Obesity, Place and Environment

The spatial distribution and correlates of weight status in South Australian preschool children

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Thesis submitted for the degree of Doctor of Philosophy

Discipline of Geographical and Environmental Studies
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June 2010

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Abstract

The issue of overweight and obesity in childhood has received a great deal of recent attention in both the academic literature and popular media. These discussions have tended to concentrate on individual responses to behavioural and nutritional choices, with limited exploration of how the wider social and economic environment might influence weight outcomes. However there is a growing body of research which has identified area level effects on health outcomes, and this suggests that location should be an important consideration in obesity research.

Currently, very little formal investigation of weight status has been conducted among children of preschool age and location is not routinely considered in obesity research, especially at the small area level and particularly with reference to children. Given that childhood overweight is known to persist into adulthood and that behavioural change may be easier to effect in preschoolers, it is appropriate to focus research attention on this age group.

This study explores an administrative data set containing over 120 000 individual records collected over ten years and supplied by the South Australian Children, Youth and Women's Health Service. Geographical Information Systems (GIS) are used to determine the prevalence, distribution and area-level correlates of obesity in South Australian four year old children between 1995 and 2003. It aims to determine if there has been significant variation in the spatial distribution of obesity prevalence between different communities over this time period, and to detect relationships between weight status, socio-economic variables and environmental attributes at a small scale which

may be able to explain some of the discrepancy. These are investigated in conjunction with the data items available for the individual children in this data set.

A univariate analysis approach using cross-tabulation and chi square testing has been used to explore the relationships between the obesity prevalence of the study population and selected socio-demographic and environmental variables at a small area level. The Australian Census of Population and Housing is the primary source of socio-demographic data, but other variables including housing characteristics, proximity to fast food outlets, proximity to recreational areas and the walkability of neighbourhoods have also been examined.

Analysis of this data set reveals an increase in obesity prevalence over time, in line with national and international trends. For individual children, birth weight, ethnicity and breastfeeding history appear to be particularly influential in the development of overweight at four years of age, but there is nevertheless a distinct spatial patterning of obesity prevalence throughout the state, and also within the metropolitan Adelaide area. While there is generally a positive association between socio-economic status and obesity, these relationships are not necessarily straightforward and the area-level physical and social environmental variables actually show a varying relationship with obesity prevalence in different communities.

This study has clearly identified neighbourhood characteristics as an important component in the complex etiology of obesity development in even very young children. It has shown that aspects of environment such as ethnicity and disadvantage should be taken into account when targeting and tailoring public health initiatives to combat the development of obesity in these populations.

The exploration of this unique, administrative data set with reference to location has illustrated the complexity of the relationship between biology and environment in the development of overweight and obesity in young children. This has implications for policy development across many spheres of government.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Julie Franzon and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Julie Franzon

June 3rd 2010

Acknowledgements

A journey like this is never taken alone. To my supervisors – Graeme Hugo, David Wilson and Gary Wittert – I would like to extend my deepest appreciation for their direction, constructive criticism, patience and much needed encouragement throughout all stages of research. Their individual expertise and enthusiasm for my work has been invaluable.

I would like to acknowledge and thank Bob Volkmer and colleagues at the Children, Youth and Women's Health Service; who enabled this study by making the primary data set available to me and supporting me while I came to grips with it. My thanks also to the other government departments and organisations who freely supplied supporting data when requested – in particular DEH, Planning SA and DAIS.

A special thank you to my friends and colleagues in the NOBLE Study and at GISCA, AISR and the Department of Geographical and Environmental Studies at the University of Adelaide for sharing this journey with me and lightening the road. In particular I would like to acknowledge Natasha Howard – my travelling companion on journeys both physical and mental during the last four years.

Finally, love and thanks to my family and friends whose interest and encouragement has meant a great deal to me. But especially to Stephen, Megan and Connor who have cheerfully dealt with my occasional withdrawals from domestic life and given me the freedom and support to pursue my goals.

List of Acronyms

ABS	-	Australian Bureau of Statistics
ARIA	-	Accessibility and Remoteness Index for Australia
ASD	-	Adelaide Statistical Division
ASGC	-	Australian Standard Geographical Classification
ATSI	-	Aboriginal and/or Torres Strait Islander
BMI	-	Body Mass Index
CBD	-	Central Business District
CD	-	Census Collection District
CDC	-	Centres for Disease Control and Prevention
CT	-	Computed Tomography
CYWHS	-	Children, Youth and Women's Health Service
DAIS	-	Department for Administrative and Information Services
DCDB	-	Digital Cadastral DataBase
DEH	-	Department of Environment and Heritage
DXA	-	Dual X-Ray Absorptiometry
GIS	-	Geographic Information Systems
GISCA	-	National Centre for Social Applications of Geographic Information Systems
IOTF	-	International Obesity Task Force
IRSA	-	Index of Relative Socio-Economic Advantage/Disadvantage
IRSD	-	Index of Relative Socio-Economic Disadvantage
LSAC	-	Longitudinal Study of Australian Children
LSG	-	Land Services Group
MARIA	-	Metropolitan ARIA
MAUP	-	Modifiable Areal Unit Problem

MRI - Magnetic Resonance Imaging

NILF - Not in the Labour Force

NOBLE - Nutrition, Obesity, Lifestyle and Environment Study

OR - Odds Ratio

SA - South Australia

SAHT - South Australian Housing Trust

SD - Statistical Division

SEIFA - Socio-Economic Indexes for Areas

SES - Socio-Economic Status

UK - United Kingdom

USA - United States of America

WHO - World Health Organisation

CHAPTER 1

Introduction: Obesity, Place and Data

1.1 Introduction

This thesis is produced within the context of intense medical, academic and media interest in what appears to be a global experience – the obesity epidemic (Hill and Peters 1998; World Health Organization 2000; Strauss and Pollack 2001; 2002; World Health Organization 2003a; Australian Institute of Health and Welfare 2004b; Wang, Youfa and Beydoun 2007). The rise in prevalence of obesity in so many different countries and contexts has captured the interest of the research community such that numerous journals are now dedicated exclusively to the reporting and discussion of this phenomenon. The sheer volume of pertinent literature published each week - along with media focus, and even social discussion – is quite overwhelming. Yet, despite the amassing of a great deal of knowledge, we have so far been unable to even halt, let alone reverse, the trend of increasing prevalence of overweight and obesity in developed and developing countries.

The last five to ten years have also been a period of increasing recognition of the importance of place in the analysis of social phenomena, particularly in health (Kaplan 1996; Yen and Syme 1999; O'Dwyer 2000; Pearce, Witten et al. 2006b). This has been complemented, and perhaps even driven, by the concurrent increase in the availability of spatial data and the adoption of the sophisticated spatial analysis technologies usually referred to as Geographic Information Systems (GIS) (Ricketts 2003; Rushton 2003). During this time there has also been increasing development and integration of more sophisticated analysis tools and programs which have been written specifically to analyse data of which location is a component (Rushton 2003).

Along the way, modern organisational structures have amassed large databases, many of which include some type of locational component. These large, administrative data sets are increasingly being recognised as a valuable resource for social researchers and, where confidentiality and privacy issues can be resolved, as well suited for spatial analysis (Virnig and McBean 2001).

The convergence of these factors has culminated in a unique opportunity for the study of overweight and obesity among preschool children in South Australia. This thesis utilises a large administrative data set within a GIS environment, together with complementary data, to investigate the spatial distribution and correlates of weight status in this population.

1.2 Aims and Objectives

As part of the overarching Nutrition, Obesity, Lifestyle and Environment (NOBLE) Study, this research is supported by an Australian Research Council Linkage Project (LP0455737). The specific aims of this project include, among others, the clarification of the major risk factors for obesity in children, the establishment of socio-economic and environmental factors which may be associated with obesity and the identification of policy implications relating to obesity (Hugo, Ruffin et al. 2004). These project aims serve as a framework to define the aims and objectives of this particular thesis, which is one among several supported by the NOBLE Study.

This study is designed as a descriptive and exploratory investigation of a particular phenomenon, as evidenced in a specific data set, using a specialised set of tools and techniques. To this end, the study is intended to answer one broad research question:

- Is there significant spatial variation in the prevalence of overweight and obesity in South Australian four year old children and, if so, what are the underlying causes of this disparity?

Inherent within the research question are the aims of the study:

- To investigate overweight and obesity in this previously neglected age group
- To identify and explore the spatial and temporal variation in overweight and obesity prevalence among South Australian preschool children
- To identify areas of high and low obesity prevalence within metropolitan Adelaide
- To identify social and environmental characteristics of these areas which may contribute to this variation
- To inform policy by identifying and describing the drivers of obesity in preschool children
- To contribute to the understanding of the underlying drivers of obesity

The stated aims will be achieved using the methods and technology of Spatial Information Science, particularly GIS programs and techniques, as a basis for the organisation and analysis of data. This will enable a new perspective on an issue which has not traditionally been treated geographically, and the inclusion of 'place' as a variable in the analysis offers further insight into the complexity of the obesity phenomenon.

These aims reflect the exploration of a new and unique data set in the context of the environment within which child overweight develops. The outcomes will enhance understanding of the interactions between individual, environment and obesity in young children and will suggest new avenues for investigation by traditional epidemiological methods. This research contributes to the current discourse on childhood overweight and obesity by using new approaches to characterise a specific population, and identifying new correlations between environmental level attributes and overweight prevalence in preschool children.

This research is also timely in that it coincides with a new focus on this age group embodied in the Universal Access to Early Childhood Education initiative, funded by the Australian Government in the 2008 federal budget (Commonwealth of Australia 2008). This initiative recognises the importance of the preschool years as a critical period for all aspects of children's development and aims to provide access to quality preschool education programs for 15 hours a week to all children. It also includes a focus on indigenous and other disadvantaged children who are currently less likely to receive a quality preschool experience but would benefit the most from it. The implementation of this initiative will offer an unparalleled opportunity to act upon the recommendations developed from this research as it will provide a point of interaction with ALL Australian preschool children and their care givers, creating opportunities for the effective monitoring and support of all aspects of their health and well being.

1.3 Key Data

The primary source for this research is an administrative database compiled in South Australia by Child and Youth Health, now an arm of the Children, Youth and Women's Health Service (CYWHS) under the South Australian Department of Health. For many years[1] this organisation has monitored the health of babies and young children in South Australia by offering a series of regular health checkups along with parenting information and support free of charge to all families in the state. These services are available to all children between birth and school entry and the information gathered and measurements made by trained staff at these assessments have been entered into a central database, commencing in 1995[2]. While attendance at many of the recommended checkups is inconsistent, CYWHS estimates that approximately 70% - 80% of South Australian children from each birth cohort attend a preschool health check offered when the child is between 4 and 5 years of age (Vaska and Volkmer 2004). The subsequent data set includes both location information and preschool height and weight measurements for over 120 000 children, which enables the children's weight status to be investigated in terms of their area of residence.

The interrogation of this data set in combination with other, relevant, spatially referenced data sets leads to a distinctive perspective on child overweight and obesity – one which is made possible by the availability of this unique South Australian data source which contains a comprehensive, consecutive record of preschool children in this Australian context and draws on the exciting developments in spatial information

[1] *For a more detailed history of this organisation, see http://www.cyh.sa.gov.au/Content.aspx?p=89*

[2] *Paper records from preceding years are still filed at individual sites. There are no plans to transfer them at this time.*

science to investigate the area-level determinants of overweight and obesity prevalence in this population.

1.4 Overweight in Context

Overweight and obesity have been recognised as contributing to mortality and morbidity since ancient times (Christopoulou-Aletra and Papavramidou 2004; Papavramidou, Papavramidis et al. 2004). In the modern world this has been confirmed by scientific research which identifies obesity as a contributing factor in the development of high blood pressure, cardiovascular disease, type 2 diabetes, psychosocial problems and some cancers, among many others (Fontaine, Cheskin et al. 1996; Bundred, Kitchiner et al. 2001). Obesity is an important component of and contributor to the metabolic syndrome, which carries particularly high risks for morbidity and mortality (Grundy, Brewer et al. 2004). It has even been suggested that the health issues resulting from overweight and obesity are similar in magnitude to those attributable to tobacco use (Catford and Caterson 2003), and that the current generation of children may be the first for many years to have a lower life expectancy than their parents (McTaggart 2004; Marciniak 2008).

In Australia, the latest research has estimated the prevalence of overweight among children and young people of various ages at 20% – 27% with approximately 5% of those being classified as obese (Booth, Michael L, Wake et al. 2001; Magarey, Daniels et al. 2001; Batch and Baur 2005; Booth, Michael L, Okely et al. 2006; Sanigorski, Bell et al. 2007). Between 1985 and 1995, the rate of overweight approximately doubled while the rate of obesity almost tripled (Baur 2003; Booth, Michael L, Chey et al. 2003) and by 2004 – the latest year for which national data are published – overweight prevalence had continued to increase, especially among boys (Booth, Michael L, Okely et al. 2006). It has been estimated that the annual increase in overweight/obesity prevalence equates to approximately 40 000 more Australian children becoming overweight each year (Sanigorski, Bell et al. 2007).

Obesity in general has been widely researched in recent years and the topic has generated a vast literature. It is well understood that overweight and obesity result from an imbalance in energy intake vs. energy expenditure (Hill and Peters 1998; Catford and Caterson 2003; Waters and Baur 2003; World Health Organization 2003b; Finkelstein, Ruhm et al. 2005; Reilly 2006b) and it is generally accepted that the human body is geared to the storage of excess energy in the form of body fat as a buffer against times of drought or famine. In an environment of constant abundance such as the modern Australian lifestyle offers, the weakness of human physiologic mechanisms for shedding excess weight has become all too apparent (Hill and Peters 1998; Marciniak 2008). More recently, the issue of overweight and obesity in childhood has developed its own specific body of literature and it is this work which places the current research in context.

Evidence from a number of countries indicates that prior to 1970, the prevalence of overweight and obesity among children in most western, industrialised countries was relatively low and has since increased two- or three-fold. This trend has been reported in the United States (Strauss and Pollack 2001; Ogden, Flegal et al. 2002; Lederman, Akabas et al. 2004a), Canada (Tremblay and Willms 2000), the United Kingdom (Reilly, Dorosty et al. 1999; Sabin, Crowne et al. 2004; British Medical Association 2005), Europe (Moreno, Sarria et al. 2000; Lobstein and Frelut 2003; Magkos, Manios et al. 2005), and Australia (Magarey, Daniels et al. 2001; Booth, Michael L, Chey et al.

2003). Child obesity prevalence is therefore high in most of the developed world and is even increasing in developing countries, particularly in more affluent urban environments (Kain, Vio et al. 1998; Hui and Bell 2003; Lobstein, Baur et al. 2004).

Most of the statistics cited above refer to school aged children and relatively little attention has been paid to the preschool population. Among the research which has been published, the indications are that preschool children – usually defined as those aged between three and five years – have levels of overweight and obesity comparable to those of older age groups and the prevalence has been increasing at similar rates (Ogden, Troiano et al. 1997; Reilly, Dorosty et al. 1999; Bundred, Kitchiner et al. 2001).

Obesity in preschool children has been shown to track into later childhood and adulthood (Serdula M. K., Ivery D. et al. 1993; Whitaker, Wright et al. 1997; Sugimori, Yoshida et al. 1999; Guo, Huang et al. 2000), where it is notoriously difficult to treat effectively (NIH Technology Assessment Conference Panel 1993; Klesges, Klesges et al. 1995). Many authors have agreed that given this scenario, both treatment and prevention efforts should also be directed towards the younger age groups (Ogden, Troiano et al. 1997; Must and Strauss 1999; St Jeor, Perumean-Chaney et al. 2002; Ells, Campbell et al. 2005; Gardner, Hosking et al. 2009).

While the greatest burden of disease risk is felt by overweight adults, there are some direct health effects of overweight which manifest in childhood (Strauss 1999; Ebbeling, Pawlak et al. 2002; Baur and O'Connor 2004). These have also been comprehensively documented and include insulin resistance which may progress to Type 2 diabetes (Young-Hyman, Schlundt et al. 2001; Sinha, Fisch et al. 2002; Wabitsch, Hauner et al. 2004; Wiegand, Dannemann et al. 2005), liver disorders (Rashid and Roberts 2000; Wieckowska and Feldstein 2005), respiratory dysfunction including sleep apnoea and asthma (Figueroa-Muñoz, Chinn et al. 2001; Gilliland, Berhane et al. 2003; Mannino, Mott et al. 2006) and orthopaedic complications (Kelsey, Acheson et al. 1972; Dietz, Gross et al. 1982). Not every overweight child will suffer all, or indeed any, of these conditions, but overweight children are at greater risk for them and the more overweight the child the greater the risk. Overweight and obese children are also at high risk for social isolation and bullying along with depression and poor self esteem (Ebbeling, Pawlak et al. 2002; Strauss and Pollack 2003; Baur and O'Connor 2004; Janssen, Craig et al. 2004), and obese schoolchildren have even been found to be at greater risk of developing acne (Tsai, Chen et al. 2006).

Despite these immediate effects on health and well being, perhaps the major consequence of childhood obesity is the tendency for overweight children to become overweight adults who are then at greater risk for the spectrum of cardiovascular and metabolic disorders with their associated higher morbidity rates (Serdula, Ivery et al. 1993; Baur and O'Connor 2004; Flegal, Graubard et al. 2005). Longitudinal studies have found that Body Mass Index (BMI) levels of children at all ages are at least moderately associated with their eventual adult BMI and this relationship becomes stronger with the increasing age of the child at baseline measurement (Whitaker, Wright et al. 1997; Strauss 1999; Freedman, Khan et al. 2005).

While it is difficult to measure the true magnitude and significance of this ‘tracking’ – the persistence of overweight and obesity throughout the life course – most current research acknowledges that tracking can and does occur from early ages, (Serdula, Ivery et al. 1993; Guo, Wu et al. 2002; Niclasen, Petzold et al. 2007), but that it is not always possible to identify those children in whom overweight is most likely to persist. What *is* known is that the earlier the tracking commences, the more severe the overweight in adulthood; that the degree of overweight in childhood is related to the risk of being overweight in adulthood (Stark, Atkins et al. 1981; Magarey, Daniels et al. 2003), and that the adults with the highest levels of overweight are most likely to have been overweight as young children (Sugimori, Yoshida et al. 1999). Given this scenario, most authors have come to agree that intervention and prevention measures in childhood are desirable.

However, successful intervention and prevention at both the individual and/or community level must rely on an in depth understanding of the factors underlying the increase in obesity prevalence. The literature on this topic ranges from the examination of specific aspects, such as genetics or breastfeeding, to discussion of the broader social and physical environment in which obesity is entrenched.

1.5 Health and Place

> *"Health and disease are not solely biomedical processes but are subject to social, economic, political, psychological and environmental influences."*
> *(O'Dwyer 2000 p35)*

Traditionally, the individual has been considered as the most desirable unit of analysis for social and health research (Diez-Roux 2001) – i.e. the comparison of the presence or absence of disease and its risk factors in each person against their other characteristics of interest (e.g. gender, ethnicity, income, education). In this way it is possible to statistically prove a direct relationship between, for example, lung cancer and smoking. However it is often difficult to obtain data for research at the individual level. Except in places where high-quality surveillance systems exist, even if individual records of disease occurrence are available it is unlikely that the full range of socio-economic and other variables of interest will be recorded for those individuals (Krieger 1992). Sometimes this is because these types of data are simply not collected concurrently, but often sensitive data are aggregated to some type of higher spatial unit to preserve privacy and confidentiality. A prime example of this is census data – both in Australia and overseas these data are collected for individuals but released in aggregated form.

Furthermore, with the growing interest in neighbourhood and area effects on health has come the realisation that perhaps area level characteristics have an influence beyond that of simply being a proxy measure for individual characteristics (Diez-Roux 2001). Although exposure to things like environmental pollution and vector-borne disease have long been recognised as being intrinsically linked with place, the advent of non-communicable conditions like obesity into the spatial epidemiological literature is a relatively new phenomenon. However there is now a clear recognition that people living in lower socio-economic status (SES) neighbourhoods have higher incidence of ill-health – including obesity - than those in higher SES environments, (Malmström, Sundquist et al. 1999; Pickett and Pearl 2001; Bernard, Charafeddine et al. 2007; Henry, Sherman et al. 2009), but traditional public health approaches may have failed to examine some of the more subtle aspects of place.

1.6 Spatial Epidemiology

Spatial Epidemiology is concerned with both the description and understanding of spatial variation in health outcomes. It involves the analysis of the geographical distribution of disease and, more recently, well-being (Elliott, Wakefield et al. 2000). Geographic Information Systems are increasingly used as the spatial engine in this type of investigation, bringing the power of modern computing to the modelling and mapping of disease and environmental relationships.

Health and ill-health always have a spatial dimension, as a person's place of residence correlates with both socio-demographic and environmental exposures (Loslier 1996).

An early and influential example of the importance of place in the analysis of health is the seminal study carried out by Dr John Snow in 1854 to trace the cause of a cholera epidemic in London. By mapping the distribution of cholera cases, he hypothesised that the source was a contaminated water supply. The epidemic was contained by removing the appropriate pump handle (Jarup 2000).

