 Stirling Hwy, Nedlands

Date: DD/MM/2010

Dear ……,

Approximately three weeks ago, you received a questionnaire seeking your professional opinions concerning the availability of (opportunity to purchase) different types of food sold in retail food outlets. If you have already completed and returned the questionnaire, I graciously thank you for your response. If you did not receive the questionnaire or it has been misplaced, I would be more than happy to provide you an additional copy.

To date, I have received a very positive response concerning the study and have canvassed a wide variety of opinions. I am confident the results will yield positive insight into food availability and health, however for those who have not yet responded your professional opinion is still highly desired.

I am writing this letter again because of the importance of your professional opinions. Although we sent questionnaire to people working in field of food and nutrition involving in research, practice, policy and lobby groups, it's only by hearing from everyone that we can be sure that the results are truly representative.

We hope that you will fill out the questionnaire and return it soon, but if for any reasons you prefer not to be answer it or withdraw from the study, please let us know by returning a note or blank questionnaire in the enclosed reply paid envelop. However, I am sincerely looking forward to have your participation in the study. I appreciate your time. I thank you so much once again for your support.

Yours sincerely,
Damber Shrestha

Appendix D-VI: Second Delphi Questionnaire

THE UNIVERSITY OF WESTERN AUSTRALIA

healthway

Second Delphi Questionnaire: Completion Instructions

Thank you for completing and returning the first Delphi study questionnaire for the "Life Course Project". The results of the first questionnaire have assisted in refining the conceptual model for this project. We received many comments and where possible we have incorporated these into the second Delphi Questionnaire. Some points you suggested may not have been included. This may have been because we felt that we could not be reliably measure what you suggested or that it was subject to change (such as seasonal availability). If you feel strongly about a point, please note this in the comments.

This questionnaire is the second and final round of the Delphi study process. The aim of this round is to seek consensus (where possible) in the opinions provided by all the Panellists. Therefore, in this questionnaire you are asked to compare the weights you assigned to the various food groups with the median score assigned by other Panel Members and, if you feel appropriate, you have the opportunity to adjust your score. This questionnaire is very similar to the previous questionnaire. However, it includes three rows against each type of food store i.e., (a) your original score (b) the group median Score from all the experts we have consulted; and (c) a row which provides you with an opportunity to revise your original score.

What You Do?

We suggest you:

- refer to the attached picture of HEP (Figure 1), definition of the food store and example provided;
- read through the original score you gave for each type of food store and the corresponding group median score;

- consider whether you are happy with your original score, or if you wish to alter your score from the previous Delphi questionnaire;
- if you wish to revise your original score, please insert your new score;
- if you do not wish to revise your original score, please leave the revised score line blank.

Please return your questionnaire by DD/MM/2010. We thank you for your participation in this Delphi process.

For example: My original score, group median score and my revised score for Butcher shop and F & V store are:

Store Type	Definition	Example	Score	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments	Previous comments
5. Meat & Fish Store	• Mainly engaged in sale of fresh meat, poultry, processed meat, fish (fresh and frozen) and other sea foods.	Dalkeith Butchery De Jong Seafood	Your original score	0	70	30	100	some products particularly processed meat may have high fat content	
			Group median score	0	85	15	100		
			Your revised score	0	90	10	100		