While Snow's study illustrates the epidemiological value of a simple mapping exercise (visualisation), modern GIS allow us to carry out far more complex research and analysis. The capability to handle multiple, large data sets for the management, analysis and display of geographic data is key to the comprehensive investigation of health problems and solutions.

1.6.1 Thinking Spatially

The terms 'space' and 'place', while often used interchangeably, are defined differently in geographical theory. While 'place' denotes a specific location, 'space' implies a dimension within which things are distributed. Curtis and Jones (1998) provide a good summary of these concepts. The current study is primarily concerned with *place*, as it attempts to identify and characterise obesity prevalence and other attributes at particular locations.

Place – or location – can be considered as another variable when analysing health data. Similar to gender, ethnicity, education or occupation, location is often related to health outcomes (Ellaway, Anderson et al. 1997). The reality is that some population sub-groups will exhibit a much higher or lower prevalence than the overall population, and these are of particular interest to the researcher as they may potentially provide the most information about the contributors and inhibitors for that health condition.

Health may vary across space simply because communities vary across space. Economic and social processes tend to drive the development and characteristics of residential communities, and different neighbourhoods can often have quite distinct demographic characteristics (Cromley and McLafferty 2002). An example of this process might be the concentration of a refugee population in a near-city suburb with transient housing, or fishing families in a seaside town. Each community will have similarities in such factors as ethnicity, education, employment and income which can be related to social functioning – attitudes and experiences which in turn reflect knowledge and priorities and form the basis for lifestyles and values, and it is these lifestyle choices which underlie many modern disease processes.

Different places also have different physical characteristics. Terrain may vary. Distance to key places such as the coast or the urban centre will vary, so this is also an attribute of place. Built environmental features – e.g. hospitals, community centres, factories - are distributed throughout the landscape but not necessarily equally and the presence or absence of these is also a characteristic of place. The type of employment available could be seen partly as an expression of these factors, and they all work together to influence the social environment of towns and neighbourhoods.

If these differences between places are recognised, they can add much to the analysis of health phenomena. The first step lies in recognising if and how a health condition varies between different locations. If such variance is observed, the researcher must then ask what it is about a certain place which contributes to the higher or lower prevalence. With the spatially referenced data sets available, location can also be used to link health data with other information about the people who live in those places, and some attempt can be made to explain the observed disparities.

1.6.2 Linking Health and Environmental Data

The key to incorporating aspects of space into an epidemiological study lies in the linkage of the health data with the available environmental data. GIS techniques and technology greatly facilitate this linkage and have been increasingly incorporated into the health sector over the last two decades, both in the fields of epidemiology and health service planning, and this has facilitated the comparison of the distribution of disease with the distribution of other factors (Briggs 1996; Rushton 2003). This methodology has been used quite widely in the past to determine health service catchment areas and support planning and resource allocation decisions in this area (Rushton, Elmes et al. 2000; McLafferty 2003; Spencer and Angeles 2007); and it is increasingly being used to generate the visualisation and testing of hypotheses in an epidemiological context (Briggs 1996). Small-area analysis of chronic conditions is an emerging application for these techniques and technology (Elliott and Wartenberg 2004).

Of course the utility of this type of analysis is highly dependent upon the range and quality of both the health and environmental data which is input. This is somewhat simplified in the case of biological or emissions exposures, but in socio-demographic analyses it is likely that not all confounding variables can be adequately accounted for. This type of research is therefore more suited to hypothesis generation and supportive analysis than definitive clinical epidemiology (Elliott and Wartenberg 2004).

1.6.3 Children and Place

Children are very much influenced by their environment. The family has the most impact on a child's life – especially in the case of preschoolers who are generally reliant on the family for their experiences and attitudes (Shonkoff and Phillips 2000a). Even children who receive input from child care situations are placed in those situations due to circumstances within their own family, and the decisions on the type of care and parental engagement with the care givers are all reflections on the child's family dynamics and attitudes. If such decisions are influenced, or choices are limited, by affordability then this is also a function of the economic resources of the family.

Given the importance of the family unit to a four year old child, it would not be surprising to find that overweight in this age group is most closely linked to familial factors and influences (Agras, Hammer et al. 2004; Zeller and Daniels 2004). However, families live and interact in defined spatial locations. This physical and social environment can be as small as a street or neighbourhood, or as large as a city or state.

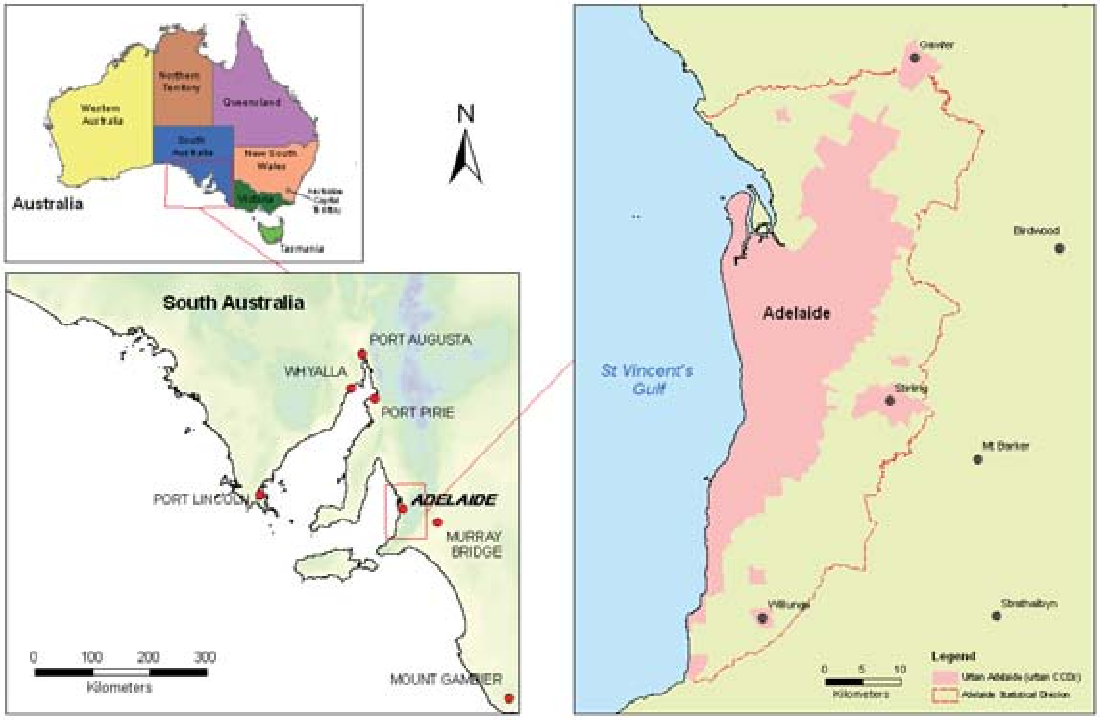
The geographical literature confirms that similar things tend to occur near each other. This is known as spatial autocorrelation and it can be seen in both physical (e.g. soil types) and social phenomena (O'Sullivan and Unwin 2003). People of a similar culture will tend to group together, as will people who have similar incomes or similar employment standing. Factors like this tend to overlap as employment, for example, generally influences income. Nor are the boundaries hard and fast – it is not possible (and would be inappropriate) to identify discrete borders for such amorphous characteristics. Bearing this in mind, though, it is possible to identify the general areas in which high numbers of people with certain characteristics live and it is also possible to characterise areas according to the traits of the people who live there. If these characteristics of area can be linked to the prevalence of obesity in four year old children, then this research will add much to the current dialogue which seeks to characterise the obesity epidemic and identify targets for prevention and intervention.

1.7 South Australia – The Big Picture

Located in the southern central region of the Australian continent, the state of South Australia has a large land area – approximately 984 000km² - and a relatively small population of just over 1.5 million people (see Figure 1.1). The majority of the population – over 1 million people or nearly 80% - live in or near the capital, Adelaide (see Figure 1.2 – 1.5), and in the major regional centres of Mount Gambier, Murray Bridge, Whyalla, Port Pirie, Port Augusta and Port Lincoln. Widely scattered smaller towns support the remaining rural/agricultural and mining population (Australian Bureau of Statistics 2006).

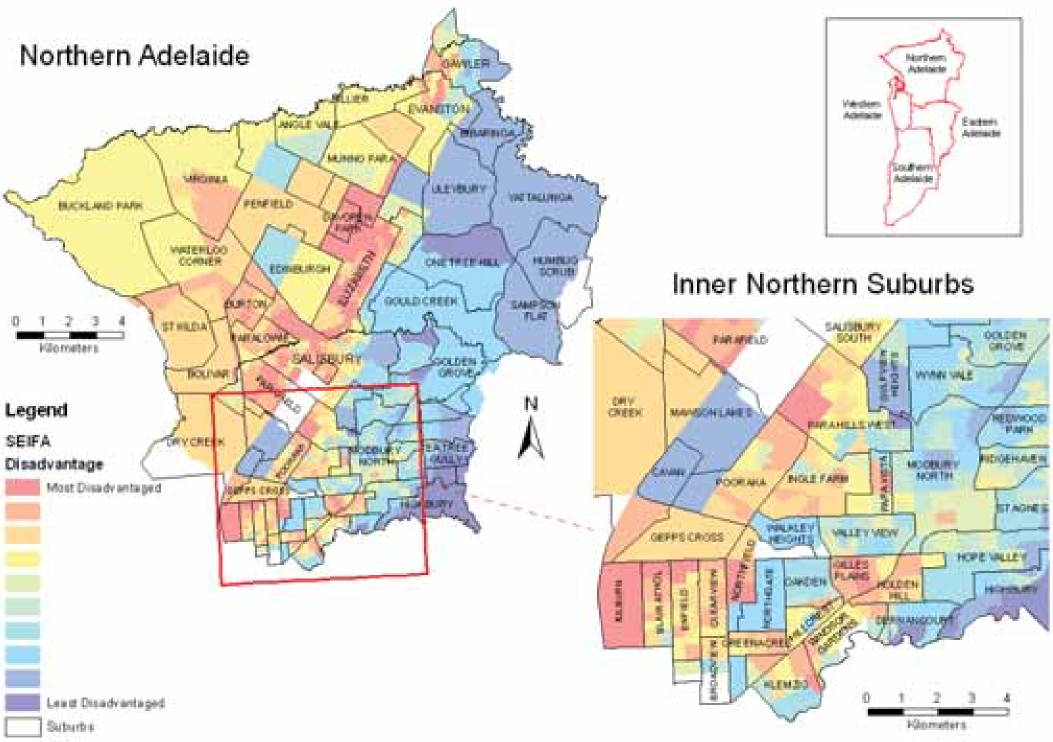
The following series of maps depict the locations of not only the regional centres (Figure 1.1), but also metropolitan Adelaide by Statistical Region (Figure 1.2 – 1.5). These metropolitan maps also display the Socio-Economic Indexes for Areas (SEIFA) index of relative socio-economic disadvantage (IRSD) for each area. The Australian Bureau of Statistics (ABS) compiles this index to quantify the socio-economic status of Census Collection Districts (CDs) relative to each other. The IRSD incorporates attributes such as low income, low educational status, high unemployment and other variables which reflect disadvantage, (Australian Bureau of Statistics 2003). In this context, the IRSD provides an insight into the distribution of more and less disadvantaged areas across metropolitan Adelaide – a spatial pattern which is relevant to much of the ensuing discussion regarding the links between socio-economic disadvantage and overweight.

Figure 1.1 Location map for Adelaide, South Australia



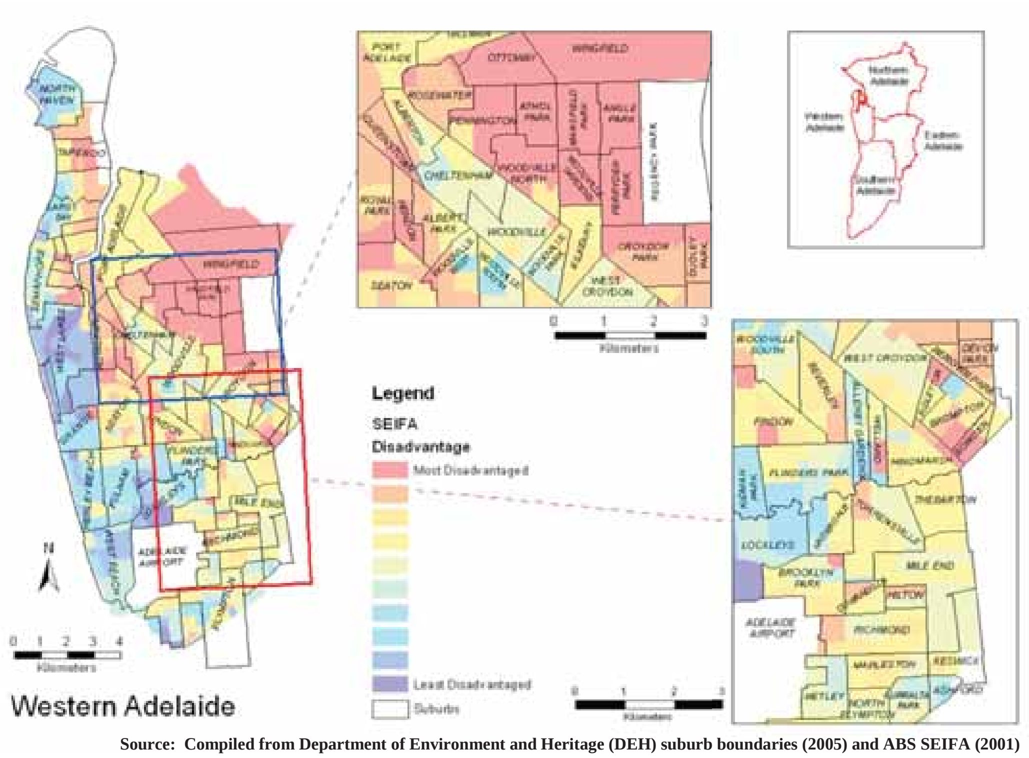
Source: ABS boundaries and locations, 2001

Figure 1.2 Detail of Northern Adelaide suburbs with relative disadvantage index



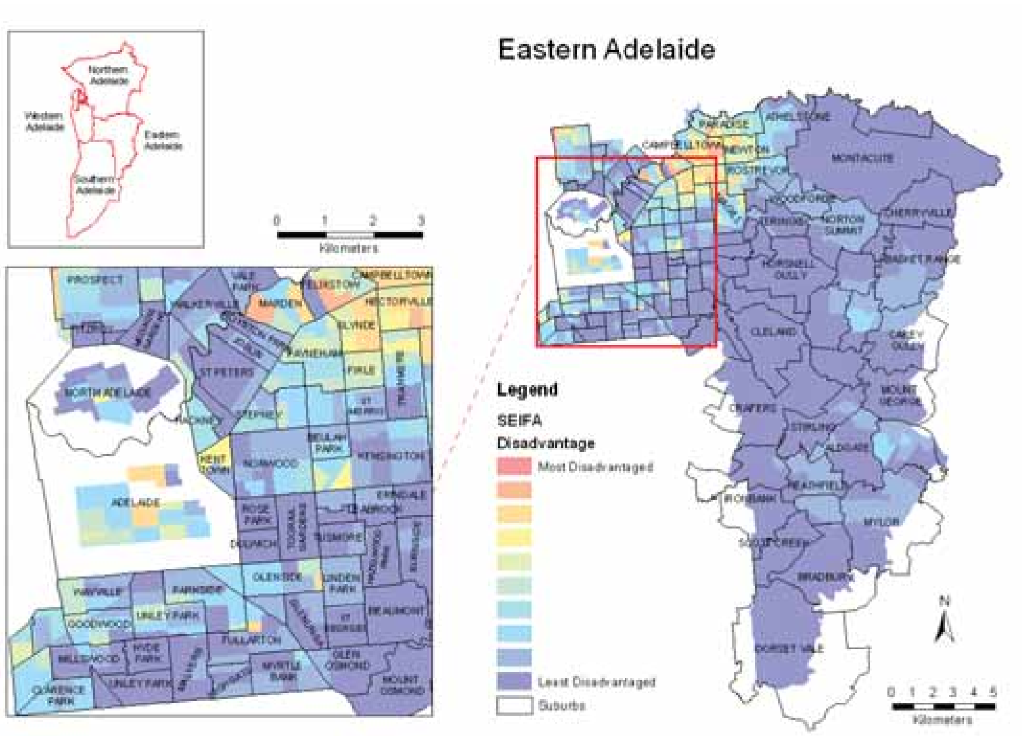
Source: Compiled from Department of Environment and Heritage (DEH) suburb boundaries (2005) and ABS SEIFA (2001)

Figure 1.3 Detail of Western Adelaide suburbs with relative disadvantage index



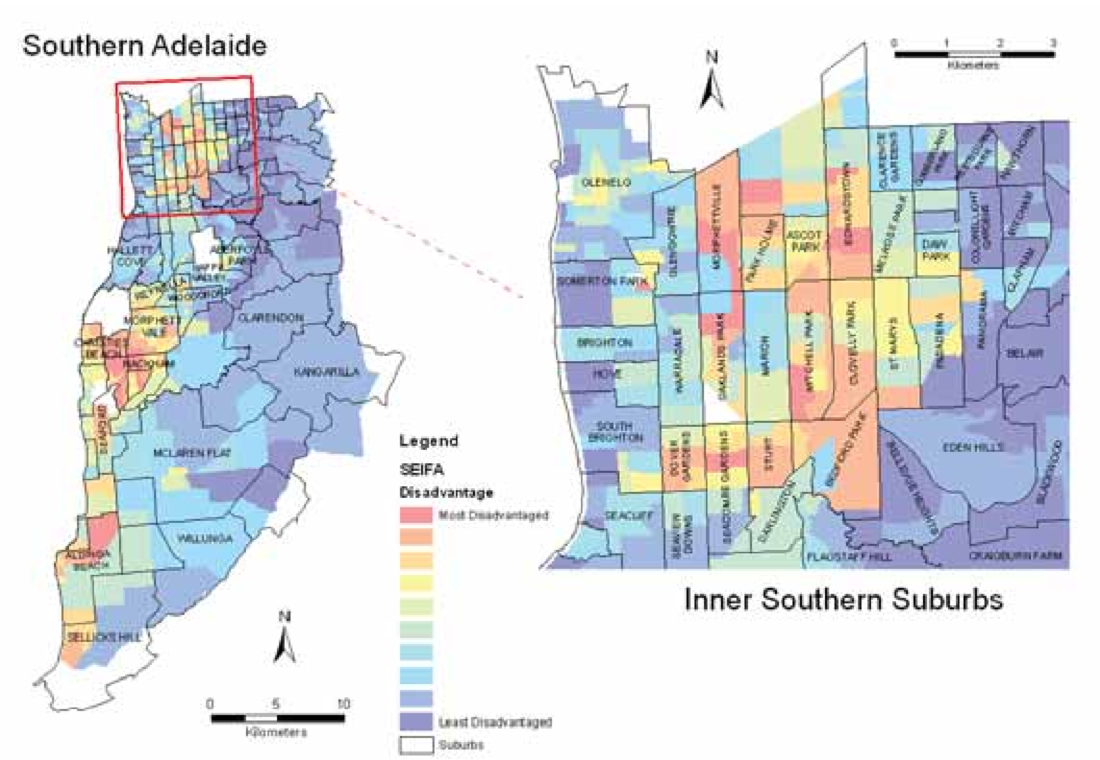
Source: Compiled from Department of Environment and Heritage (DEH) suburb boundaries (2005) and ABS SEIFA (2001)

Figure 1.4 Detail of Eastern Adelaide suburbs with relative disadvantage index



Source: Compiled from Department of Environment and Heritage (DEH) suburb boundaries (2005) and ABS SEIFA (2001)

Figure 1.5 Detail of Southern Adelaide suburbs with relative disadvantage index



Source: Compiled from Department of Environment and Heritage (DEH) suburb boundaries (2005) and ABS SEIFA (2001)

South Australian children are being born into and raised in communities that reflect immigration policy and trends since the Province was proclaimed in 1836. Initial colonisation by British settlers and subsequent waves of immigration from the United Kingdom (UK) and Ireland, particularly in the post war period, established and perpetuated a white, Anglo-Saxon population as the dominant cultural influence. Meanwhile, significant numbers of immigrants from other regions have also formed distinct communities, for example German Lutherans settled in the Barossa Valley and the Adelaide Hills; Greek and Italian migrants settled in areas like Port Pirie, the Riverland and the Western and Eastern suburbs of Adelaide, (adjacent to the River Torrens), and Vietnamese refugees formed communities which are concentrated in the Western suburbs (Migration Museum 1995). In 2001, the overseas born population of South Australia totalled almost 300 000 people, of which 83% (250 000 people) lived in metropolitan Adelaide (Australian Bureau of Statistics 2002).