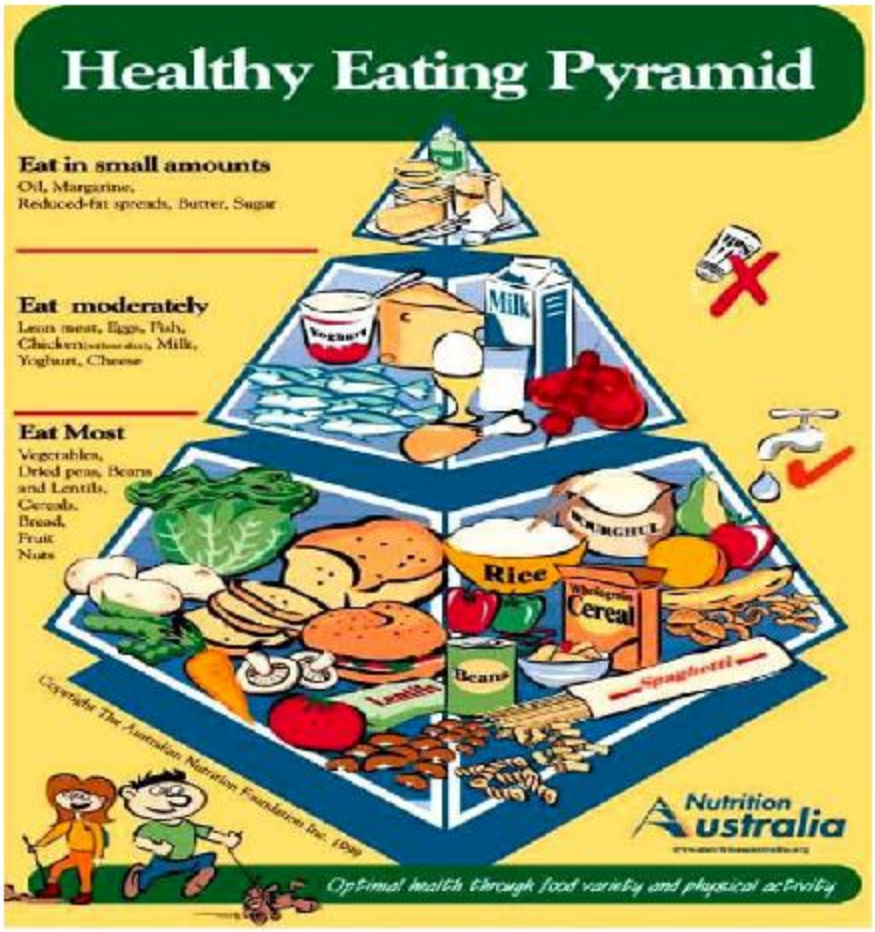


Figure 1: Healthy Eating Pyramid adopted from Nutrition Australia (1999)

We have provided you with your score from the first Delphi questionnaire and the Group Median Score. Please make any revisions that you wish to your score. Please refer HEP (Figure 1), definition of the food store and example as a guideline.

Store Type	Definition	Example	Score	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
1. Bakery	• Mainly engaged in the sale of bread, biscuits, rolls, croissants, muffins or other flour products with or without packaging.	Baker's Delight Brumby's Belmont Bakery	Your Original Score				100	
			Group Median Score				100	
			Your Revised Score				100	
2. Cake, Pastries and Other Sweet Shop	• Primarily sell cakes, pies, pastry and other sweets such as doughnut.	Corica Pastries Donut King Muffin Break Jesters	Your Original Score				100	
			Group Median Score				100	
			Your Revised Score				100	
3. Lolly/Candy, nut and Confectionary Shop	• Primarily sells candy, nut and chocolates.	Chokeby Road	Your Original Score				100	
			Group Median Score				100	
			Your Revised Score				100	
4. Ice Cream Shop	• Primarily sell ice cream and candy.	Crusty Kones Wendy's Gelare	Your Original Score				100	
			Group Median Score				100	
			Your Revised Score				100	
5. Meat & Fish Store	• Mainly engaged in sale of fresh meat, poultry, processed meat, fish (fresh and frozen) and other sea foods.	Dalkeith Butcher De Jong Seafood	Your original score				100	
			Group median score				100	
			Your revised score				100	

Store Type	Definition	Example	Score	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
6. Café/Coffee Shop	• Primary provide ready-to-drink coffee/tea • Also sells meals and snacks and soft drinks • Provide facility to consume on the premises.	Dome Coffee The Wild Fig Café Gloria Jeans	Your original score				100	
			Group median score				100	
			Your revised score				100	
7. Cafeteria	• Self-service restaurant usually attached to worksite.		Your Original Score				100	
			Group Median Score				100	
			Your revised score				100	
8. Convenience Store	• A small store selling a limited variety of foods mostly snacks (e.g., crisps, chocolate and sweets), soft-drinks, etc • may attach to fuel station.	Gas station with food items (food marts – star mart) Seven-Eleven	Your original score				100	
			Group median score				100	
			Your revised score				100	
9. Delicatessen	• Small food outlets mainly engaged in the preparation and sale of meals or light refreshment that are ready for immediate consumption • Serve food without table service • Tend to have greater varieties of options than "traditional fast food restaurants".	Bryan's Delicatessen	Your original score				100	
			Group median score				100	
			Your revised score				100	
10. Deli and Fine Food Store	• Sells ready-to-eat, fine and imported cooked or processed foods.	Arkana Road Deli	Your original score				100	
			Group median score				100	
			Your revised score				100	