Indigenous Australians occupy a unique place in the socio-demographic structure of South Australia. Although only representing approximately 1.6% of the total population, (Australian Bureau of Statistics 2002), these descendants of the native inhabitants of the Australian continent exhibit some of the highest levels of disadvantage in such indicators as income, unemployment, education and health – especially when these statistics are compared to those of non-indigenous South Australians (Hugo 2003; Hetzel, Page et al. 2004). This disadvantage appears to have its roots in the displacement and marginalisation of Aboriginal peoples which occurred with European settlement (Gibbs 1990; Migration Museum 1995). In 2001, almost 23 500 people in South Australia were identified as indigenous (Australian Bureau of Statistics 2002).

Today, the majority of the state's aboriginal people live in regional and remote areas. However there is a significant indigenous population of almost 11 000 people in the metropolitan area (Australian Bureau of Statistics 2002), largely concentrated in the northern and western suburbs of Adelaide, which represent a continuing trend towards the urbanisation of South Australia's indigenous population (Hugo 2003).

South Australia has an aging population structure with 14.4% aged 65 or over in 2001 and predicted to increase to nearly 17% by 2011 (Australian Bureau of Statistics 2008b). There is a correspondingly low fertility rate, however fertility is not distributed evenly throughout the population but is related to socio-economic status. Fertility is higher among low SES women, and also among indigenous women (also predominantly low SES) who also tend to have children at a younger age (Hugo and Franzon 2006; Australian Bureau of Statistics 2008a). The implications of these statistics are that more South Australian children are being born into and raised in lower SES households where they have more siblings and their parents are younger than those of children born to high SES mothers. These statistics are significant for this research which links socio-economic indicators with the weight status of four year old children.

1.8 Structure of the thesis

This thesis is structured so that the issue of overweight and obesity in South Australian preschool children is explored with reference to the global epidemic of overweight and obesity. Locally available data and statistics are used to build up a picture of the distribution and correlates of overweight in the study population, starting from a broad perspective and gradually focusing in on smaller geographical areas.

Chapter 1 has introduced the topic and presented the aims and objectives of this research, along with a brief description of the primary data and the concept of health and place. This chapter has also introduced the state of South Australia – its history, geography and demography – which is the background within which this population of preschool children have been born and raised.

Chapter 2 reviews the current literature on overweight and obesity, with particular emphasis on research relating to children. This chapter summarises the general and specific factors which have been identified as possibly contributing to the development of overweight in individuals and populations. The concepts and measurements underlying the definitions of overweight and obesity for both children and adults are also reviewed, as these theories underpin the choice of criterion standard used in the analysis of the CYWHS data set. Current initiatives for the prevention and treatment of overweight in children are also explored in light of the aim to develop policy recommendations from the current study.

Chapter 3 presents an in-depth examination of the primary data set supplied by the CYWHS. The quality and extent of the data are verified, and comparisons are made with appropriate census data to identify any sections of the population which may be under-represented in the database. The processes and decisions used to determine the final set of records used for analysis are also reviewed. Supplementary data sourced from other agencies is also summarised in this chapter, and the ecological and statistical methods used to integrate these data with the CYWHS database are introduced.

Chapter 4 begins the exploration of the CYWHS data set in relation to the overweight and obesity prevalence of the children. Moving from a state-wide perspective on the change in prevalence over time through to increasingly finer levels of location classification we can see that children living in different types of communities exhibit different patterns of overweight and obesity prevalence. A more comprehensive analysis of the overweight prevalence among children living within the six regional cities of South Australia is presented, and the distribution of overweight among children living in metropolitan Adelaide is also examined in more detail.

Chapter 5 progresses to an assessment of overweight prevalence according to the few individual characteristics of the children which have been derived directly from the CYWHS database. This analysis includes such variables as birth weight, breast feeding status and language group, which prove to be quite influential in the development of overweight in this population. This analysis is then expanded upon with the introduction of variables derived from environmental data sets for which values for individual children in the urban area have been extracted. These physical environmental factors include housing, recreation and fast food restaurants, among others.

This analysis is expanded upon in Chapter 6 with the inclusion of area level census data to investigate the correlations between neighbourhood socio-economic measures and obesity prevalence among the urban study population. The comparison is performed by grouping the urban CDs into quintiles according to the percentage of the population recorded for each census variable of interest, and cross-tabulating the census quintile with the percentage of obese children in those same CD groupings.

Chapter 7 focuses more closely on the differential distribution of overweight prevalence among the study population in urban Adelaide and demonstrates the use of GIS and kernel density techniques to create surfaces from which areas of high or low concentrations of overweight children can be identified. Five small areas derived from this analysis are then further scrutinised in terms of some of the socio-demographic and environmental variables which have shown a relationship with obesity prevalence in previous chapters. The five areas are compared with each other and with the urban area as a whole to determine if the relationships between census and environmental statistics are robust at the small area level.

Chapter 8 summarises the findings of this study and revisits the original aims and objectives in light of the outcomes from the area level analysis of socio-demographic and environmental variables. Final recommendations are given for both current policy directions and for further research to support the development of even more appropriate public health policy initiatives.

1.9 Conclusion

The exploration of this unique South Australian data set with an emphasis on the contribution of place to the development of overweight and obesity in preschool children will require the synthesis of both data and techniques to develop an understanding of the ways in which the various socio-demographic and physical environments surrounding these children influence the energy imbalance which manifests as overweight. The ability to link disparate data sets based upon location will be the key which enables this to occur.

Using these available data and techniques it will be possible to contribute to the global obesity debate from a new perspective which has implications for both South Australian and other government policy development. Identification of the population distribution and correlates of overweight in four year old children may also indicate where social and demographic processes are operating in other age groups, so that policy/intervention can be maximised for all sectors of the population.

CHAPTER 2

Informing the Present:

Childhood Obesity in the Literature

2.1 Introduction

This chapter explores the issue of overweight and obesity by reviewing the existing literature and identifying the potential contributors to this epidemic. It is particularly important to place the current work in context by reviewing the existing knowledge regarding the determinants of obesity in children. While the imbalance in energy intake vs. energy expenditure – manifested in such behaviours as increase in sedentary activities, decrease in incidental physical activity and the ready availability, promotion and consumption of energy dense foods (McLennan 2004) - can be seen as the root cause of overweight and obesity (Papas, Alberg et al. 2007), it is the drivers behind this imbalance which must be understood if there is to be any hope of modifying those behaviours. The issues identified here have been used to guide the investigation of the CYWHS data set in terms of the identification of overweight and obesity in young children, and the recognition of social and environmental variables which may prove to influence the overweight prevalence in this population.

This discussion falls naturally into three aspects – biology, social environment and physical environment. While some research has investigated the relationships between obesity and possible causal factors from more than one of these categories, most studies have concentrated on a limited number of variables from a single perspective. Nevertheless, looking at many variables concurrently is desirable if the researcher is to fully appreciate the complexity of the interactions between biology, environment and weight status, and to detect meaningful patterns which might offer some insight as to the best targets for intervention.

Given the paucity of published literature specifically dealing with overweight in preschoolers, this review has not been limited to any particular age group. The determinants of obesity in older children and adults have been much more widely researched and provide a useful guide to the factors which should be considered in undertaking this type of research in a preschool population.

2.2 Definition of Child Overweight and Obesity

The terms 'overweight' and 'obesity' are attempts to classify levels of adiposity (fatness). Obesity generally refers to the level of adiposity at which health risks are clearly elevated (WHO Expert Committee on Physical Status 1995). Overweight has also been called 'pre-obesity' and refers to a level of adiposity which may, on its own, affect health and well-being and is of concern because of the potential to progress to obesity (Health Canada 2003). Importantly, only in adults have increasing health risks been associated with a particular level of overweight. In children, we generally rely on definitions which identify the normal range of height/weight (or other measure) for that age group and classify individuals whose measurements fall outside of those ranges as either overweight or underweight. An appropriate and valid definition of overweight and obesity in young children is a key requirement for this work, as it forms the basis for the measurement and classification of the CYWHS children according to their weight status.

Adiposity in both children and adults can be measured in a number of different ways. Computed tomography (CT) and magnetic resonance imaging (MRI) provide the most accurate determination. Dual-energy x-ray absorptiometry (DXA) is another scanning method which can be used with a high degree of confidence to assess the actual percentage of body fat. The use of these methods in small research studies is established and accepted, however none of them are practical or financially viable for the routine assessment of adiposity in population or epidemiological studies. Likewise measures of total body density, total body water or total body potassium are complex procedures requiring laboratory and other resources (Lohman, Boileau et al. 1975; Aboul-Seoud and Aboul-Seoud 2001)

A number of anthropometric measures of adiposity have therefore been developed which are economical and straightforward to use at the population level. These include skin fold thickness, waist circumference, hip-waist ratio and body mass index (BMI). These measures have been shown to generally correlate with measures of adiposity obtained using the more precise scanning or laboratory methods (Forbes and Amirhakimi 1979). Because of the typically uneven distribution of body fat, the use of one anthropometric measurement in preference to another will result in slightly different prevalence rates of overweight and obesity identified in a given population (Gill, Chittleborough et al. 2003). Ideally, then, some combination of the anthropometric measures would be used to improve the estimation of total body fat, but in reality (especially in clinical settings) this may be impractical.

Anthropometric measures are usually assessed in relation to criterion standards - values above which health risks become apparent (Kuczmarski and Flegal 2000). These values are related to risk in populations, and are not recommended as a definitive guide for clinical intervention in individuals. It should be remembered that overweight and obesity and their associated health risks actually occur on a continuum such that an individual with measurements below the indicated values may still be at risk of chronic health problems (World Health Organization 2003b).

Body Mass Index (BMI), calculated by dividing a person's weight in kilograms by their height in metres squared - wt(kg)/ht(m^2) - is perhaps the most commonly used indicator of adiposity in both adults and children. The measurement of height and weight does not require specialised equipment, is not invasive and can be carried out in almost any setting. While not a perfect indicator of adiposity, BMI has been validated against measures of body density (Bellizzi and Dietz 1999) and is accepted as an indicator of body fat (WHO Expert Consultation 2004; Reilly 2006a). Height and weight can be self-reported but are best measured according to a clinical protocol which eliminates the tendency for bias in self reported data (Kuczmarski and Flegal 2000; Australian Institute of Health and Welfare 2004a).

The BMI cut off values recommended by the World Health Organisation of 25kg/m^2 (overweight) and 30kg/m^2 (obesity) for adults (Australian Institute of Health and Welfare 2004a) have been linked to increased risk of morbidity (Willett, Dietz et al. 1999) and mortality (Flegal, Graubard et al. 2005) and are used as a common reference standard throughout the world (Kuczmarski and Flegal 2000). However there is some evidence to suggest that these values are not appropriate for all ethnic groups. Specifically, morbidity and mortality increases at lower BMI values for people of Asian descent, (WHO Expert Consultation 2004), and at higher BMI values in Polynesian populations (Inoue and Zimmet 2000; Denney-Wilson, Booth et al. 2003). Given the rapid increase in the size of these two populations in Australia in recent years (Australian Bureau of Statistics 2007), this may have implications for the use of BMI in an Australian context.

In children, although high BMI-for-age has been validated as an indicator of increased morbidity (Janssen, Katzmarzyk et al. 2005), it has not been determined if there is a particular degree of adiposity above which health risks become apparent. This is complicated by the fact that children's BMI exhibits normal variation during their periods of growth and development. Therefore charts are used which relate BMI to age and sex and identify the population ranges for children and adolescents between 2 and 17 years of age, (Cole, Bellizzi et al. 2000; McLennan 2004). In the 1970s, the Centers for Disease Control and Prevention (CDC) in the USA developed a set of height-for-age and weight-for-age charts for infants and children which were used to monitor the growth patterns of individual children. In 2000 these were updated using measurements from a more modern reference population. This 2000 update also included for the first time BMI-for-age percentile charts for both girls and boys. Documentation relating to these charts recommends using the 95th percentile as a cut off for 'overweight' and the 85th percentile as the cut off for 'at risk of overweight' (Centers for Disease Control and Prevention 2002), which correspond to 'obese' and 'overweight' respectively. These charts have been widely used in international settings to evaluate growth and development in childhood.

Another standard for overweight and obesity in childhood has subsequently been developed by Cole *et. al.* (2000) which uses an international reference population of children aged 2 – 18 years from 6 different countries. The centile curves which have been developed pass through the significant adult BMI values of 25kg/m^2 (overweight) and 30kg/m^2 (obese) at the age of 18, corresponding to the increased risks of morbidity and mortality seen at these levels in adult populations. Once again, gender specific charts have been developed to take into account the differences in growth rate and body composition between the sexes. On the negative side, it has been found that, at least in some populations, these international definitions are less sensitive than national reference standards in the detection of obesity and that they may erroneously identify a higher obesity prevalence in girls than in boys (Reilly 2006a). Nevertheless, the use of an international reference population and the relationship with significant adult BMI cut-off values means that this standard is less arbitrary in nature, and the value of an international reference for consistency in measurement and comparison across populations is significant.

A recent paper examined the two currently accepted definitions and recommended that both be adopted as standard references of child overweight/obesity in Australia - the CDC BMI-for-age charts for clinical use[3] and the Cole international definitions for use in research settings (Denney-Wilson, Booth et al. 2003 p76). This recommendation has been endorsed by the Australian Institute of Health and Welfare (Australian Institute of Health and Welfare 2001 p84). Given this recommendation, and the increasing use of this new standard in worldwide obesity research, the Cole international definitions have been used in this study to identify the population prevalence of overweight and obesity in the CYWHS data set.

2.3 Similar Studies

Although the current study is unique in the amount of data analysed in relation to this age group and in the way in which it has been spatially referenced, the published literature includes several examples of studies where some aspects have parallels with the current project. The results from these analogous studies point to issues which can be investigated in greater depth using the CYWHS data.

[3] There are currently no Australian BMI-for-age reference charts – CDC BMI-for-age charts are recommended for use in clinical practice (Australian Institute of Health and Welfare 2001, p.84).

In an Australian context, the weight status of preschool children as an exclusive group has been reported by only a small number of authors (Campbell, M, Williams et al. 2006; Zuo, Norberg et al. 2006). Children of this age are also included in the Longitudinal Study of Australian Children (LSAC) (Sanson, Nicholson et al. 2002; Wake, Hardy et al. 2007) and the Sentinel Site for Obesity Prevention (Kremer, Bell et al. 2006; Sanigorski, Bell et al. 2007) and the literature developed from these two studies also includes analysis of the relationship between overweight/obesity and a number of possible determinants. The prevalence of overweight (including obesity) among preschool aged children reported in the Australian literature ranges between 19% and 30%. However, the two study populations with the highest prevalence – Kremer *et al.* (2006) and the Sydney cohort reported by Zuo *et al*. (2006) - are drawn from low SES environments where overweight and obesity might be expected to be higher than among a more representative population. If these populations are removed from consideration, the prevalence range reported from these recent Australian studies is between 19% and 25%, which is comparable to the 19.4% previously reported from the CYWHS data for 2002 (Vaska and Volkmer 2004).

Administrative data are being increasingly used for health related research (Frohlich, Dunn et al. 2007), and Bundred *et al*. (2001), Jones *et al*. (2005) and Brunt *et al.* (2008) have used UK data sets which are similar to the CYWHS data to detect increase in overweight prevalence over time. Similar studies have also been conducted in Canada (Canning, Courage et al. 2004) and the USA (Hernandez, Uphold et al. 1998) using administrative data, but only for one birth cohort so population temporal change cannot be determined.

Spatial analysis is also being used – generally in a limited fashion – to explore the issue of obesity in children. It has been used to assess the relationship between children's weight status and such factors as neighbourhood crime rates and proximity to fast food restaurants (Burdette and Whitaker 2004). Differences in overweight prevalence by area of residence have been documented in preschool children in the UK (Hawkins, Griffiths et al. 2007), but area of residence - often reported as neighbourhood SES - as a variable is more likely to be found in the literature pertaining to overweight in older children (Kinra, Nelder et al. 2000; Tudor-Locke, Kronenfeld et al. 2007) and adults (Ellaway, Anderson et al. 1997).

A recent study published by Procter *et al.* (2008) has drawn together many of these elements in a spatial assessment of obesity and its area-level covariates for a population of children, including preschool children sampled through routinely collected data, in the city of Leeds. The covariates for each area included measures such as social capital, fruit and vegetable consumption and household spending on food, which are beyond the scope of this study; however these were calculated using micro simulation rather than directly measured. Nevertheless, the authors were able to apply Geographically Weighted Regression (Fotheringham, Charlton et al. 2002) and thus determined that many covariates have a different relationship with obesity in different areas, which sometimes contradicts the global relationship. This is an important finding for the current research, as it highlights the spatial variability of both obesity prevalence and area-level contributing factors in a similar population.

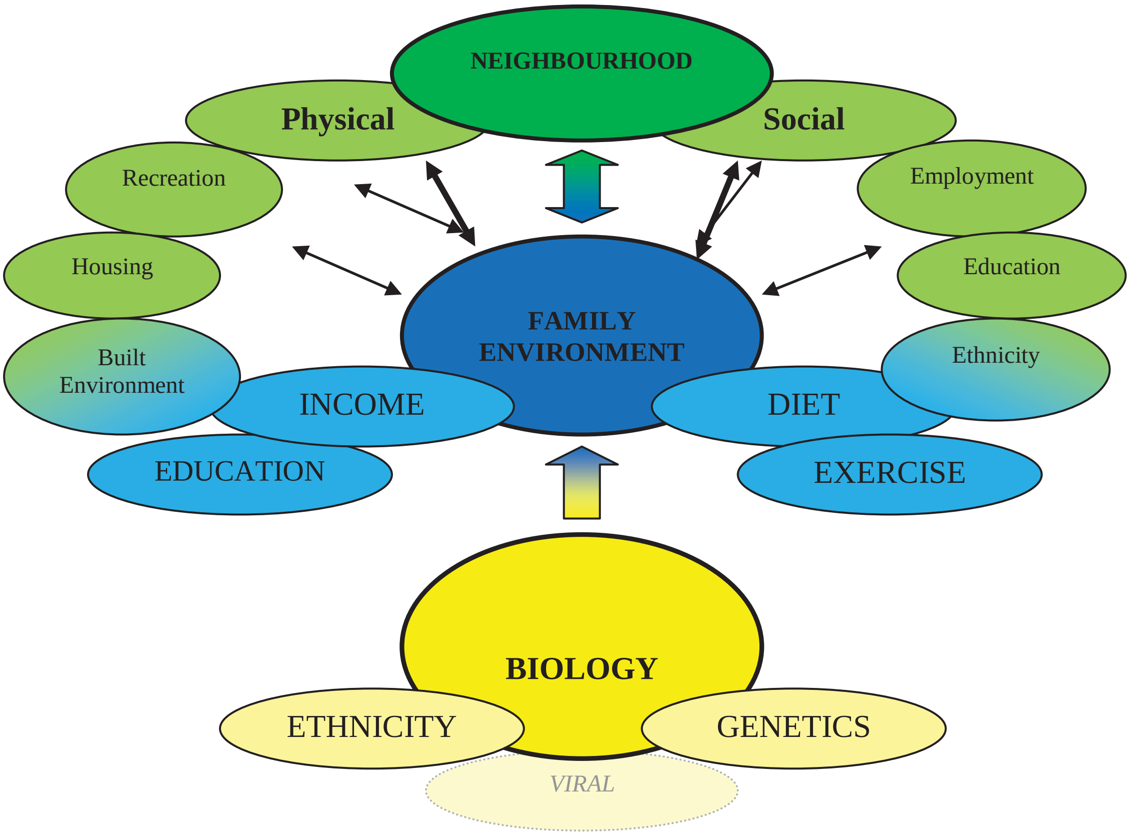
Overall, it can be seen that there is some precedent, particularly in recent years, for the type of analysis proposed for the current study. The use of administrative data sets and area level variables for the investigation of obesity in children has been established, and the potential for building on this existing research using the large, state-wide CYWHS data set and spatial information techniques and technology to link a wide range of data is clear.

2.4 Risk Factors for Overweight and Obesity

As one of the aims of this study is to identify social and environmental characteristics which may contribute to spatial variability in obesity prevalence, it is important to recognise those factors which have already been shown to have a relationship with overweight. Knowledge of these factors will guide the choice of variables for inclusion in the current study in such a way as to offer new insights while building on the existing knowledge base. This section contains only a relatively brief overview of the many themes which have been researched quite extensively. Factors which have been chosen for further analysis in this study are discussed in greater depth in later chapters.

As mentioned earlier, the factors identified fall roughly into three categories – physical environment, social environment and biological determinants (Swinburn, Egger et al. 1999). These categories are not necessarily discrete – for example, breastfeeding could appropriately be considered as either a biological or a social environmental factor - and it is likely that factors from all categories interact to promote the current obesity crisis; however they serve as a useful guide to structure this discussion. Figure 2.1 (below) provides a conceptual summary of the determinants of overweight in children and the complex interaction between all facets. In this model, biology has an underlying role which modifies the influence of the physical and social aspects of both families and neighbourhoods in the determination of child weight status.

Figure 2.1 The Determinants of Childhood Overweight



Source: Compiled by the Author

2.4.1 Biological Factors

It is clear that an individual child's risk of overweight is at least partially influenced by genetic factors and the intrauterine environment (Bouchard 1995; Allison and Faith 1997; Chagnon, Rankinen et al. 2003; Druet and Ong 2008). In the general population[4], it has been suggested that genetic factors account for anywhere between 20% and 90% of variance in BMI. (Maes, Neale et al. 1997), with a number of genes associated with a predisposition to excess adiposity (Comuzzie and Allison 1998; Baur and O'Connor 2004).

[4] Excluding people born with a recognised genetic syndrome, such as Bardet-Biedl Syndrome, of which obesity is characteristic.

Until very recently, it has been accepted that the human genotype has not changed over the last few decades, so that genetics could not be held responsible for the current high rates of overweight and obesity. It was argued that it is the influence of altered environmental factors which have made the expression of ‘obesity genes’ much more widespread (Hill and Peters 1998; Dietz and Gortmaker 2001; Ebbeling, Pawlak et al. 2002). However, recent research in the field of epigenetics has established that small, *heritable* changes do occur over a person’s lifetime which can change the phenotype expressed by the underlying genotype (Fraga, Ballestar et al. 2005; Junien, Gallou-Kabani et al. 2005). This is an emerging field of research which has the potential to contribute a great deal to our understanding of overweight and obesity. If it is true that heritable changes occur during the lifespan, it may be even more important to prevent obesity – and potential epigenetic changes – from occurring in young children.

In this context, it is important to note that numerous studies have established a strong correlation between parental and child obesity (Klesges, Klesges et al. 1995; Agras, Hammer et al. 2004). Overweight mothers are also more likely to have high birth weight babies, which has also been linked to later obesity (Eriksson, Forsen et al. 2001; Whitaker 2004; Blair, Thompson et al. 2007). Thus obesity could be seen, at least partly, as an heritable condition, but it must be stressed that the responsibility of genetics alone as opposed to a complex interaction between the genotype, epigenetics and other environmental factors is poorly understood. For example it is likely that attitudes and behaviours around eating and activity are also ‘inherited’ through exposure in the household.

Although the relationship between ethnicity, socio-economic status and obesity has yet to be fully documented, ethnic heritage has also been implicated in the uneven distribution of obesity prevalence. While some studies have found that ethnicity – including the genetic characteristics associated with race - is an independent risk factor for obesity in English (Saxena, Ambler et al. 2004), American (Wang, Youfa and Tussing 2004) and Australian (Waters, Ashbolt et al. 2008) children; other authors argue that racial and ethnic minorities tend to exhibit a disproportionate level of social disadvantage which explains most of their increased risk for obesity (Lindquist, Reynolds et al. 1999; Kuepper-Nybelen, Lamerz et al. 2005). Studies from the continental United States (Strauss and Pollack 2001; Ogden, Flegal et al. 2002; Wang, Youfa and Beydoun 2007) provide further evidence for ethnic disparities in overweight and obesity, while the same trend has also been reported from New Zealand, (Gordon, Ferguson et al. 2003) and Hawaii (Baruffi, Hardy et al. 2004). Little research has attempted to quantify the contribution of culturally based attitudes and practices around food and lifestyle behaviours and choices with the development of obesity (Wang, Youfa and Beydoun 2007), but it seems likely that the expression of these socio-cultural influences may also contribute to increased obesity prevalence in some sections of the population (Duke, Bryson et al. 2004).

Another avenue being explored by some researchers which should be considered under the heading of biological factors is the concept of virus-induced obesity (Astrup, Lundsgaard et al. 1998; Vangipuram, Yu et al. 2007; Atkinson 2008). It has been found that infection with certain pathogens may promote adiposity in animals and that human adenovirus-36 in particular increases the accumulation of fat in human adipose cells. Antibodies against this virus – indicating prior infection – were also detected at a much higher rate in obese people than the non-obese (Vangipuram, Yu et al. 2007). This is an intriguing research development which may eventually come to explain some of the observed variation in obesity prevalence within populations.

Given the limited amount of information regarding biology which can be extracted from or applied to the CYWHS database, the factors identified in this section will not feature strongly in the analysis. Nevertheless, it is vital for both the researcher and the reader to remember that biological variation and predisposition may underpin susceptibility to overweight in both individual children and population groups. While this predisposition may not be modifiable, the environment in which energy imbalance actually develops may be a target for intervention so as to moderate the impact of biological tendencies.

2.4.2 Physical Environmental Factors

It has been claimed that modern lifestyles create an environment that is 'obesogenic' (Swinburn, Egger et al. 1999; Giles-Corti, L et al. 2004) or promote weight gain. The abundance of high calorie snack foods displayed at many points of sale and a preference for sweetened drinks/sodas (Ludwig, Peterson et al. 2001; Welsh, Cogswell et al. 2005), together with constant exposure to food advertising, the proliferation of labour saving devices and a reliance on the automobile for transport are all factors which can contribute to the energy imbalance which leads to obesity (Swinburn, Egger et al. 1999; French, Story et al. 2001; McLennan 2004). Added to this is an increasing preference for sedentary recreation, (television, electronic games, etc.), which is also believed to contribute to overweight, by displacing energy-expending active recreation and increasing non-nutritional eating (French, Story et al. 2001; Jordan and Robinson 2008).

The physical environment can also refer to the way in which our surroundings are structured and it has two aspects – the natural environment and the built environment (Gebel, King et al. 2005; Papas, Alberg et al. 2007). The built environment is of particular interest to this discussion as aspects of it are measurable in a way which can be incorporated into the analysis of obesity prevalence in the CYWHS data set, and it is potentially modifiable. It can be micro-scale, as in the number of bedrooms or the presence of stairs in a house, or macro-scale as in the arrangement of transport routes within a region or the accessibility to goods and services from a given location.

The siting of amenities related to food purchase and consumption is one aspect of the built environment which may have a bearing on the weight status of the population. The location and density of supermarkets (Morland, Wing et al. 2002; Inagami, Cohen et al. 2006) and fast food restaurants (Reidpath, Burns et al. 2002; Block, Scribner et al. 2004; Powell, Chaloupka et al. 2007) have both been investigated in relation to obesity. Lower SES neighbourhoods were found to have both a higher density of fast food restaurants and a lower density of supermarkets, with an association between supermarket access and obesity persisting even after controlling for neighbourhood SES.

One of the major ways in which the built environment can influence weight status is in the way it can either promote or discourage physical activity. Physical activity is one half of the energy-in vs. energy-out equation which can result in weight imbalance, and as such receives a great deal of attention in the literature (Gillis, Kennedy et al. 2006). The structure and design of the physical environment – for example, the provision of footpaths and bicycle lanes - can directly influence levels of physical activity, and also enable or hinder access to the facilities and services which may impact health and well being. This has implications for the development of obesity (Booth, Katie M., Pinkston et al. 2005).

Physical activity can be classified as either structured or unstructured. Structured activity refers to regular and often vigorous activity usually undertaken in a particular location or facility, while unstructured activity can include 'lifestyle' activities such as gardening and housework, walking or cycling to work or the shops, and backyard play (Gebel, King et al. 2005). Current opinion holds all types of physical activity to be valuable for health and well being, not just vigorous aerobic exercise, although of course this has particular benefits for cardiovascular health (Richardson, Kirska et al. 2004; Miles 2007).

As all movement, whether incidental or formal exercise requires space to be performed in then it follows that the availability and design of space will influence the type and amount of movement that can be undertaken by an individual. Almost all authors agree that people are moving less today than they were twenty years ago and that this is a significant contribution to the obesity epidemic. A recent study (Gillis, Kennedy et al. 2006) has shown that overweight children tend to be measurably less active at an earlier age, but do not perceive themselves as less active than their normal weight peers.

It follows that the more active the adults in their life are, the more likely children are to be active. This could occur through joint participation in incidental and recreational activities – e.g. walk to the shop together, have a game of backyard cricket – and/or through role modelling of the importance and enjoyment of regular physical activity. Thus aspects of the physical environment which might seem to be relevant only to adults may actually have an influence on children's' weight status.

The built environment may include barriers to physical activity, especially within residential neighbourhoods, and this can include such aspects as busy roads with no safe pedestrian access/crossings, and lack of open spaces in the form of playgrounds, recreation reserves or recreational trails within an exploitable distance from people's homes (Veugelers, Sithole et al. 2008). The opposite is also true, in that the structure and facilities of a neighbourhood can actually promote physical activity (Sallis and Glanz 2006; Papas, Alberg et al. 2007).

Land use mix has been identified as an influence on physical activity, with residents in neighbourhoods with a greater mix more likely to walk for recreation or active transport, and less likely to be overweight or obese (Saelens, Sallis and Frank 2003; Heath, Brownson et al. 2006). The combination of land use mix with measures of road connectivity and residential density to create an index of walkability has also been linked to objectively measured physical activity (Saelens, Sallis, Black et al. 2003; Frank, Schmid et al. 2005). Similarly, the absence of footpaths (sidewalks), poor access to recreational facilities and living on a highway was found to be associated with overweight and/or obesity in adults in Perth, Australia (Giles-Corti, Macintyre et al. 2003). Some authors have also found that *perception* of the built environment – for example perceived distance to shops, recreational facilities - is as strongly related to physical activity measures, and even weight status, as the objective measures (Giles-Corti, Macintyre et al. 2003).

Incidental activity in adults can be influenced by the design of buildings; for example providing accessible and pleasant stairwells which people may then use in preference to the lifts or escalators, especially if only travelling one or two floors. This can be reinforced by initiatives such as placing motivational signs at the 'point of decision' which encourage people to take the stairs (Centers for Disease Control and Prevention 2001; French, Story et al. 2001). In a broader context, the provision of cycle lanes and footpaths may encourage active transport while improved access to efficient public transport will encourage its use with the associated walking at each end of the journey (French, Story et al. 2001). In the case of children, homes with sufficient, inviting outdoor space to facilitate active play and neighbourhoods with playgrounds or other open, recreational space and safe access routes to them and to schools are examples of environments which may promote physical activity (Timperio, Crawford et al. 2004).

While no direct measure of physical activity can be associated with the CYWHS database, data sources relating to the built environment can be linked to this database based on location. Spatial data on walkability, fast food restaurants, recreational space and accessibility are available for the Adelaide area, and these factors have been incorporated into the analysis based on the literature which has found a relationship between these aspects of the physical environment and weight status.

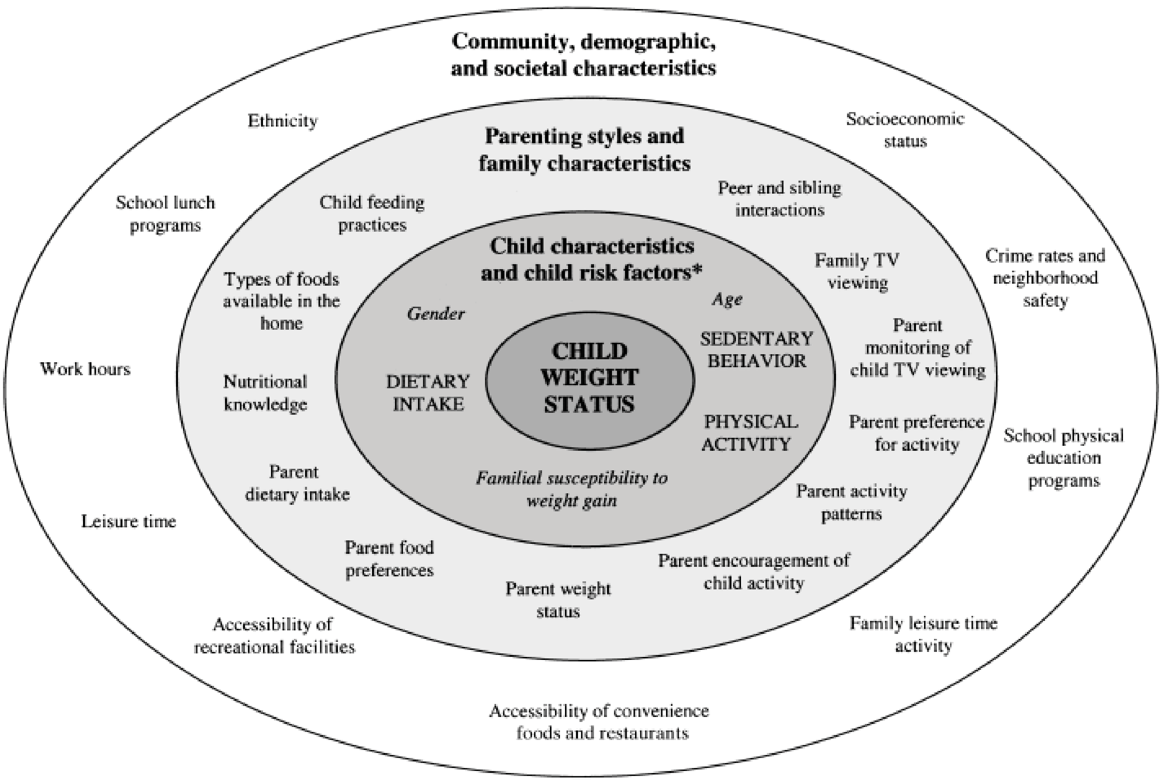
2.4.3 Social Environmental Factors

> *"The family provides an environment in which patterns of food intake and activity are learned early in life." (Agras, Hammer et al. 2004 p24-25)*

A social ecological approach to child health (see Figure 2.2) recognises the influence of family, school, neighbourhood and community factors in healthy social and emotional growth and development (Earls and Carlson 2001). Within this context, the primary social and economic interface for young children is the family. Parents shape the socio-emotional environment in the home, model interpersonal attitudes and are influential in determining children's dietary patterns and activity levels (Rhee 2008). Some of the specific mechanisms by which parents may influence their child's weight status are through infant and child feeding practices, and modelling of nutrition and activity behaviours and attitudes (Campbell, Karen, Crawford et al. 2002b; Duke, Bryson et al. 2004; Rhee 2008). These are potentially modified by ethnicity and SES.

Breastfeeding is a nutritional choice which may be influenced by socio-cultural norms as well as physical factors. The relationship between breastfeeding (and the duration of breastfeeding) and later obesity has received a great deal of attention in the literature, with some authors detecting a protective effect (von Kries, Koletzko et al. 1999; Gillman, Rifas-Shiman et al. 2001; Armstrong and Reilly 2002; Harder, Bergmann et al. 2005; Woo, Dolan et al. 2008) and others finding minimal or no benefit (Hediger, Overpeck et al. 2001; Burdette, Whitaker et al. 2006; Toschke, Martin et al. 2007). The studies vary in the measurement of adiposity, the factors controlled for, the age at which adiposity was assessed, and the method and timing of data collection about infant feeding practices. The collected evidence appears to be slightly in favour of the protective effect, and subsequently the promotion of breastfeeding is generally recommended especially as it also has many other benefits for both mother and child (Arenz, Ruckerl et al. 2004; Owen, Martin et al. 2005).

Figure 2.2 The Ecological Model of Predictors of Childhood Overweight



Source: Davison and Birch (2001 p161)

Research has also shown that neglect – behaviour self reported by the mother – is associated with an increased risk of obesity in children (Whitaker, Phillips et al. 2007), while early life trauma increased the likelihood of obesity in adults (Gunstad, Paul et al. 2006). Other authors have determined that many parents do not perceive their overweight children as overweight (Baughcum, Chamberlin et al. 2000; Chamberlin, Sherman et al. 2002; Etelson, Brand et al. 2003; Carnell, Edwards et al. 2005; Campbell, M, Williams et al. 2006; Fisher, Fraser et al. 2006). This may have implications for prevention and intervention, as parents are not likely to seek advice or facilitate diet and activity modifications for children whose well-being they neglect in other ways, or who they do not believe to be at risk. The fact that there tends to be a relationship between these maternal behaviours and lower socio-economic status implies a complex relationship between SES, attitudes and environment which goes beyond a simple causal mechanism and points to a multi-faceted syndrome in which childhood obesity is only one outcome.

The relationship of socio-economic status with both child and adult overweight has been frequently examined in the literature. It has been well documented that, in developed countries, there is an inverse relationship between Socio-Economic Status (SES) and adult obesity, particularly in females (Sobal and Stunkard 1989; Jeffery and French 1996; Wamala, Wolk et al. 1997; Everson, Maty et al. 2002; Zhang and Wang 2004; Ball and Crawford 2005), although study results involving males and children have been more varied (Sobal and Stunkard 1989; Parsons, Power et al. 1999; Booth, Michael L, Wake et al. 2001). The relationship between SES and obesity may be further modified by ethnicity (Zhang and Wang 2004).

One possible explanation for this lies in the measurement of SES. Social standing is a difficult concept to measure precisely, relying as it does on perception and attitude as much as on measurable attributes like income and education. The use of different indicators for SES may result in inconsistent results from the same study population (Ball and Crawford 2005). Such indicators can include education, income, household type (marital status) and occupation, and with regard to children these factors are usually assessed for their parent/s or a reference caregiver. For example, a lower level of maternal education is often identified as a risk factor for childhood overweight (Baughcum, Chamberlin et al. 2000; Campbell, Karen, Crawford et al. 2002b; Kuepper-Nybelen, Lamerz et al. 2005), while lower family incomes have been linked with higher numbers of obese preschool children in Australia. (Dickenson and Johnstone 2005). It should be remembered that all of these measurements of social class are truly only *indicators*, and it is very difficult to assess how so many factors work together to influence a person's perceived place in society and precisely how this affects their health and well-being.

It is also becoming quite common to apply a measure of SES for a given area as a variable when researching the health status of the residents of that area (Diez-Roux 2001; Pickett and Pearl 2001; Bernard, Charafeddine et al. 2007). This enables the comparison of areas with different SES, and this methodology has often been used in studies of SES and obesity in both adults and children. SES in this context is often assessed using a combination of variables to create an index of disadvantage, such as the Socio Economic Indexes for Areas (SEIFA) derived from Australian census data (Australian Bureau of Statistics 2003). Ideally, multi-level analysis is used so that individual factors are controlled for when assessing the effect of neighbourhood SES on overweight. The studies which have had the appropriate data and used this methodology have reported an effect of neighbourhood SES which persists after controlling for individual factors (Dollman and Pilgrim 2005; Chen and Paterson 2006; Janssen, Boyce et al. 2006; Oliver and Hayes 2008).

While there is data on breastfeeding status and ethnicity available with the CYWHS data set, there are no individual measures of socio-economic status available. The analysis is therefore reliant on area-level SES variables obtained through the census. Using these data, it will be possible to determine whether the relationship between area-level measures and obesity is generally consistent with that reported in the literature for individuals, and whether the use of area data can add new insight to the current understanding of these relationships.

2.4.4 Discussion

The vast literature which continues to be generated on this topic examines many aspects of overweight and obesity in adults and children. The evidence for the influence of biology, the physical environment and the social environment on the development of obesity is varied and probably inter-related in ways which are difficult to quantify and not fully understood (Kraemer, Stice et al. 2001). It seems likely that while biological factors may predispose to obesity, it is the interaction of individuals with the social and physical environment and the resources available to them from these environments which drive the emergence of the energy imbalance.

While family factors often show the most direct associations with child overweight, these families are formed and function in the wider neighbourhood and social contexts which in turn may influence the family dynamics. As such, we should certainly not discount neighbourhood effects in the development of child obesity.

2.5 Intervention and Prevention

"If a child is obese at the age of four, he or she will have a 20 percent likelihood of being overweight as an adult."(DeMattia and Denney 2008 p84)

Overweight and obesity in adults is notoriously difficult to treat successfully (Foreyt, Goodrick et al. 1981). It is a chronic and persistent condition and the morbidity and mortality risks associated with it are largely invisible to the sufferer until they are well established. Although it is important to continue intervention/treatment recommendations for people who are already overweight, it is obvious that strategies to prevent excess weight gain in the first place may be more successful. As obesity in childhood has been established as a risk factor for obesity in adulthood (Serdula M. K., Ivery D. et al. 1993; Whitaker, Wright et al. 1997; Strauss 1999; Freedman, Khan et al. 2005), it makes sense to focus prevention and intervention strategies at this age group.

2.5.1 Current Recommendations

"Most overweight and obesity management efforts have focused on encouraging individuals to "eat less and move more." However, people do not make decisions in a vacuum." (Segal and Gadola 2008 p196)

In recent years, several national health bodies have formulated recommendations designed to modify the obesogenic environment for all sectors of the population (National Health and Medical Research Council 1997; World Health Organization 2000; National Audit Office 2001; British Medical Association 2005; National Preventative Health Taskforce 2008). These include the promotion of active transport, modification of urban design and planning processes, the revision of food labels and the adjustment of menus in cafeterias and school canteens. However limited data exists on the implementation and, particularly, the effectiveness of such programs (Jaime and Lock 2009).