Store Type	Definition	Example	Score	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
11. Fast Food Restaurant	• Served complete meals ordered without the assistance of wait person or table service • Require payment before eating • Provide customers a place to consume their meals on-site/drive through • Can be franchise or independently owned • Serve predominately pre-processed and prepare to order in a highly standardised, mechanised fashion.	McDonald's Red Rooster KFC Hungry Jacks Burger King Nando's	Your original score				100	
			Group median score				100	
			Your revised score				100	
12. Pizza Shop	• Primarily sells pizza.	Pizza Hut Eagle Boys Pizza Domino Pizza	Your original score				100	
			Group median score				100	
			Your revised score				100	
13. Fruit & Vegetable Store	• A retail seller of fresh fruit and vegetables.	Apple Fresh Bella Fruit & Veg	Your original score				100	
			Group median score				100	
			Your revised score				100	
14. Full Service Restaurant (Sit-down restaurant)	• Food outlets which served complete meals ordered with the assistance of waiters or waitresses available for service • Provides facilities for customers to consume their meals on site.	Jo Jos, Matilda Bay Maharaja Indian Restaurant Seaview Restaurant	Your original score				100	
			Group median score				100	
			Your revised score				100	

Store Type	Definition	Example	Score	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
15. Health Food Store	• Primarily oriented towards the sale of health foods, for example, natural food store.	Alive Organics Elementals Health Food and Eco Store Manna Wholefoods	Your original score				100	
			Group median score				100	
			Your revised score				100	
16. Supermarket	• Self-service grocery store typically belonged to a large chain/locally owned • Offered a full range of consumer foods/full-line of groceries, meat, fish, vegetables (fresh and frozen), fruit (fresh and canned), bread, dairy, etc. • Also includes ethnic grocery stores (store selling specialized ethnic food lines, may carry ethnic foods).	Woolworths Coles IGA Farmer Jack Kongs Oriental Supermarket	Your original score				100	
			Group median score				100	
			Your revised score				100	
17. General Takeaway	• Food store selling a wide variety of ready-to-eat food and meals, often high in fat (meat pies, sausage rolls, fried fish, chips, etc)	Fish and Chips shops	Your original score				100	
			Group median score				100	
			Your revised score				100	
18. Ethnic Takeaway	• Food store selling ready-to-eat food and meals with Ethnic origin/name.	Chinese, Indian, Thai, Indonesian, and other Ethnic (Italian, Lebanese, Turkish, Mexican, Greek, etc)	Your original score				100	
			Group median score				100	
			Your revised score				100	

Store Type	Definition	Example	Score	Eat Most/100	Eat Moderate/100	Eat Small/100	Total	Comments
19. Food Hall	• Mixed specialties, have counters that are dependent in a department store/shopping centre/mall • Share same dinning area.	International Food Court, Wembley Carousel Shopping Centre Food Hall	Your original score				100	
			Group median score				100	
			Your revised score				100	
20. Fresh Sandwich Bar	• Mainly sells fresh sandwich, salads, rolls, etc	Subway	Your original score				100	
			Group median score				100	
			Your revised score				100	
21. Sushi Bar	• Primarily sells fresh Sushi.	Pink Rice ZushiBento Nagano Sushi	Your original score				100	
			Group median score				100	
			Your revised score				100	
22. Fresh Juice Bar	• Small outlets that offer fresh fruit juice.	Java Juice	Your original score				100	
			Group median score				100	
			Your revised score				100	
23. Market (Farmers Market or Grower Market)	• Provides mainly fresh fruit, vegetables, eggs, meat and fish, etc.	Station street market, Subiaco	Your original score				100	
			Group median score				100	
			Your revised score				100	

Appendix E: TRavel, Environment and Kids Project: Student Questionnaire

20728

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TRavel, Environment and Kids (TREK) Project: Student Questionnaire

INTRODUCTION

Thank you for agreeing to take part in the TREK Study.

This questionnaire asks about how you get to and from school and other places in your neighbourhood.

It also asks questions about the activities you do in your spare time, and how you feel about your neighbourhood.

You will be guided by the person who gave you this questionnaire.

This is not a test - there are no right or wrong answers, but we would like you to answer as many of the questions as possible.

If you need help to answer the questions, please raise your hand and ask.