Many authors recommend an individual, family centred approach to the treatment of childhood obesity, particularly in pre-adolescents whose dietary and activity behaviours are largely dependent on the opportunities and accepted practices within their family unit (Molnar 2001; Baur 2003; Golan 2006; Plourde 2006). Small, achievable goals such as a decrease in sedentary recreation, an increase in incidental exercise, eating out less and snacking less on high energy density foods and adopting healthier cooking practices and food choices are all interventions that may decrease the rate of weight gain in a child and, if maintained, protect against obesity in the longer term (Hesketh, Waters et al. 2005). Opportunities for intervention may also exist by modifying the home, school and community environments through education and policy (Dietz and Gortmaker 2001; Ells, Campbell et al. 2005; DeMattia and Denney 2008; Segal and Gadola 2008). Such modifications might include initiatives around work/life balance or healthy eating programmes in schools. Swinburne *et al.* (1999) suggest an approach to assessing the environment from micro- to macro-level within a framework which then allows potentially modifiable factors to be identified.

An example of an Australian intervention program is the NSW Healthy School Canteen Strategy promoted by the NSW government in response to the key initiatives which emerged from the NSW Childhood Obesity Summit (Develin 2004). In the United States, the America on the Move program, (The Partnership to Promote Healthy Eating and Active Living 2005), is being expanded to schools and families and other authors report trial programs underway, (Campbell, Karen, Waters et al. 2002; St Jeor, Perumean-Chaney et al. 2002). The evidence for the success or otherwise of programs of this type is limited and difficult to characterise (Summerbell, Waters et al. 2005; Flodmark, Marcus et al. 2006; Saunders 2007). They also tend to target school-aged children almost exclusively, and it seems that programs aimed at this age group, while easier to deliver, may not meet the needs of a population in which a significant number of children are already overweight at school entry (Klesges, Klesges et al. 1995; St Jeor, Perumean-Chaney et al. 2002; Hesketh, Waters et al. 2005).

While successful intervention requires a sustainable change in lifestyle which can be difficult to achieve (Campbell, Karen, Waters et al. 2002), *prevention* of childhood overweight and obesity is even more complex . It requires the development of population strategies which can be complicated and costly to implement and the results of which are difficult to measure. To be successful, it requires families and communities to adopt and sustain 'healthy' lifestyles (i.e. not conducive to the development of energy imbalance) *without* the spur of the personal deterioration in health and well-being which may be experienced by an overweight or obese individual.

Hill and Peters (1998) recommend a number of societal initiatives to modify the obesogenic environment. Increased and enjoyable physical activity in schools would be a key factor, along with consumer education about appropriate portion sizes and the energy density of foods. They believe that restaurants and grocery stores need to be a part of the solution by offering more and inexpensive fruits, vegetables and whole grains while restaurants should also aim for a reduction in portion sizes, especially of high energy density foods. They also suggest offering incentives for increased physical activity such as lower insurance rates.

Many of these strategies are aimed at individuals or specific target groups such as schools. While these are valid and valuable – indeed health care professionals *need* to concentrate on individuals – obesity is a concern at a population level and as such population health initiatives need to be developed to complement individual approaches. If a population health strategy is to be successful in intervention and/or prevention of overweight in young children, the environment in which overweight flourishes needs to be understood and targeted. This study is ideally positioned to further define that environment and identify where and to whom public health initiatives can be most appropriately directed.

2.6 Discussion

This chapter has summarised the current research into overweight in individuals and populations, with particular attention to its development in children. The issues and findings discussed here form the background for the analysis of the CYWHS data set, from the identification of a suitable definition of overweight and obesity in this age group to the assessment of the intervention and policy environment within which recommendations arising from this research will be formulated.

An understanding of the literature around the biological and environmental determinants of obesity is important as it provides the context within which decisions have been made about particular variables to be examined in relation to obesity prevalence in the CYWHS data. The influence of, and the interactions between, biology and environment are both complex and crucial to the understanding of the development of energy imbalance in preschool children. This study aims to build on previous research and further identify the area-level environmental correlates which offer some insight into overweight in this population and, based on these results, identify particular areas and/or population groups where prevention and intervention efforts could be most appropriately directed.

CHAPTER 3

Data and Methods

3.1 Introduction

This chapter encompasses an examination of the CYWHS records which form the basis of the data used in the present study, and explores the quality and representativeness of these data while detailing the procedures used in preparing this administrative database for use in academic research. This process is vital to establish the validity of the results in both the local and national context. The procedures used to explore the data set and the supplementary data against which the CYWHS research database has been analysed are also described, as is the software used to carry out the analysis.

Ethical approval to undertake this research was obtained in the first instance from the Children, Youth and Women's Health Service Research Ethics Committee as the custodian of the primary data set, and this was ratified by the University of Adelaide Human Research Ethics Committee.

3.2 The CYWHS Data Set

The initial data set provided by CYWHS comprised some 150 299 de-identified records – 77 174 (51.3%) males and 73 118 (48.6%) females – of children who were recorded as having attended a preschool check at approximately 4 years of age between 1995 and 2004. A number of different data items related to physical, social and organisational characteristics have been collected in the database as listed in Table 3-1. However not all variables have been recorded for each child, and items marked with an asterisk were routinely included in the data set only from 1999 onwards, with full reporting from 2000.

Data cleaning was undertaken to eliminate from the analysis children whose records indicated[5]:

- gender unknown (7)
- age unknown (6434)
- height and/or weight unknown (21795)
- duplicate records (638)

Table 3-1 Variables supplied with the CYWHS database

Variable Name	Description
ID	Unique record number
Gender	Sex of child
Postcode	Postcode of residence at time of preschool check
Suburb	Suburb of residence at time of preschool check
Date of Birth	Reported birth date
Date of Check	Date attended preschool check
Height	Height measured at preschool check
Weight	Weight measured at preschool check
Birth Weight (kg)*	Reported birth weight
Indigenous Status*	Identified as Aboriginal &/or Torres Strait Islander
Language spoken	Primary language of family
First time mother	Child born to a first time mother
Breast fed at 3 months*	Reported as being breast fed at 3 months of age
Breast fed at 6 months*	Reported as being breast fed at 6 months of age
Clinic attended	Where preschool check conducted
1-4 week visit*	Attended 1-4 week check
6-8 week visit*	Attended 6-8 week check
6 month visit*	Attended 6 month check
18 month visit*	Attended 18month check
2-3 year visit*	Attended 2-3 year check
Preschool visit*	Attended preschool check
Extra visits*	Number of other visits to CYWHS clinics outside scheduled checks
Torrens house use*	Number of times Torrens house residential facility attended

**Data item only reliable for children assessed from 2000 onwards*

Source: CYWHS

[5] Many records have more than one data item missing

Further data exploration revealed the presence of outlying values in the height and weight variables. These were removed (322 further records) from consideration as follows:

- height < 70cm or height > 170cm
- weight <10kg or weight > 50kg

These ranges, based on visualisation of the distribution of the data values, are deliberately quite broad in an attempt not to mask true biological difference in the analysis sample. As a further check, Body Mass Index (BMI) was used to detect a mismatch in height and weight. BMI is calculated by dividing a child's weight in kilograms by their height in metres squared – wt/ht^2. An abnormally low or high BMI is likely to indicate an error in either one of the original measurements, or in the data transcription, therefore a further 37 records with a BMI less than $10kg/m^2$ or greater than $40kg/m^2$ were removed from further analysis as these figures were considered to reflect data error (Vaska and Volkmer 2004).

The preschool assessment is targeted at children between the ages of four and five years (approximately 48 months to 60 months) who are approaching school entry. Age was calculated by subtracting the date of birth from the date of the preschool visit. The actual age range of children in the data set is -58 to 125 months, clearly indicating some data error. Therefore only records with a calculated age of between 48 and 60 months (inclusive) have been retained in the analysis data set, although it is acknowledged that some of the records with ages outside these limits are almost certainly accurate. The remaining records total 120 776 – 80.4% of the original data - and it is this number which forms the research database.

Almost 30 000 records were excluded from the research database for the reasons summarised on the preceding pages, and it is necessary to compare the characteristics of the included and excluded records to confirm that they do not differ significantly. Of the excluded records, some 6 000–plus children who were assessed in 2004 did not have crucial information such as height, weight and date of preschool visit transferred into the database. While Table 3-2 provides a summary of the characteristics of the records in the research database compared to those excluded from further analysis, the 6434 records which have had to be excluded due to the clerical issues have not been analysed as part of the 'Excluded' category as their exclusion is the result of an administrative process and is not representative of true data variation. There are 23 089 records remaining in the 'Excluded' category.

Table 3-2 Comparison between included records, excluded records and total database for selected characteristics

	Included %	Excluded %	Total %
Male	50.9	53.2	51.3
Female	49.1	46.8	48.6
ATSI*ª	1.2	1.4	1.3
Language - English	94.6	92.9	94.3
Breastfeeding at 3 monthsª	33.0	33.7	33.2
Breastfeeding at 6 monthsª	28.3	28.4	28.3
Attended at least 1 scheduled check (other than preschool)ª	78.6	82.9	79.7
Made extra visits to clinicsª	64.1	66.7	64.8
Attended Torrens Houseª	1.5	1.9	1.6

**Aboriginal and/or Torres Strait Islander*
ªReliably recorded from 2000 onwards – n=46902 (Included) and n=17429 (Excluded) and n=64331 (Total)

Source: Compiled from CYWHS data, 1995-2003

While the proportions of most variables are relatively consistent across the data sets, it is worth noting that children identified as being of Aboriginal or Torres Strait Islander origin are slightly under-represented in the research database, as are children from non-English speaking backgrounds. This is perhaps not surprising, as it may be more difficult to obtain and record information in a clinical setting when there is a language and/or cultural barrier present. However, the variation in percentage between included and excluded children remains very small and the analysis is unlikely to be biased by the exclusion of those children for whom crucial data are not recorded.

Also under-represented in the analysis database are children who utilised CYWHS services other than the preschool check, with a higher proportion of the excluded children having attended both scheduled (recommended) checks and accessed a CYWHS service at other times. This raises the question of why some children are accessing CYWHS services and support more often and is there any relationship between these variables and overweight at age four?

It could be hypothesised that children from lower SES backgrounds are more likely to need and utilise these services to supplement the possibly limited emotional, financial, social and educational resources which their families bring to the task of raising young children. If this is the case, the exclusion of some of these children from the analysis database could lead to an underestimation of the prevalence of overweight and obesity, as higher rates of these conditions have consistently been shown to be associated with lower socio-economic status (Dickenson and Johnstone 2005; Dollman and Pilgrim 2005; Janssen, Boyce et al. 2006).

Alternatively, it could be argued that children from higher SES backgrounds are more likely to use CYWHS services because their families are more likely to see regular monitoring of the growth and health of their children as important and desirable. Likewise they might feel more comfortable (possibly less intimidated) interacting with CYWHS professionals and therefore more likely to seek assistance if and when they recognise a problem; which they are better equipped to do in the first place by their education and life experience. If this scenario is valid, then it is likely that their exclusion from the analysis would lead to an overestimation of overweight and obesity prevalence. Without knowing the motivations behind the use of CYWHS services, it is impossible to do more than speculate on whether this disparity will bias the overweight prevalence in the data set. However it seems unlikely that the small difference (approximately 4%) will have any significant effect.

3.2.1 Demographic Representation

It is important to understand the research database not only in terms of its comparability to the set of excluded records, but in terms of its representativeness of South Australian 4 year old children in general. Table 3-3 shows the number of children in the research database by their year of birth, and compares this to the number of children actually born in South Australia in the same year, (the birth cohort). The percentage of each birth cohort captured by the research database is also listed[6].

The lower percentage of the birth cohort captured in 1990 is an artefact of the timing of the data collection process, due to the fact that many of this cohort completed their preschool check prior to the commencement of central storage of these records in 1995. Similarly in 1999, many children would not yet have completed this check by January 2004 which is the limit of the research database. The low percentages in these years are therefore not indicative of any bias or shortfall. If these years are discounted, it can be seen that the CYWHS preschool check has captured 70% - 80% of each birth cohort up until those born in 1996, where a funding shortfall in 2001 led to a reduction in the number of preschool assessments performed in this and subsequent years (Volkmer 2004).

[6] 1 child born in December 1989 and otherwise included in the data set has been omitted from the table.

Table 3-3 Year of birth and percentage of birth cohort

Year	Birth Cohort	Research Database	% of birth cohort
1990	19 852	9 895	49.8
1991	19 637	15 181	77.3
1992	20 001	15 135	75.7
1993	19 842	14 561	73.4
1994	19 670	14 019	71.3
1995	19 467	13 619	70.0
1996	18 974	12 359	65.1
1997	18 531	10 551	56.9
1998	18 612	11 977	64.4
1999	18 398	3 478	18.9
TOTAL	***192 984***	***120775***	***62.6***

Source: Compiled from birth cohort data supplied by the Pregnancy Outcomes Unit, Department of Health 1990-1999 and CYWHS data 1995-2003

Table 3.4 shows a similar comparison between the census count of four year old children in both 1996 and 2001 and the number of children in the CYWHS database who were four years old at those dates. The percentages are similar to those seen for the corresponding birth cohorts in Table 3-3, and taken together these two tables indicate a good representation of South Australian children within the research database. The drop in assessments from 2001 onwards is of some concern, especially as CYWHS have reported that available resources at this time were targeted to lower SES areas (Hetzel, Page et al. 2004), which may result in an exaggerated high prevalence of overweight children during this time period. This discrepancy is particularly noticeable in 2002 when the lowest numbers of assessments were performed. Hetzel *et al* (2004) have omitted the 2002 statistics from their analysis for this reason. However, subsequent analysis (see Section 3.2.3.3 and Chapter 4) has not shown any evidence of this effect, and these data have been retained for analysis in this study.

Table 3-4 Comparison of CYWHS numbers with census count of four year olds

	Census Count	CYWHS Records	%
1996	19764	15185	76.8
2001	18665	11452	61.4

Source: ABS census 1996 and 2001 and CYWHS data 1995-2003

3.2.2 Direct comparison

Apart from the potential data bias in 2002, it is possible that some particular groups of children may be under- or over-represented in other ways in the research database. Census data were again used to explore this possibility. Given the limited amount of demographic information available in the research database, it is only possible to directly compare – with caution – three indicators, and this comparison is presented in Table 3.5.

Table 3-5 Comparison of census variables and CYWHS data

			CYWHS	Census
			%	%
2001	Gender of 4 year olds (% Male)	State	50.9	51.1
		Urban	50.6	51.0
		Regional	51.0	51.0
	Indigenous 4 year olds	State	1.5	3.1
		Regional	3.9*	7.8
	Other language	State	4.3	11.8
		Urban	6.1	14.6
		Regional	0.1*	4.3
1996	Gender of 4 year olds (% Male)	State	50.9	51.7
		Urban	51.2	51.8
		Regional	47.2	49.8
	Indigenous 4 year olds	State	0.9	3.0
		Regional	1.7	7.3
	Other language	State	3.1	12.3
		Urban	4.2	15.2
		Regional	0.7*	5.1

** Very low number of children in this category*

Source: ABS census 1996 and 2001 and CYWHS data 1995-2003

This table compares the percentage of four year old children in the research database in each category with the percentage of the population enumerated in a similar category at the census. All of these comparisons need to be assessed with some caution, especially in the case of the Other Language category where the census statistics represent the entire population as opposed to four year old children only. Also, the data items were collected for different purposes by different agencies and the actual questions asked may vary so as to elicit slightly different information. As such, these figures can be used as an *indicator* only of the representativeness or otherwise of the database.

There are 15 185 children in the analysis database who were four years old on census night 1996 and 11 452 who were four years old on census night 2001. Of these, approximately 51% were male, which is virtually identical to the census proportion for both years. However the proportion of children identified as indigenous is significantly lower in the CYWHS database, indicating that indigenous children are not routinely captured by the CYWHS preschool checks. This may be due, in part, to the fact that CYWHS does not routinely have access to children in the most remote parts of the state – including the Anangu Pitjantjatjara lands and similar Aboriginal holdings – where a high proportion of the state's indigenous peoples live. However, urban indigenous children are still under represented in the research database.

There is also greater disparity evident when comparing children who speak another language with the census population of people who speak another language at home. While this could reflect an under representation of children from non-English speaking backgrounds in the database, it is also possible that the CYWHS database identifies only children (or families) who speak no or very little English at all while the census figures represent all people who report speaking a language other than English at home.

Probably both of these explanations contribute to the observed discrepancy, and common sense indicates that children from non-English speaking backgrounds probably are under-represented in the database, although not to the extent suggested by the census comparison.

In summary, while the gender balance in the database appears to reflect the total population distribution; indigenous children and children from non-English speaking backgrounds may be under-represented. This has implications for the estimation of the prevalence of overweight and obesity in this population, as both urban indigenous people and ethnic minorities have been demonstrated to have a higher prevalence of overweight than non-indigenous, English-speaking people (Australian Bureau of Statistics 1998; Flegal, Carroll et al. 1998; Dabelea, Pettitt et al. 1999; Strauss and Pollack 2001; Wake, Hardy et al. 2007). The implications for this research are that any prevalence estimates will be conservative, with the actual population prevalence of overweight and obesity likely to be slightly higher than that reported from these data.

3.2.3 Spatial comparison

Other demographic indicators can be assessed using a spatially referenced subset of the research database which can be compared to spatially enabled socio-demographic information derived from the ABS Census of Population and Housing. This method has some limitations, which are detailed below, and it is impossible to make a precise comparison. However, it is possible to gain a 'feel' for the representativeness of the data set in these areas.

3.2.3.1 Geocoding

Individual records were assigned to a spatial location by a process known as geocoding. Within a GIS environment, the location information provided for each record was matched to a spatial database based on the property cadastre and land valuation data provided by South Australian government agencies (see Section 3.5). A total of 86 335 records – 71.5% of the research database – could be matched to a property address and therefore assigned to a Census Collection District (CD), which is the smallest unit of geography for which census data are collected and reported.

Before any analysis of this spatially referenced subset of the database was undertaken, it was necessary to establish that the geocoded records being used did not differ significantly from the records which were unable to be assigned to a CD, to ascertain that they are still representative of the database as a whole. An initial evaluation of the proportion of records by year (Table 3-6) indicates that prior to 1997; detailed address information which would enable the record to be point geocoded was either not routinely collected or not transferred to the electronic database. Therefore data from these years (1995 and 1996) cannot be reliably used in any detailed spatial analysis.

The geocoded records have also been compared to the uncoded records in terms of the variables included in the research database to establish that there are no significant differences between the two sets of records (data not shown). While there are lower percentages of children who have been breastfed and who have attended extra consultations with CYWHS in the geocoded subset, these differences are not large and are considered unlikely to bias the analysis.

Table 3-6 Comparison of geocoded and uncoded records by year

	Geocoded Records		Uncoded Records	
	#	% of total	#	% of total
1995	475	3.1	15027	96.9
1996	9598	63.1	5601	36.9
1997	12680	85.3	2188	14.7
1998	11982	84.6	2176	15.4
1999	11988	84.7	2159	15.3
2000	11268	85.0	1981	15.0
2001	10027	85.1	1752	14.9
2002	8052	83.5	1590	16.5
2003	10265	83.9	1967	16.1
Total	86335	71.5	34441	28.5

Source: CYWHS data 1995-2003

3.2.3.2 Comparing census population and CYWHS population by location

This comparison was conducted using CD-based statistics from the 2001 census. Using the CData 2001 program (Australian Bureau of Statistics 2002), selected socio-demographic characteristics for each CD were extracted and the state-wide statistics for each variable were also calculated to determine which CDs had values greater or less than 1 standard deviation from the mean. These CDs were classified as either ‘high’ or ‘low’ for that variable. The percentage of the census population of 4 year olds recorded in these ‘high’ or ‘low’ CDs was then calculated, and compared to the percentage of the CYWHS children who were recorded as living in these same CDs on the respective census nights. If areas with a certain socio-demographic characteristic (e.g. a high percentage of high income families) are shown to have a lower percentage of four year olds included in the database than actually reside there, it suggests that children from high income families may be under-represented in the analysis.

This process was limited by constraints of both data and method. Census data relevant to the database is only available for two points in time – 1996 and 2001 – and it is unknown if or how the base population may have varied in non-census years. The comparison can also only be conducted using those records which have an appropriate spatial reference and given the low number of records able to be geocoded in 1996, only the 2001 census and records could reliably be used for this comparison.

The percentage of children from the CYWHS database compared with the percentage of the census population of 4 year olds who live in 'high' and/or 'low' CDs for the selected census variables are presented in Table 3-7. Of the 35 variables examined, only 5 categories show a difference of greater than 2% between the database and the 2001 census 4 year olds. These all reflect a greater number of census children in areas with 'positive' socioeconomic indicators than have been captured by CYWHS, which is not surprising given that CYWHS have acknowledged a bias towards assessing children in lower socioeconomic areas at this time when funding was decreased. However, across the majority of the variables – almost all of which can be considered socioeconomic indicators – there is little appreciable difference in the percentage of children recorded. The conclusion is that the CYWHS database at the time of the 2001 census is generally representative of the South Australian 4 year old population, with some slight under representation of children living in higher SES areas.

Table 3-7 Comparison between CYWHS and Census children living in CDs with high and/or low values for selected census variables

Measure		CYWHS Population	Census Population
		%	%
Indigenous*	High	9.4	9.0
English Speaking	Low	8.2	9.9
Weekly Income <$500	High	15.4	14.6
Weekly Income >$2000	High	10.8	11.3
	Low	12.1	12.3
Australian Born	Low	10.5	11.2
Asian Born	High	8.2	8.9
SE European Born	High	10.5	11.5
School Year 8 or less	High	9.3	9.8
Bachelor Degree or Higher	Low	12.1	11.2
	High	11.8	12.6
Other post secondary qualification	High	20.5	19.2
	Low	13.8	14.0
Unemployed	Low	2.8	4.6
	High	14.0	12.7
Moved within last year	High	7.6	8.0
Moved within last 5 years	High	11.7	11.4
Managers, Administrators, Professionals	High	6.6	11.1
	Low	20.4	17.3
Production, Transport,	High	20.3	18.5
Labourers & related workers	Low	11.2	12.3
Separate Houses	Low	12.0	12.0
Housing Trust Properties	High	15.9	14.2
Rented Dwellings	High	14.7	14.2
	Low	8.5	8.5
0 Motor Vehicles	High	12.0	11.8
	Low	10.3	12.5
3 Motor Vehicles	High	4.7	11.0
	Low	4.7	4.8
Lone Parents	High	16.0	15.4
	Low	6.1	9.1
DeFacto Partners	High	10.5	10.5
	Low	7.4	8.5
Married	High	8.3	9.2
	Low	10.6	11.2

**(urban area only)*

Source: CYWHS data 1995-2003 and ABS census 2001

3.2.4 Weight Status and Gender

The weight status of the children in the research database has been established by using the measured height and weight information for each child to calculate Body Mass Index (BMI) as described in Chapter 2. The BMI scores obtained were then assessed against the cut off values for overweight and obesity as published by Cole *et al* (2000) (see Table 3-8), and each child was therefore classified as overweight, obese or not overweight. Cole proposed that the mid-year cut points (for example, at age 4.5 years for the 4.0 year to 5.0 year age group) would give unbiased estimates of the prevalence of overweight and obesity for each year of age. This has been verified for this research population (Franzon, Hugo et al. 2008) and the mid-year cut points only, (highlighted in Table 3-8), have subsequently been used to define overweight and obesity for the purposes of this research.

Table 3-8 BMI cut off points for overweight and obesity by month of age

	OVERWEIGHT		OBESE	
Age	Males	Females	Males	Females
(months)	*%*	*%*	*%*	*%*
48	17.55	17.28	19.29	19.15
49	17.54	17.26	19.28	19.14
50	17.52	17.25	19.28	19.14
51	17.51	17.23	19.27	19.13
52	17.5	17.22	19.27	19.13
53	17.48	17.2	19.26	19.12
54*	**17.47**	**17.19**	**19.26**	**19.12**
55	17.46	17.18	19.26	19.12
56	17.45	17.17	19.27	19.13
57	17.44	17.17	19.27	19.14
58	17.44	17.16	19.28	19.15
59	17.43	17.16	19.29	19.16
60	17.42	17.15	19.3	19.17

**Mid-year cut point*

Source: Franzon *et al* (2008)

There are gender differences in the growth and development of children, so much so that separate growth reference charts are used for boys and girls. BMI also differs by gender and the international definition of child overweight and obesity designed by Cole *et al* take this into account by considering males and females separately. In this definition, and other BMI-for-age percentile charts, females reach overweight and obesity at a lower BMI score than males. It has also been shown that female children consistently exhibit higher rates of overweight than males especially when assessed using the Cole definitions (Reilly 2006a). This is certainly true of this data set, with female's prevalence of overweight (including obesity) up to 5 percentage points higher than males in some areas (Table 3-9). Given an intrinsically different body type and growth pattern, not to mention a possible bias in the measurement standard, it is plausible that different factors might influence the weight status of different genders. To this end, further analysis has been stratified by gender.

Table 3-9 Overweight and obesity by gender

	MALE			FEMALE		
	Overweight	**Obese**	**Both**	**Overweight**	**Obese**	**Both**
Location	*%*	*%*	*%*	*%*	*%*	*%*
Complete Data Set	11.2	4.0	15.3	13.8	5.1	18.8
Metropolitan	10.9	4.1	15.0	13.6	5.1	18.7
Rural	11.2	3.7	14.9	15.3	5.3	20.5
Regional Centres	15.1^	4.8	19.8	16.5^	6.7	23.1
Urban Subset (geodocded)	12.1	4.3	16.4	14.5	5.6	20.1

^Regional overweight is the only category where the gender difference is not statistically significant

Source: CYWHS data 1995-2003

3.3 Aspects of space

If, as has been suggested, population health can be related to the spaces and places occupied by people then it must be decided how best to define where people live and how best to measure the characteristics of those places. Issues of spatial scale, aggregation of data and data linkage must all be addressed.

A place can be a home, a neighbourhood, a city, a state or a country. How an individual fits into and interacts at each of these levels could potentially be associated with his or her health outcomes. When *population* health, as opposed to individual health, is the theme of interest then understanding the way in which people are grouped together to define a population is also crucial to the interpretation of any analysis.

3.3.1 Scale

The importance of geographical scale for the analysis of both physical and social phenomena lies in the inherent generalisation that occurs when we study the real world. Any study which we design can only incorporate a representation of the reality, as it is impossible to recreate the full size and complexity of the spaces and places in which we are interested (Montello 2001). In this context, scale refers to the size of the spatial units used for analysis – i.e. for which data are aggregated.

The size of the spatial units dictates the amount of data generalisation which occurs within each unit and could range from a country, to a state, to a city, to a postcode, to a suburb and even smaller. Clearly, the generalisation of data required to report on a phenomenon for an entire country is much greater than that required for a postcode, and will be useful for different purposes. However, the prevalence of obesity calculated for a large administrative unit such as a state or county may mask important differences between different population groups, some of which can be identified or explained by location.

3.3.2 The Modifiable Areal Unit Problem (MAUP)

Closely related to scale is the Modifiable Areal Unit Problem. The aggregation of data to a particular scale of (usually) administrative units, which are often arbitrary with respect to the issue under investigation gives rise to this problem (O'Sullivan and

Unwin 2003). Each time the number of spatial units decrease, (i.e. the area and the number of observations grouped together gets larger), then some of the variability is lost from the observations through the generalisation of the data. Investigation of the same data could lead to different statistical outcomes depending on the level of aggregation which is used.

3.3.3 Ecological Fallacy

The ecological fallacy – first identified in 1950 as the 'ecological correlation' (Robinson 1950) – is the tendency to infer the characteristics of individuals based on the characteristics of an aggregate group to which they belong (Firebaugh 2001). This most commonly takes the form of identifying a relationship between a variable and an outcome at some level – maybe a neighbourhood or a statistical local area – and assuming that the same relationship holds true for individuals. In actuality, the observed relationship may be an artefact of the grouping of population.

3.3.4 Implications for this research

The core of this research is an ecological analysis of the prevalence of overweight/obesity and its relationship with various area level variables. As such, issues of scale, MAUP and, especially, the ecological fallacy are crucial to consider throughout. The possibility that a perceived association between obesity prevalence and a risk factor may actually be a function of the relationship of both to a third, independent variable is a very real concern; as is the possibility that normal variation in obesity prevalence may be wrongly identified as significant due to the spatial units being used.

While neither problem can be fully controlled for, the examination of the data at different spatial scales and the inclusion of as many variables as possible goes some way towards ensuring the best possible outcome. However it is crucial that both the researcher and the reader bear in mind that these issues may have a bearing on the results, and that the power of this study lies in the ability to identify patterns in the distribution of obesity in the preschool population which may serve as an indicator for further research and a guide to prevention efforts.

3.4 Spatial Attribution of the CYWHS Data

The strength of this research lies in the exploration of the children's weight status in concert with their area of residence. Depending on the spatial scale of the analysis for any particular section, the children may have been assigned to a location based on the suburb recorded in the data set, or by matching the geocoded point to an appropriate boundary. Suburb or locality (town) matching is possible for over 98% of the records in the research database, and coding at this level enables analysis of a large number of records at a broad scale within the state of South Australia. While this is extremely valuable for the overview of regional differences in overweight and obesity, suburbs are still quite large spatial units and analysis at this level could potentially mask important local variation in overweight prevalence.

Point geocoded records can be analysed at a much finer scale. Not only can these records be used to create the surfaces seen in Chapter 7, but they can be analysed against the values of other variables at that particular point. Point records can also be assigned to a small spatial administrative unit, the CD. CDs can then be grouped according to other characteristics, enabling those records to be analysed as a part of that particular grouping. This technique has already been used to compare the research database with the census population (Section 3.2.3.2), and will be one of the main procedures used to group the records for analysis in future chapters.

The main limitation of this method is in the number of records with sufficient location information to enable geocoding. Using geocoded records only effectively excludes rural children for whom standard street addresses are frequently not available. However, if this type of analysis is constrained to the urban area then not only do we capture a greater percentage of the database in that area, (of those children identified as living in the metropolitan area by suburb, over 80% can be point geocoded), but we also focus on the area of the state where the greatest proportion of children live and where there is more supplementary data available. This is not an ideal situation, but to analyse the non-urban children in the research database at a finer scale is not practicable given the low density of children in these areas, the quality of location information provided and the amount of supplementary data readily available.

It is also unfortunate that there are only a limited number of geocoded records for the time period around the 1996 census. This is one of the main reasons behind the use of 2001 census figures only, as seen later in the thesis, with the corresponding selection of a sub-group of records for analysis from that particular time period. This precludes a comparison between change in SES indicators and change in obesity prevalence for small areas between the two census dates, which would be a desirable addition to the analysis.

3.5 Supplementary Data Sets

Data were sourced from a number of agencies to support this research and have been used extensively in the validation and analysis of the primary data set. Most data have been made available in a spatially referenced format, which is readily incorporated in a GIS environment. Table 3-10 lists the types of data used and the source agencies. The data are described more fully in the appropriate sections throughout the thesis.

Table 3-10 Supplementary data providers

Source	Data	Notes	Year
Australian Bureau of Statistics	Census Statistics 1996 and 2001 Census geography boundaries	*Extracted using CData96 and Cdata2001*	*1996* *2001*
Department of Environment and Heritage (DEH)	South Australian Property Cadastre and land valuation data Suburb boundaries	*In conjunction with DAIS*	*2005*
Department for Administrative and Information Services (DAIS) - Land Services Group	Land valuation data	*In conjunction with DEH*	*2005*
Department of Health - Pregnancy Outcome Statistics Unit	Perinatal birth records		*1995-2001*
Office for Recreation and Sport	Recreational trail routes		*2002*
PlanningSA	Land use	*Derived from DCDB and valuation data*	*2004*
The University of Adelaide - GISCA	Metropolitan ARIA (Accessibility and Remoteness Index)	*Accessibility to facilities and services*	*2002*
GeoScience Australia	1:250 000 topographic data for Adelaide region	*Used to create digital elevation model→slope*	*2004*
Electronic White Pages	Selected fast food restaurant locations	*Point locations digitised from address details*	*2003*

Source: Compiled by the author

3.5.1 Administrative Boundaries

Throughout the analysis, children are often grouped according to an administrative region or boundary within which overweight prevalence is then calculated. These spatial units are drawn almost exclusively from the ABS 2001 census of population and housing ('the census') and were acquired in digital form using the CData 2001 program. The boundaries form part of the Australian Standard Geographical Classification (ASGC) and those used in this study are described as follows:

Census Collection District (CD) - the smallest unit of census geography, related to the workload of a census collector and consisting of around 220 households in urban areas. CDs can be aggregated to most of the larger spatial units.

Statistical Division (SD) - generally analogous to state planning areas in South Australia, the SD of greatest importance in this study is the **Adelaide Statistical Division (ASD)**, which represents the wider city of Adelaide and includes areas which may be subject to future urban development. It is a very stable geographical unit, unlikely to change between census years in contrast to the actual urban centre boundary.

Statistical Region (SR) – the statistical regions are large areas designed for the output of survey and census statistics at a broader scale. South Australia has 6 SRs, of which the four that divide the ASD into Northern, Western, Eastern and Southern Adelaide have been used in this study.

Urban Centre/Locality (UCL) – areas defined by grouping CDs together according to population size. An urban centre is a population cluster of 1000 or more people, while a locality is a cluster of between 200 and 999 people. Urban centres with 20 000 or more people, such as the Adelaide urban centre, consist of contiguous CDs with a population above a certain threshold and also incorporate lower population CDs which are bordered by other urban CDs. The urban Adelaide area used for this study includes all of the urban CDs contained within the ASD. The total urban area is therefore not contiguous, but includes all of the densely populated areas in greater Adelaide.

Source: Australian Standard Geographical Classification (ASGC) ABS 2001

The ASGC also includes a classification called Derived Suburbs, which consist of CDs aggregated to match actual Australia Post suburbs as closely as possible. While this works quite well in some areas, there can be significant discrepancies in the spatial extent of the two. In South Australia, the Department of Environment and Heritage (DEH) maintains a file derived from the Digital Cadastral Database (DCDB) and valuation data which delineates suburb boundaries as recognised by residents and Australia Post. These digital spatial boundaries have been made available for this study and used to provide a more accurate delineation of the suburbs which people live in and identify with.

3.6 Software

All analysis in this research was carried out in a desktop computing environment, using several commercial software programmes to manage and display spatial data and perform statistical analysis. The key spatial software was ArcGIS version 9.2 (ESRI 2005), of which ArcMap was the main component used to display and manipulate spatial data. Data were imported from ArcMap into SPSS version 15 (SPSS 2006) for specialised statistical analysis, and were often exported back to ArcMap for display and/or further manipulation. Results were tabulated and presented using Microsoft Excel (Microsoft Corporation 2006).

Census statistics and boundaries from both the 1996 and 2001 Australian Census of Population and Housing were accessed using the CData programs produced by the Australian Bureau of Statistics and built upon the MapInfo GIS software program. The data extracted in this software environment were then imported into ArcMap for integration with other data sets and further analysis.

3.7 Ecological and statistical methods

> *"Many variables measured at the individual level are strongly conditioned by social processes operating at the levels of social groups or societies."*
>
> *(Diez-Roux 1998 p216)*

While the initial descriptive work in this thesis reports on the variation in overweight prevalence according to time and region, the bulk of this research is focused on urban Adelaide and draws from an ecological model of health and well-being where the health of individuals is influenced by both individual and environmental factors and the interaction between the two also mediates the outcomes (Diez-Roux 2001). In this context, overweight and obesity in four year old children is considered to be related not only to their individual characteristics but also to the family and neighbourhood environments in which they live and interact. The preferred methodology for investigating these relationships and interactions is multi-level modelling (Diez-Roux 1998; Janssen, Boyce et al. 2006), which takes into account both individual and neighbourhood characteristics to determine the strength of various influences on the outcome of interest.

The use of aggregate measures to investigate neighbourhood effects on health is a relatively new approach which has been subject to some important criticisms. Chief among these is some ambiguity regarding the actual meaning of these measures, and whether they represent a true effect conferred by a higher-level entity (the neighbourhood) or whether they are simply a summary of individual-level variables and therefore not representative of another layer of influence at all (Carey 2000; Diez-Roux 2000; 2001) Multi-level analysis, which nests individuals within areas and includes both individual and area-level predictors in regression equations can account for this ambiguity by teasing out the different contribution of each level to the outcome measure.

For studies of this type the outcome of interest is generally the measured effect of the higher order grouping which is revealed after controlling for individual factors (Rice and Jones 1997). This is a problem for the current study in that the extent and quality of individual-level data for the children in the research database is not robust enough to support a multi-level approach. It would be inappropriate to use neighbourhood education levels (for example) as a predictor in a multi-level model when there is no information available about the parental education levels which have the most impact on individual children. The model would be flawed in its estimation of neighbourhood effects because the lower order effects could not be sufficiently accounted for. In the absence of the individual statistics need for multi-level modelling, the ecological relationships between individuals' weight status and environment have been explored in a more stratified fashion; with individual variables, as listed in the database, and assigned variables, as created in the GIS environment and applied to individuals; being examined as the first layer of influence. The outcomes of this have informed the second level of analysis, where area level variables are compared with the obesity prevalence of children living in those areas.

The area level variables which have been selected for comparison with obesity prevalence have been chosen, in most cases, on the basis of previous research which has identified some relationship between that statistic (for either individuals or areas) and the presence of overweight in people of any age group[7]. Many of these previous studies have been cited in Chapter 2. These broad variable categories and the rationale for their inclusion are summarised in Table 3.11 (below).

Table 3-11 Analysis variables and selection rationale

Variables	Rationale
Socio-Demographic	
IRSD (Index of Disadvantage)	Extensive literature detailing associations between SES and overweight
Age Structure	Background demographic indicator
Ethnicity - Indigenous	Significant association with overweight in many studies Varying associations with weight status reported. Can be considered as an indicator of disadvantage
Family/Houshold Structure	Association with weight status in some studies
Education & Qualifications	Significant association with weight status in many studies
Employment	Association with weight status in some studies
Occupation	Association with weight status in some studies
Dwelling Type & Tenure	Association with weight status in some studies
Internet Use	Sedentary leisure activities considered a contributor to overweight in many studies Underresearched
Physical Environmental	
Housing	Association with overall health status in some studies
Fast Food	Extensive literature concerning poor dietary choices and obesity. Extensive academic and mainstream interest in the contribution of fast food to overweight
Recreational Facilities	Significant association with weight status in many studies
Walkability	Active transport associated with weight status in many studies
Accessibility	Access to community resources associated with better health status in some studies
Topography	May be directly related to energy expenditure. Underresearched

Source: Compiled by the author

Cross tabulation, with chi square testing for significance, has been used throughout these first two levels of analysis. The children are grouped according to the distribution of the values for the indicator variable being assessed, and the percentage of the population overweight and/or obese in each group is calculated. The grouping of

[7] Due to the relative scarcity of studies involving preschool children and the lack of knowledge about the specific mechanisms of overweight development in this age group, possible contributors have been identified from the literature relating to all age groups.

variables is most often done by quintile, but different means of categorisation have been used where appropriate. This grouping mechanism goes some way towards smoothing the effects of the previously identified bias towards inclusion of children from lower SES backgrounds in the database. The final layer of analysis draws upon the results from the cross tabulation and chi square testing to describe and compare the environment in five discrete neighbourhoods with very different obesity prevalence statistics.

3.8 Conclusion

Extensive exploration and validation have resulted in a database which can confidently be used to explore the prevalence of overweight and obesity and its variation over time and space within South Australia. Despite the issues in data collection around 2002, the research database has been shown to be representative of both the distribution of four year old children and the characteristics of the South Australian population at key time points. A focus on urban children – particularly those who were assessed around the time of the 2001 census - for detailed analysis is a function of data availability and the integrity of both the CYWHS research database and the supplementary data sets.

A wide range of supplementary data have been incorporated into the analysis to characterise the environments in which overweight and obesity have developed in this population of South Australian children. Integration and analysis has been made possible on this scale by the commercial GIS software which enables efficient management and manipulation of spatially referenced data.

CHAPTER 4

Distribution: Overweight in place and time

4.1 Introduction

This study is based on the premise that overweight and obesity in this South Australian preschool population varies spatially. In this chapter, that assertion will be examined using the spatially referenced records available in the CYWHS data set and the variation will be evident from the mapping techniques employed.

This chapter begins the exploration of overweight and obesity in the CYWHS data set and is initially concerned with describing the trends and distribution of overweight prevalence over time and throughout the state. The location information available with the data set allows the children to be further classified according to their area of residence, and this analysis provides some interesting insights into the differences in overweight prevalence between different types of residential locations.