COMPLETION INSTRUCTIONS

Please use a **BLACK** pen

Please shade the circles completely ●

Please write clearly in the single boxes or free text areas

A	B	C		1	2	3

PLEASE WRITE IN CAPITAL LETTERS

Please remember to write in CAPITAL letters

If you make a mistake or want to change any of your shaded answers, please place a cross through the incorrect answer ✗ and shade the correct answer ●

For written answers, please cross it out and write your new answer just above or below the one you have crossed out

~~INCORRECT~~

CORRECT

THE UNIVERSITY OF WESTERN AUSTRALIA

Child ID Number

Department for Planning and Infrastructure Government of Western Australia

20725

SAMPLE QUESTIONS

The following questions are EXAMPLE QUESTIONS

1. **How strongly do you agree or disagree with the following statements?**
(Please shade only **ONE** circle for each statement)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know or does not apply to me
I love school	○	○	○	○	○	○

2. **Does your family have a guinea pig?** (Please shade **ONE** only)
○ Yes
○ No

3. **What is your first name?** (Write your answer in **CAPITAL** letters in the box below)

If you don't have any questions, we can begin answering the questionnaire now.

SECTION A: ABOUT YOU

A1. **What year are you in at school?** (Please shade **ONE** only)
○ Year 5
○ Year 6
○ Year 7

A2. **How old are you today?** (Please shade **ONE** only)
○ 8 ○ 9 ○ 10 ○ 11 ○ 12 ○ 13

A3. **Are you a boy or a girl?** (Please shade **ONE** only)
○ Boy
○ Girl

A4. **Do you have a bike at home that you could ride if you wanted to?** (Please shade **ONE** only)
○ Yes
○ No

A5. **HOW OFTEN do you eat or drink the following?**
(Please shade only **ONE** circle for each)

	Never	1-3 times a month	1-2 times a week	3-6 times a week	Every day
Pizza	○	○	○	○	○
Burgers from McDonalds, Hungry Jacks, etc	○	○	○	○	○
Soft drinks such as Coke, Pepsi, Lemonade	○	○	○	○	○

A6. **In a usual week (Monday to Sunday) HOW OFTEN do you eat breakfast?** (Please shade **ONE** only)
○ Never ○ 1-2 days ○ 3-5 days ○ 6-7 days

A7. **How many pieces of fruit do you usually eat each day?** (Please shade **ONE** only)
○ I don't know ○ I don't eat fruit ○ 1 piece or less ○ 2-3 pieces ○ 4 or more

SECTION B: TRAVELLING TO AND FROM SCHOOL

B1. How do you USUALLY get TO and FROM school? (Please shade **ALL** that apply)

	Shade the circles to show how you usually get TO school	Shade the circles to show how you usually get home FROM school
By car	○	○
Walk alone	○	○
Walk with other children	○	○
Walk with an adult	○	○
With 'Walking School Bus'	○	○
Ride a bike alone	○	○
Ride a bike with other children	○	○
Ride a bike with an adult	○	○
Ride a scooter or skateboard alone	○	○
Ride a scooter or skateboard with other children	○	○
Ride a scooter or skateboard with an adult	○	○
By bus	○	○
By train	○	○
Another way - Please write it below in CAPITAL letters	○	○

B2. If you could choose, how would you most like to get TO and FROM school? (Please shade **ONE** only)

- ○ By car
- ○ Walk alone
- ○ Walk with other children
- ○ Walk with an adult
- ○ With 'Walking School Bus'
- ○ Ride a bike alone
- ○ Ride a bike with other children
- ○ Ride a bike with an adult
- ○ Ride a scooter
- ○ Ride a skateboard
- ○ By bus
- ○ By train
- ○ Another way (write the way below)

B3. Why would you most like to get TO and FROM school this way? (Please shade **ALL** that apply)

- ○ I live a long way from school
- ○ It is quicker
- ○ I live close to school
- ○ I have a lot to carry
- ○ It is fun
- ○ I can go with my friends
- ○ I can talk to friends on the way
- ○ There is no need to wait for others
- ○ I can stop at other places on the way
- ○ It is less tiring
- ○ I feel safer
- ○ I can avoid bullies
- ○ I can avoid dogs
- ○ I feel independent
- ○ Other reasons (write below)

1. 2.

SECTION C: WALKING AND CYCLING

C1. How strongly do you agree or disagree with the following statements about walking to school?
(Please shade only **ONE** circle for each statement)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know or does not apply to me
It takes too much time to walk to school	○	○	○	○	○	○
It is safe for me to walk to school without an adult	○	○	○	○	○	○
My friends think it is cool to walk to school	○	○	○	○	○	○
Walking to school is easier for me than being driven	○	○	○	○	○	○
I think walking to school is cool	○	○	○	○	○	○
My friends like to walk to get places	○	○	○	○	○	○
My school encourages students to walk to school	○	○	○	○	○	○
I feel safer being driven to school than walking there	○	○	○	○	○	○

C2. How strongly do you agree or disagree with the following statements about riding a bike to school?
(Please shade only **ONE** circle for each statement)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know or does not apply to me
It takes too much time to ride a bike to school	○	○	○	○	○	○
It is safe for me to ride a bike to school without an adult	○	○	○	○	○	○
My friends think it is cool to ride a bike to school	○	○	○	○	○	○
Riding a bike to school is easier for me than being driven	○	○	○	○	○	○
I think riding a bike to school is cool	○	○	○	○	○	○
My friends like to ride a bike to get to places	○	○	○	○	○	○
My school encourages students to ride a bike to school	○	○	○	○	○	○
I feel safer being driven to school than riding a bike there	○	○	○	○	○	○

C3. How strongly do you agree or disagree with the following statements?
(Please shade only **ONE** circle for each statement)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I am sure that I could walk to school without an adult present	○	○	○	○	○
I am sure that I could ride a bike to school without an adult present	○	○	○	○	○
I am sure that I could walk to the shop closest to home without an adult present	○	○	○	○	○
I am sure that I could ride a bike to the shop closest to home without an adult present	○	○	○	○	○
It takes too much time to walk to the shop closest to my home	○	○	○	○	○
It takes too much time to ride a bike to the shop closest to my home	○	○	○	○	○

SECTION D: YOUR SCHOOL

D1. How strongly do you agree or disagree with the following statements about your school? (Please shade only **ONE** circle for each statement)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
There are lots of cars dropping other children off at my school	○	○	○	○	○	○
There is a safe place to leave a bike if I ride to school	○	○	○	○	○	○
I have to cross a busy road if I walk or ride a bike to school	○	○	○	○	○	○
There are safe places to cross the road near my school	○	○	○	○	○	○
I feel safe in the pick up area at my school	○	○	○	○	○	○

SECTION E: YOUR NEIGHBOURHOOD

E1. How strongly do you agree or disagree with the following statements about the neighbourhood where you live? (Please shade only **ONE** circle for each statement)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
There is a lot of traffic in my neighbourhood	○	○	○	○	○	○
I am worried about strangers in my neighbourhood	○	○	○	○	○	○
It is safe for me to play at the park closest to my house without an adult present	○	○	○	○	○	○
The park closest to my house has fun or interesting things for me to do	○	○	○	○	○	○
My neighbourhood is a nice place to walk around	○	○	○	○	○	○
My neighbourhood is friendly	○	○	○	○	○	○
You often see people out on walks in my neighbourhood	○	○	○	○	○	○

E2. I have many friends in my neighbourhood. (Please shade **ONE** only)

○ Yes
○ No

E3. There are lots of boys or girls my own age to hang out with in my neighbourhood. (Please shade **ONE** only)

○ Yes
○ No

SECTION F: YOUR ACTIVITIES

F1. Which of these things did you do in the LAST WEEK (from Monday to Sunday)?

I did these things in the last week (from Monday to Sunday):	Shade all the things you did last week	Did you walk or ride a bike to get there?	Did you walk or ride there with an adult?
EXAMPLE: Went to my aunty's house	●	● Yes ○ No ○ Sometimes	○ Yes ○ No ● Sometimes
Went to a park, playground or playing field	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Played team sport	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went swimming	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Visited my own friend's house	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Visited family or family friend's house	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to the local shop	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to other shops	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to the post-box	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to the local library (not school library)	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to my club or youth group	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to the movies	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to watch sport	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to music lessons	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Went to Sunday school/church	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes
Caught a bus	○	○ Yes ○ No ○ Sometimes	○ Yes ○ No ○ Sometimes

F2. Which of the things below did you do last week?

I did these things in the last week (from Monday to Sunday):	Shade all the activities you did last week	Did you do the activity with an adult?
Went for a walk in my neighbourhood	○	○ Yes ○ No ○ Sometimes
Took the dog for a walk	○	○ Yes ○ No ○ Sometimes
Rode my bike in the street	○	○ Yes ○ No ○ Sometimes
Played in the street	○	○ Yes ○ No ○ Sometimes
Played outside in the yard	○	
Used the computer or played electronic games at home	○	
Watched TV at home	○	

F3. How much time did you spend doing each of the following activities in the LAST SCHOOL WEEK (Monday-Friday)?