4.2 Overweight in South Australia

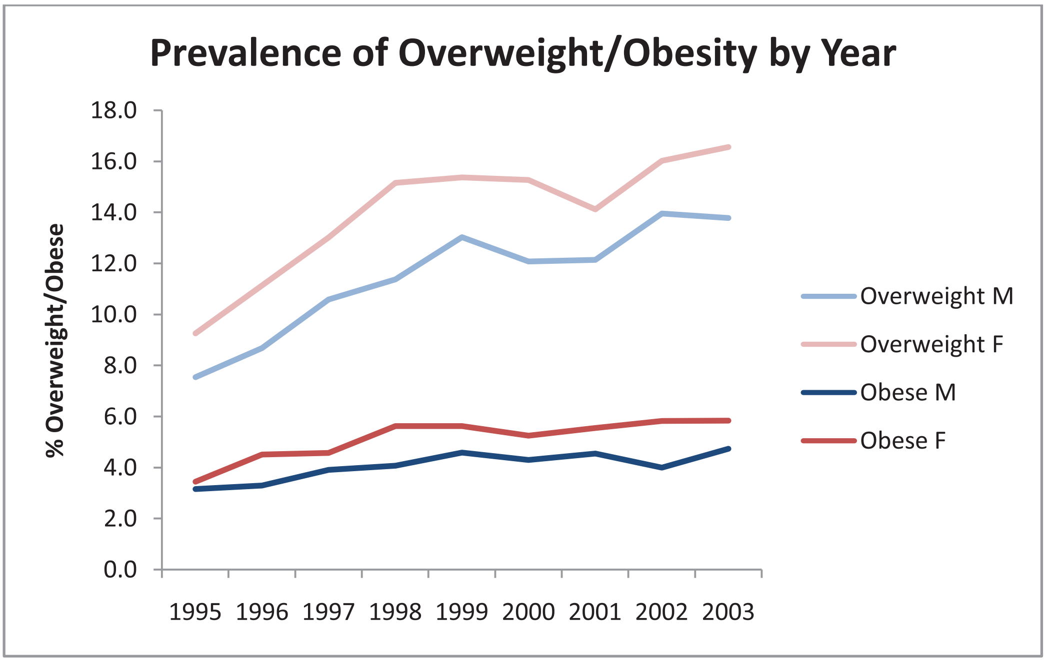
The CYWHS research database contains information from successive cohorts of four year old children, and as such we can examine the change in both overweight and obesity prevalence over time. In common with so many other countries (e.g. (Reilly, Dorosty et al. 1999; Bundred, Kitchiner et al. 2001; Rodriguez Artalejo, Lopez Garcia et al. 2002; Magkos, Manios et al. 2005) and so many other age groups (e.g. (Flegal, Carroll et al. 2002; Ogden, Flegal et al. 2002), the prevalence of overweight and obesity in South Australian preschool children has increased over time, with overweight prevalence increasing by approximately 80% for both genders and obesity prevalence increasing by almost 50% in males and 70% in females over the period from 1995 to 2003. These data are presented in Table 4-1 and illustrated in Figure 4.1 and have previously been reported in slightly different form by Vaska and Volkmer (2004) and Hetzel *et al* (2004).

Table 4-1 Overweight and obesity prevalence by year in the CYWHS data set

		1995	1996	1997	1998	1999	2000	2001	2002	2003
		%	%	%	%	%	%	%	%	%
Overweight	M	7.5	8.7	10.6	11.4	13.0	12.1	12.1	14.0	13.8
	F	9.3	11.1	13.0	15.2	15.4	15.3	14.1	16.0	16.6
Obese	M	3.2	3.3	3.9	4.1	4.6	4.3	4.5	4.0	4.7
	F	3.4	4.5	4.6	5.6	5.6	5.3	5.6	5.8	5.8

Source: CYWHS data 1995-2003

Figure 4.1 Change in overweight and obesity prevalence over time in the CYWHS data set



Source: CYWHS data 1995-2003

It is notable that in 2001, when CYWHS resources were first directed toward lower SES areas where a higher prevalence of overweight might be expected (see Section 3.2.1), the overweight prevalence actually dropped sharply and then resumed in subsequent years at a level consistent with that recorded in the years immediately prior to 2001. This indicates that the change in CYWHS policy at this time did not cause significant bias towards lower SES groups in the data set.

These figures represent the trend for the entire state of South Australia over this time period, and while this is valuable information it is also important to see if, and how, this varies by location. Previous research has identified differences in the overweight prevalence of children and adults living in different places – most commonly divided into rural and urban areas of residence (Booth, Michael L, Wake et al. 2001; Wang, Youfa 2001; Oliver and Hayes 2008). In developing countries, urban children have generally been shown to be more likely to be overweight than rural children, while the reverse is true in Western countries (Swinburn, Caterson et al. 2004; Wang, Longde, Kong et al. 2005).

This same pattern of rural/urban difference has been previously identified in South Australia. Using CYWHS data, Hetzel *et al.* (2004) identified a higher prevalence of overweight (including obesity) in country South Australia than in the Adelaide Statistical Division. Confirming this, chi square testing on a basic metropolitan/non-metropolitan classification as presented in Table 4-2 for the current study verifies that non-metropolitan children are significantly more likely to be overweight than their metropolitan counterparts, although obesity prevalence is comparable despite the area of residence. The relationships are similar for both males and females.

Table 4-2 Overweight in the CYWHS data set by metropolitan/non-metropolitan location

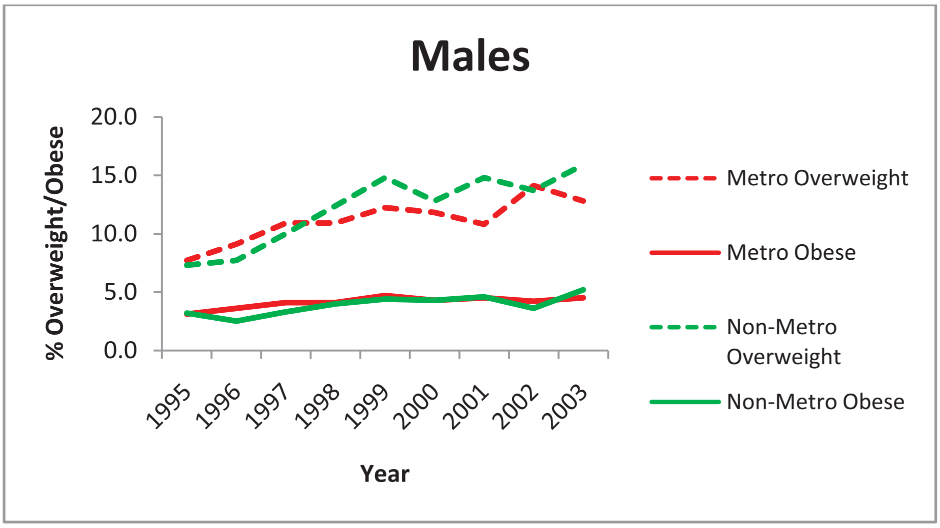
	Males		Females	
	Metro	**Non-Metro**	**Metro**	**Non-Metro**
	%	%	%	%
Overweight	10.9**	12.0**	13.6*	14.2*
Obese	4.1	3.9	5.0	5.1

**P<0.05   **P<0.005*

Source: CYWHS data 1995-2003

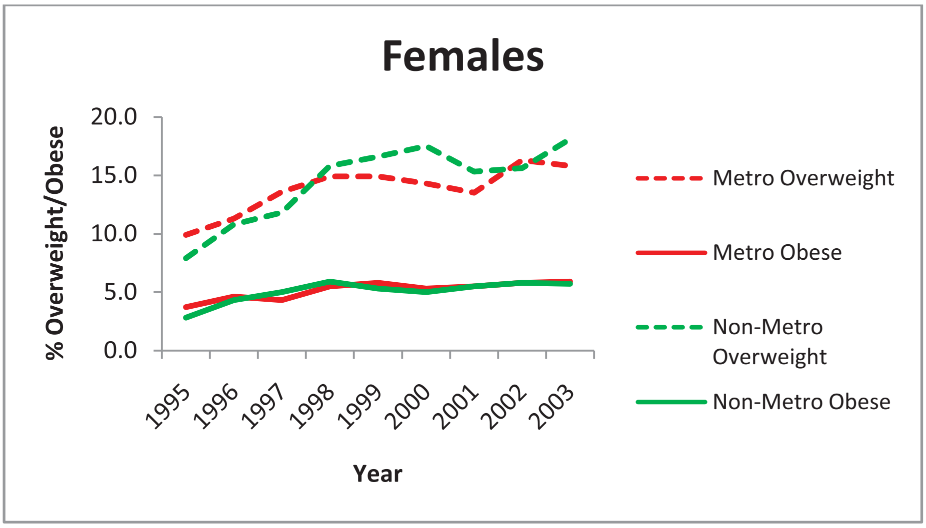
However when the data are examined by year (Figure 4.2 and Figure 4.3) it appears that this relationship has not been consistent over time. There is some indication that, prior to 1997, overweight prevalence was actually higher among metropolitan children but since then has clearly been higher in the non-metropolitan children. There is a brief cross over again in 2002, but this is most likely due to the previously discussed issues with data collection at that time and may not be truly indicative of variation. This pattern is reflected in the obesity prevalence, especially for males, but the percentage differences are much smaller than those for overweight.

Figure 4.2 Overweight and obesity by metropolitan location over time,, 1995 - 2003 (Males)



Source: CYWHS data 1995-2003

Figure 4.3 Overweight and obesity by metropolitan location over time, 1995 – 2003 (Females)



Source: CYWHS data 1995-2003

The fact that the pattern of overweight prevalence between urban and rural children is similar to that observed in other developed countries is no surprise. It is, however, interesting to note that this was not necessarily the case prior to 1998. In order to speculate on the possible reasons for this apparent change, it is important to recognise that the children in each group live in communities which are far from homogenous. The non-metropolitan children in particular live in circumstances ranging from isolated rural properties to small country towns to larger regional centres. The more detailed location coding undertaken on the research database for this study has therefore recognised several discrete location types within the state which offer further insight into the distribution of the overweight children among this population.

4.2.1 Overweight by place – discrete location types

This analysis can be further refined by considering location more precisely than simply rural or urban. The 86 335 geocoded records have been matched to location categories which take into account both the urban/rural dichotomy and the population of rural towns. Locations were defined as follows based upon 2001 ABS census population data and boundaries:

- **Urban** – the Adelaide urban area as delineated by the urban CDs defined by the ABS (Australian Bureau of Statistics 2001)
- **Regional Centres** – population centres with over 10 000 people. There are 6 'rural cities' in this category: Mount Gambier, Murray Bridge, Port Pirie, Port Augusta, Port Lincoln and Whyalla
- **Large Towns** – defined localities (Australian Bureau of Statistics 2001) with population between 5 000 and 10 000 people
- **Small Towns** – defined localities with population less than 5 000 people
- **Rural Balance –** the remainder of the state, outside of locality or city boundaries

(Refer to the Location Map (Chapter 1, p17) for an overview of the distribution of the urban and regional centres within South Australia)

Table 4-3 shows the overall prevalence of overweight and obesity for these five location categories. Chi square testing shows that the variation in prevalence by location is statistically significant for both genders, and this relationship is particularly strong for overweight. The regional centres exhibit the highest prevalence of both overweight and obesity, but no other location is consistently higher or lower than the others. These results suggest that much of the higher overweight prevalence among non-metropolitan children is attributable to those living in the major regional centres.

Table 4-3 Overweight and obesity in the CYWHS data set by location category

	Females		Males	
	Overweight	Obese	Overweight	Obese
	%	%	%	%
Urban	14.27**	5.38	11.51**	4.33
Regional Centres	16.47**	6.65*	15.08**	4.77
Large Towns	14.97	5.15	11.10	2.64*
Small Towns	15.65**	5.23	11.24	4.00
Rural Balance	13.49	5.64	11.12	2.99*

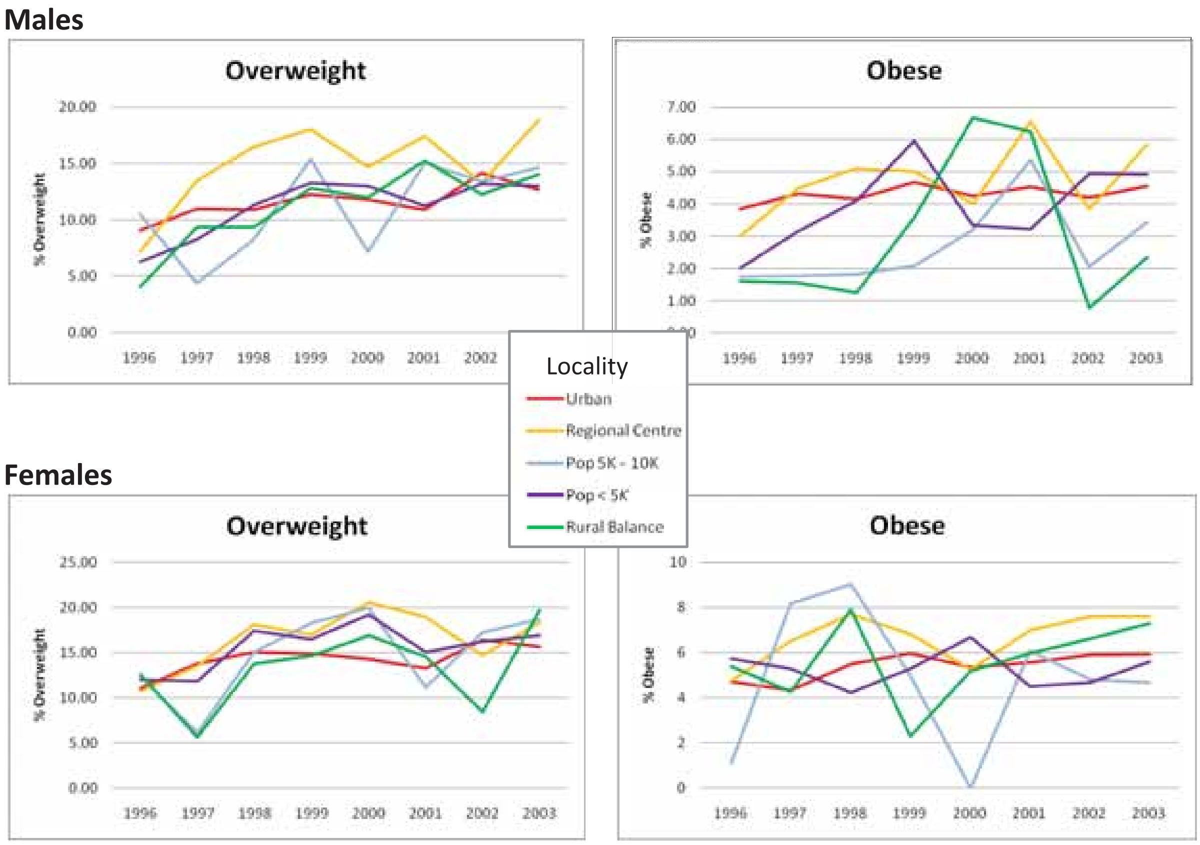
**P<0.05 **P<,0.005*

Source: CYWHS data 1995-2003

Breakdown of these statistics by year of record (Figure 4.4) confirms this trend in that the Regional Centres consistently display a higher prevalence of overweight and, to an extent, obesity than the other locations. It is also apparent that a steep increase in both overweight and obesity prevalence occurred in the regional centres during the period 1996-1999 while the increase in the urban prevalence during this same time period was much less. This may well have resulted in the cross over of metropolitan/non-metropolitan overweight prevalence in 1998 identified in the previous section, meaning that this phenomenon could be due primarily to the high rate of increase in overweight prevalence in the regional centres.

Although there is an evident increase in overweight prevalence over time in all locations, there is still a great deal of variability from year to year, especially in the obesity statistics. It is not apparent whether this inconsistency represents true data variability, or whether there have been issues with the collection and/or recording of the data. Low numbers of children in some categories in some years could be an issue; although in only a few instances does the total number of children in a location drop below 100.

Figure 4.4 Overweight and obesity by location, 1996 – 2003 inclusive



Source: CYWHS data 1996-2003

4.2.2 Regional Centres

While the urban area will be examined more closely in the following sections, and the low numbers of children in other location categories preclude further breakdown, it is possible to further study the 'Regional Centres' in terms of the six individual rural cities which make up this broader category. The location of the cities within South Australia and their relative isolation from urban Adelaide can be seen in the location map (Chapter 1, p 17), while the percentage of children overweight and obese in each city is listed in Table 4-4 and presented graphically in Figure 4.5. Of particular note is the high prevalence of both overweight and obesity in Port Lincoln, Port Pirie and, to a lesser extent, Port Augusta while Mount Gambier and Murray Bridge have a comparatively low prevalence.

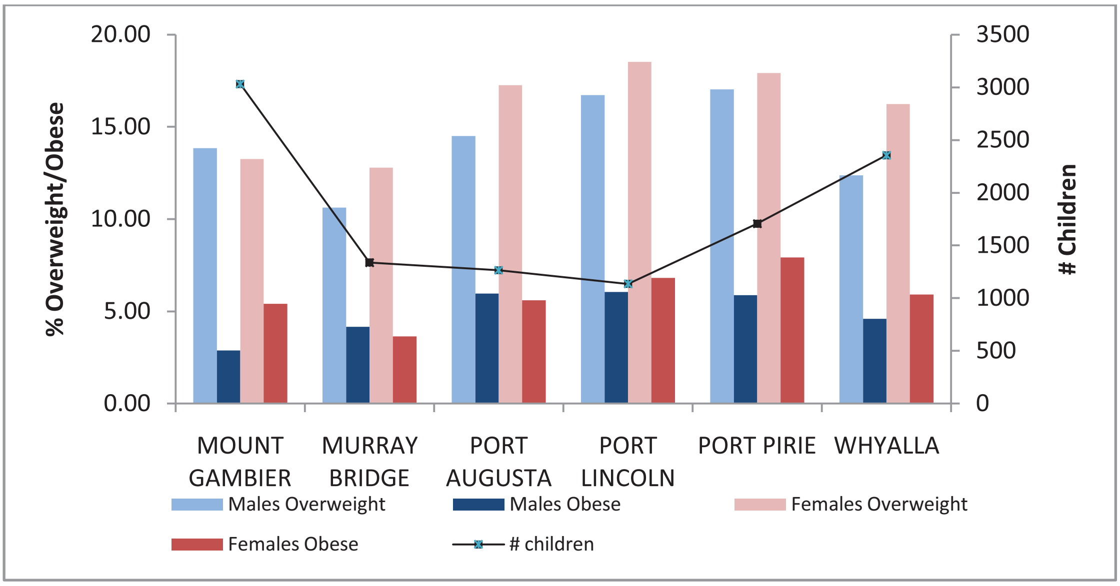
Table 4-4 Overweight and obesity by regional centre, 1996-2003 inclusive

	Females		Males	
	Overweight	**Obese**	**Overweight**	**Obese**
	%	%	%	%
MOUNT GAMBIER	13.27**	5.40	13.85	2.87**
MURRAY BRIDGE	12.79**	3.63*	10.63**	4.16
PORT AUGUSTA	17.27	5.59	14.50	5.95
PORT LINCOLN	18.53**	6.82	16.73	6.05
PORT PIRIE	17.93**	7.93*	17.04**	5.87**
WHYALLA	16.24	5.91	12.37	4.59

**P<0.05 **P,0.005*

Source: CYWHS data 1995-2003

Figure 4.5 Overweight and obesity by regional centre, 1996-2003 inclusive



Source: CYWHS data 1995-2003

Given the disparate obesity prevalence, selected census data for both 1996 and 2001 has been extracted and presented in Table 4.5 in order to develop a picture of the social and economic climate in these very different cities. Port Augusta and Port Pirie are the only cities not to have recorded a population increase between the census dates, and the population in all cities appears to have aged slightly, although less so in Port Lincoln.

By 2001, Mount Gambier and Port Lincoln were the least disadvantaged cites although Mount Gambier clearly had the lowest levels of unemployment and the highest median household income. Port Pirie has undergone the greatest change in disadvantage status, with the SEIFA index increasing from the most disadvantaged in 1996 to a more moderate level, actually less disadvantaged than Whyalla, in 2001. Whyalla is the only city to show a decrease in the SEIFA index (i.e. becoming more disadvantaged), while Mount Gambier's disadvantage score has remained very constant.

Port Augusta has a very high percentage of indigenous persons, while Whyalla has a very high percentage of people born overseas. However, the percentage of the population who speak another language in Whyalla is only slightly higher than in the other cities, indicating that many of the overseas born population in this city come from English-speaking countries, most likely representing an older population of post-war British migrants.

Recent research in the role of environmental toxins as endocrine disruptors may also have some relevance to this discussion. Port Pirie, Port Augusta and Whyalla, (sometimes referred to as the 'Iron Triangle') are industrial cities with economies largely based around such activities as lead smelting, steel manufacture and power generation (Government of South Australia 2004), all of which generate significant pollution. As such, the exposure of the local populations to significant levels of endocrine disruptors must be considered as a potential contributor to the development of overweight, however it is not yet known whether this effect operates in young children (Grün and Blumberg 2009).