	Shade how many days you did this activity last week	How much time did you USUALLY spend doing this activity
EXAMP! F: Playing at your best friend's house	0 1 **2** 3 4 5	0 Hours; 45 Minutes
Watching television (programs and movies), videos and DVDs at home	0 1 2 3 4 5	Hours; Minutes
Playing electronic games with PlayStation, Nintendo, or Game Boy	0 1 2 3 4 5	Hours; Minutes
Spending time on the computer and/or internet doing homework	0 1 2 3 4 5	Hours; Minutes
Spending time on the computer and/or internet apart from doing homework	0 1 2 3 4 5	Hours; Minutes
Playing outside in the yard at home	0 1 2 3 4 5	Hours; Minutes
Playing with the dog in the yard	O No dog; 0 1 2 3 4 5	Hours; Minutes
Walking the dog in the neighbourhood	O No dog; 0 1 2 3 4 5	Hours; Minutes

Almost finished. You are doing really well!!!

F4. **During LAST WEEKEND (Saturday and Sunday) how much time each day did you do each of the following?**

Write the time you spent doing each activity on Saturday and Sunday

	How much time did you spend on this activity last SATURDAY?		How much time did you spend on this activity last SUNDAY?	
Watching television (programs and movies), videos and DVDs at home	Hours	Minutes	Hours	Minutes
Playing electronic games with Playstation, Nintendo, or Game Boy	Hours	Minutes	Hours	Minutes
Spending time on the computer and/or internet doing homework	Hours	Minutes	Hours	Minutes
Spending time on the computer and/or internet apart from doing homework	Hours	Minutes	Hours	Minutes
Playing outside in the yard at home	Hours	Minutes	Hours	Minutes
Playing with the dog in the yard	○ No dog Hours	Minutes	Hours	Minutes
Walking the dog in the neighbourhood	○ No dog Hours	Minutes	Hours	Minutes

F5. **Were you sick last week, or did anything stop you from doing your normal physical activities?**
(Please shade **ONE** only)

○ Yes

○ No

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SECTION G: MAPPING EXERCISE

G1. You will be given a map which shows your school and the streets around it.

(1) Mark the position of your home on the map with a cross (X).

(2) Use the red pen to draw a line along the roads that you usually follow to get from your home TO school.

(3) Use the green pen to draw a line along the roads that you usually follow to get FROM school to your home.

(4) Marked on the map are shops, parks and other places in the area around your school. Circle all the places that you have walked to or ridden a bike to.

(5) If somewhere that you go to is not marked, put a cross (X) and write what sort of place it is.

(6) If you haven't walked or ridden your bike to any places on the map, please shade the circle below.

○ I haven't walked or ridden my bike to any places on the map

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○ 1	○ 21	○ 41	○ 61	○ 81
○ 2	○ 22	○ 42	○ 62	○ 82
○ 3	○ 23	○ 43	○ 63	○ 83
○ 4	○ 24	○ 44	○ 64	○ 84
○ 5	○ 25	○ 45	○ 65	○ 85
○ 6	○ 26	○ 46	○ 66	○ 86
○ 7	○ 27	○ 47	○ 67	○ 87
○ 8	○ 28	○ 48	○ 68	○ 88
○ 9	○ 29	○ 49	○ 69	○ 89
○ 10	○ 30	○ 50	○ 70	○ 90
○ 11	○ 31	○ 51	○ 71	○ 91
○ 12	○ 32	○ 52	○ 72	○ 92
○ 13	○ 33	○ 53	○ 73	○ 93
○ 14	○ 34	○ 54	○ 74	○ 94
○ 15	○ 35	○ 55	○ 75	○ 95
○ 16	○ 36	○ 56	○ 76	○ 96
○ 17	○ 37	○ 57	○ 77	○ 97
○ 18	○ 38	○ 58	○ 78	○ 98
○ 19	○ 39	○ 59	○ 79	○ 99
○ 20	○ 40	○ 60	○ 80	○ 100

Routes to and from school: ○ Same ○ Different

SECTION H: PICTURES

H1. Below are pictures of the people who work on the TREK project.

In the space on the next page, please draw a picture of yourself and how you would like to get to school.

Billie

Gina

Claire

Karen

0560

This scannable questionnaire was constructed by
Savant Surveys and Strategies
www.savant.net.au
(08) 9325 1500

20728

H2. Please draw a picture of yourself and how you would like to get to school.

THANK YOU FOR TAKING PART IN THE TREK STUDY!