Table 4-5 Selected socio-economic statistics for South Australian regional cities, 1996 and 2001

	MOUNT GAMBIER		MURRAY BRIDGE		PORT AUGUSTA		PORT LINCOLN		PORT PIRIE		WHYALLA	
Census Year	1996	2001	1996	2001	1996	2001	1996	2001	1996	2001	1996	2001
Total Population	22,037	22,751	15,893	16,532	14,244	13,516	12 182	13 233	13,960	13,575	23,644	21,614
Indigenous (%)	1.1	1.3	3.9	4.2	13.5	15.1	4.8	4.7	1.6	2.4	2.2	2.9
Born overseas (%)	10.5	9.8	8.7	8.9	8.0	7.4	10.3	8.9	7.6	7.7	24.7	22.4
Speak other language (%)	4.8	3.9	4.3	4.2	4.0	3.6	4.1	3.4	4.9	4.6	6.4	5.5
Aged 14 or less (%)	23.6	22.5	23	22.7	24.4	22.3	24.3	22.8	21.6	21.9	24.2	22.9
Aged 65 and over (%)	11.5	12.7	13.3	14.3	10.4	11.7	13.4	13.0	14.4	15.5	9.9	11.9
Median Age	32	34	34	36	32	35	33	34	35	37	32	35
Median household income ($/week)	546	706	461	565	489	629	469	668	436	523	503	582
Unemployed (%)	8.9	6.9	11.9	9.8	14.8	10.3	14.4	8.8	18.6	13.8	13.8	13.1
Completed year 8 or below (%)*		12.0		17.2		14.0		12.4		17.0		10.3
Completed year 12*		25.3		21.6		20.2		24.8		18.7		25.7
Bachelor degree (%)	4.2	5.2	2.4	3.0	3.2	4.5	3.6	5.0	2.8	3.9	4.7	5.0
Postgraduate degree (%)	0.3	0.5	0.2	0.2	0.3	0.3	0.4	0.4	0.2	0.3	0.6	0.5
SEIFA (disadvantage) score^	956.157	957.072	905.583	916.952	909.876	943.262	931.115	957.259	880.6	920.829	913.37	911.209

**These data were not collected in the 1996 census*

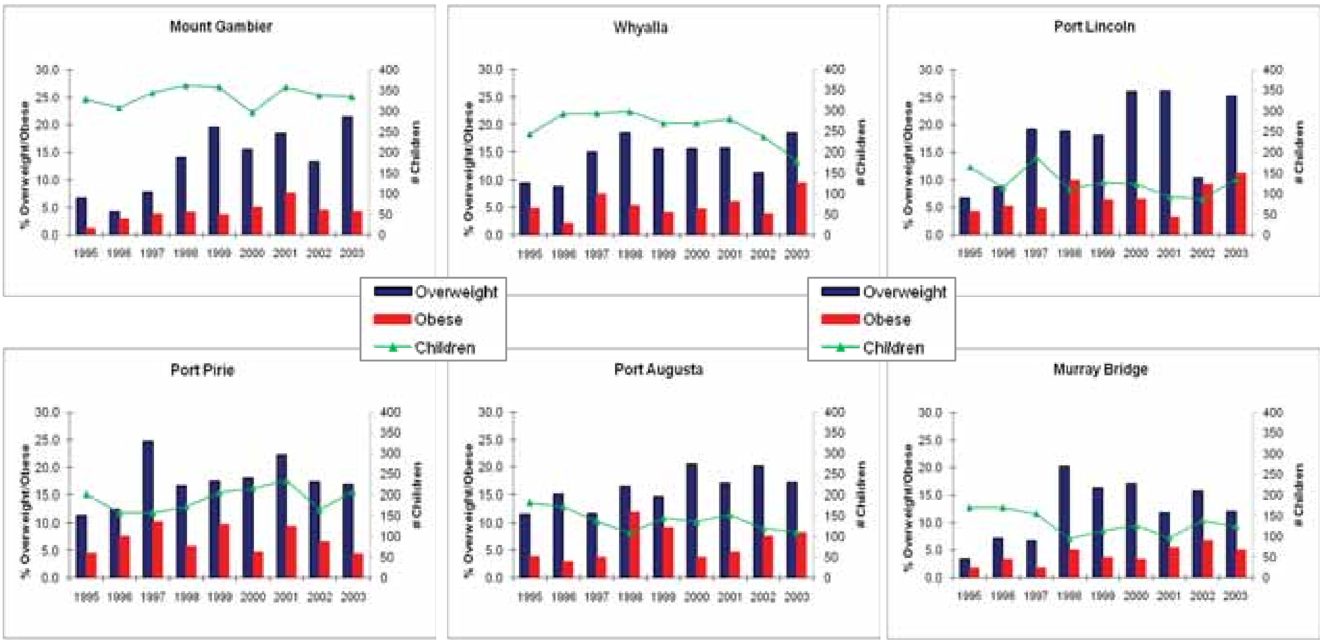
^ A lower number indicates a higher degree of relative disadvantage

Source: Compiled from ABS census data 1996 and 2001

Given these discrepancies, it is desirable to view the change in overweight prevalence over time in each community. Low numbers in some communities in some years have dictated that the statistics for males and females be combined for this analysis. The results, presented in Figure 4.6, show that a great deal of variability is present in all six cities such that there is barely any gradient evident for obesity prevalence; and only Mount Gambier, Port Lincoln and, to a lesser extent, Murray Bridge exhibit a clear tendency for overweight prevalence to increase over time. The number of children assessed has remained relatively stable in each community during the time period.

Looking further at Figure 4.7, which compares the change over time in the regional centres by displaying the same data in two different ways, it is easy to see the higher overweight prevalence in the latter years of the study period. This 'weighting' is illustrated quite well by the radar chart, as is the generally higher prevalence of overweight in Port Lincoln (in red) throughout the study period, despite a sharp dip in 2002. Also notable is the sharp spike in overweight prevalence in 2003 for several of the cities. This does not appear to be related to the number of children assessed (refer to Figure 4.6) and it is difficult to ascertain whether there have been issues of data collection and recording which may have affected these statistics, or whether both the highs and lows are representative of true data variation and are an indication of the inconsistent expression of the overweight phenomenon such that trends can only be detected over longer time periods or within much larger data sets.

Figure 4.6 Overweight and obesity in regional centres over time



Source: CYWHS data 1995-2003

Figure 4.7 Comparison of overweight (including obesity) in regional centres 1995 – 2003

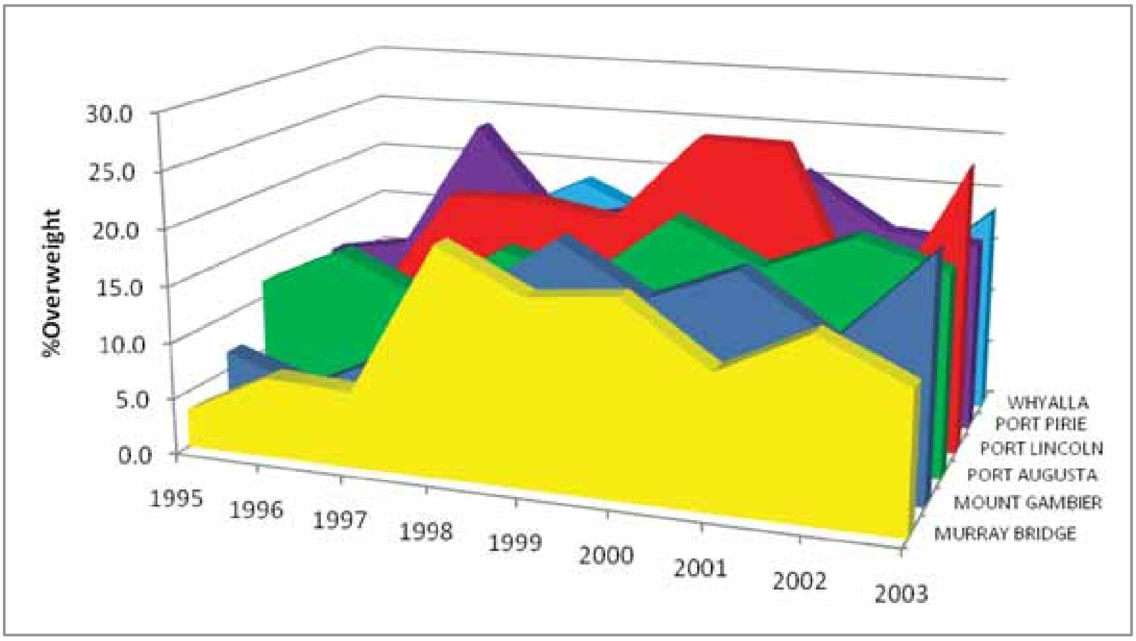


Figure 4.7a Area Chart

Figure 4.7b Radar Chart

Source: CYWHS data 1995-2003

4.2.3 Discussion

This data exploration has demonstrated that there are indeed differences in the overweight prevalence of four year old children according to the type of community in which they reside. Despite the high variability from year to year, especially when numbers are lower, it is also evident that the underlying trend has been for an increase in both overweight and obesity prevalence over time, although this becomes less defined as the location category becomes more precise.

The higher prevalence of overweight (inclusive) among children living outside the Adelaide area appears to be largely driven by the rates in the major regional centres. This, in turn is driven by high prevalence in Port Lincoln, Port Augusta, Port Pirie and Whyalla, with Port Lincoln exhibiting consistently high overweight and obesity prevalence. The first reaction is to look for socio-demographic explanations for these observed differences (refer to Table 4-5), and it is true that Port Pirie and Whyalla have some of the highest levels of overall disadvantage. However Murray Bridge also has a similar SEIFA disadvantage score but a contrastingly low prevalence of overweight, while Port Lincoln is actually the least disadvantaged city by 2001 – which is surprising in the context of the high prevalence of overweight recorded amongst the preschool children.

Table 4-5 shows that Port Lincoln is not unique among the cities in terms of its population size or structure. Although the percentage of both indigenous and overseas born persons is relatively high, it is Port Augusta and Whyalla respectively which exhibit the highest extremes of these statistics. Port Lincoln has, however experienced the greatest drop in the unemployment rate between the two census years, and by 2001 was second only to Mount Gambier in low unemployment. The implications of this are unclear, but it is possible that this sharp drop in unemployment is indicative of a population which suddenly finds itself with more financial resources, and perhaps this has led to lifestyle changes which are conducive to the development of overweight.

Given the relationship between overweight and disadvantage which has consistently been observed in the literature (see Chapter 2, Section 2.4.3) these observations are unexpected, especially when the two least disadvantaged cities have respectively the highest and one of the lowest overweight prevalence statistics. Murray Bridge is also something of an anomaly – with an intermediate level of disadvantage but a relatively low overweight prevalence, especially in the early years of data collection. There is obviously scope for further research, with a much finer level of analysis than that presented here, into the differences within and between these communities which may explain the disparity in overweight prevalence amongst the preschool children.

4.3 Urban Children and Overweight

The different types of communities which make up the non-metropolitan population of South Australia are relatively easy to identify and compare in terms of overweight and obesity prevalence. However the metropolitan area is not homogenous in terms of population characteristics either, and could also be expected to show variation in the distribution of overweight children. This variation will be demonstrated within the Adelaide Statistical Division (ASD) and particularly the urban area using recognised administrative boundaries as the units of analysis (see location maps, Figure 1.1 – Figure 1.5).

4.3.1 Prevalence of overweight

Within the Adelaide Statistical Division, all records for all years were matched to the suburbs coverage supplied by the Department of Environment and Heritage (DEH).

The records were summarised by suburb name, (Plympton North and Plympton South were aggregated with Plympton to form one suburb), and the number of children overweight (including obese) was totalled for each suburb, along with the total number of children recorded in that suburb. There are 422 suburbs in the ASD, of which 341 had 30 or more children from the database identified as living there (low 31 children, high 2 211 children, mean 240 children).

Using the records of all the geocoded children within the ASD, (*n = 82687)* the percentage of the CYWHS children who were overweight for each suburb was calculated (minimum 5.4%, maximum 34.0%, mean 16.8%) and is illustrated in the following series of maps. These statistics include children who were overweight and obese combined, as low numbers of obese children within the majority of suburbs preclude meaningful analysis of obesity as a separate category. Similarly, suburbs with less than 30 children (81 suburbs) for the entire data set or less than 20 children (92 or 96 suburbs) for males and females separately, have been excluded from mapping in a compromise between displaying meaningful statistics while still presenting an overview of the entire study area. Most of the excluded suburbs are located near the outer boundary of the ASD (see Figure 4.8), and are not densely populated to start with.

When these data are viewed spatially, (Figure 4.8) for all children there is clearly a higher prevalence of overweight in the western and northern suburbs; with many areas where over 20% of the children are overweight or obese. The eastern suburbs show a generally lower prevalence, with a number of areas below 10%, while in the south the percentage is moderate to low – generally between 10% and 20%. When these data are broken down into separate maps for males and females these same general patterns remain evident and the higher prevalence of overweight in females also becomes apparent. Although it would be desirable to see the pattern of change over time, low numbers already mean some suburbs are excluded from mapping and additional stratification by year of record would further exacerbate this problem so that the maps would become meaningless.

By grouping the suburbs according to which statistical region they fall within (see Figure 1.2 – Figure 1.5) and then calculating the average percentage of overweight in those four areas, it is possible to quantify this regional pattern. These results are presented in Table 4-6, where it can be seen that Western and Northern Adelaide clearly have the highest percentage of overweight children while Eastern and Southern Adelaide have the lowest.

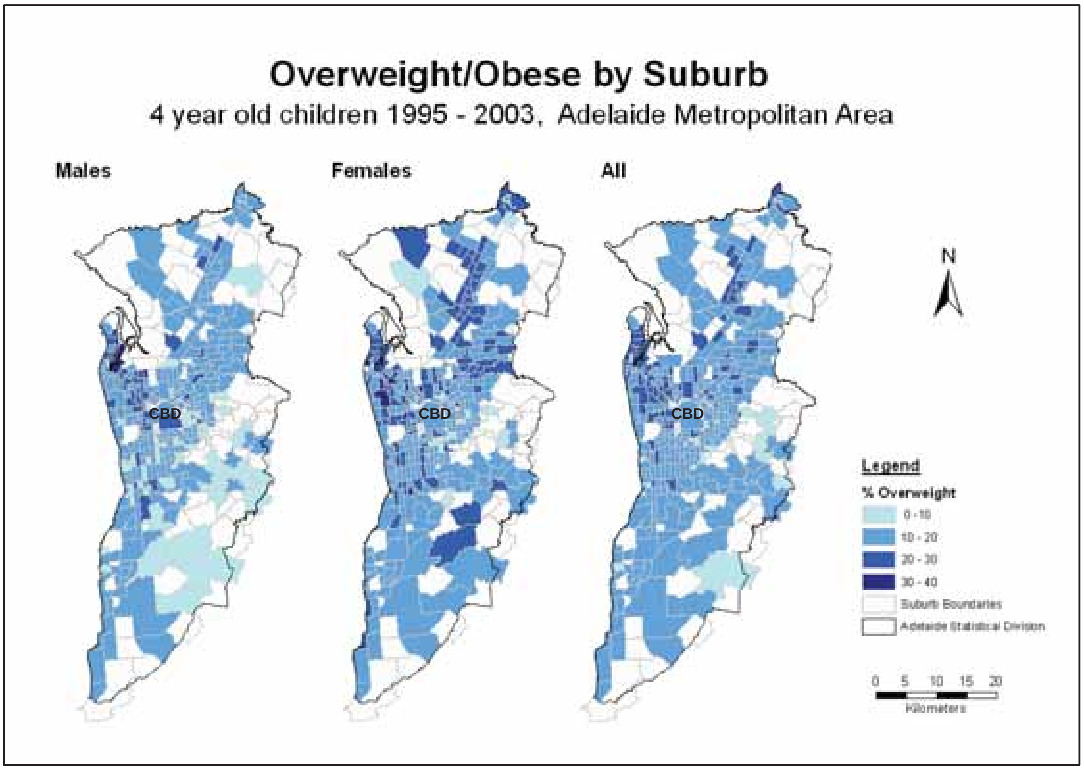
Table 4-6 Prevalence of overweight (including obesity) by statistical region of Adelaide

	Northern	Western	Eastern	Southern
% Overweight	17.9	21.3	13.9	15.0
Average BMI (Males)	16.1	16.3	15.9	16.0
Average BMI (Females)	16.0	16.1	15.7	15.9
SEIFA disadvantage	945.1	959.3	1074.4	1023.0

Source: CYWHS data 1995-2003 and ABS SEIFA 2001

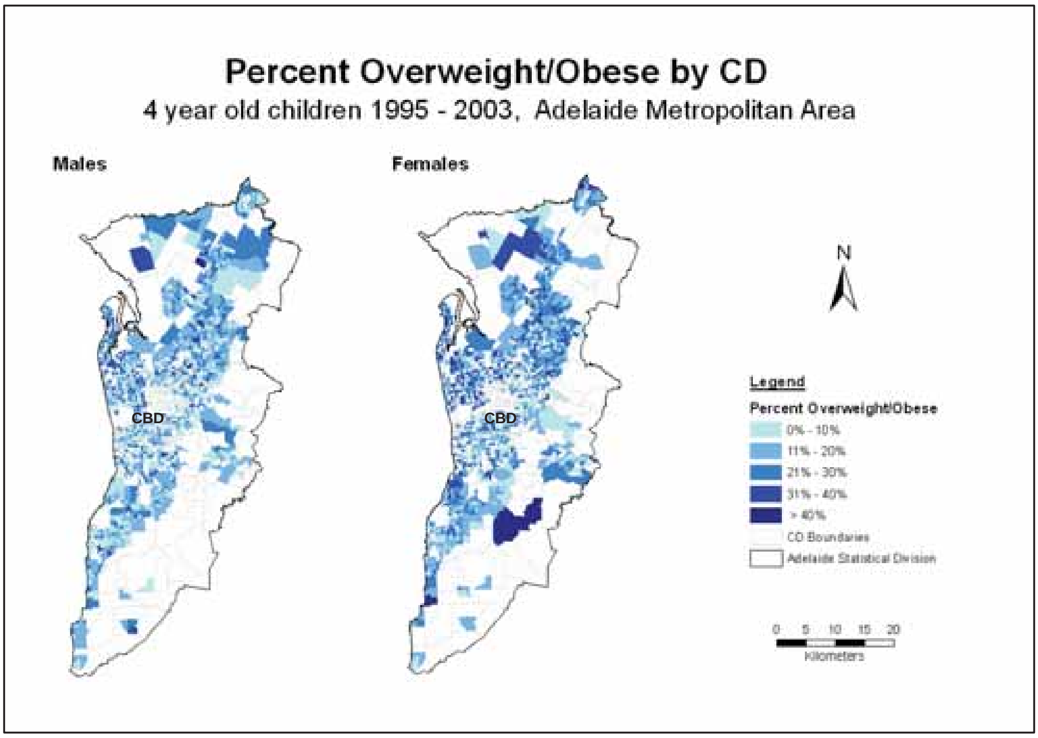
Using the geocoded records only, percent overweight can also be mapped by CD – the smallest available administrative unit (Figure 4.9). This can only be done for all the years combined, due to low numbers of children in individual CDs. Even for all years, ten records per CD has been chosen as the minimum number to display and this is low for meaningful results. However, the same broad pattern is still evident – a higher prevalence in the northern and western areas and lower in the east.

Figure 4.8 Percentage of children overweight (including obese) by suburb



Source: CYWHS data 1995-2003

Figure 4.9 Percentage of children overweight (including obese) by CD

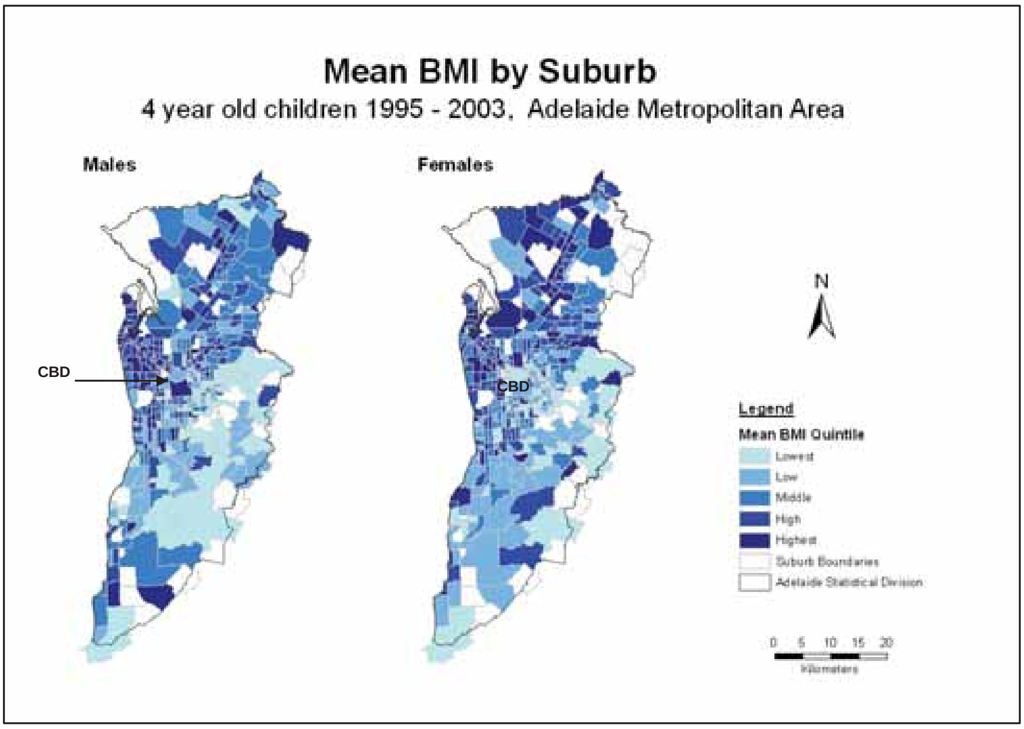


Source: CYWHS data 1995-2003

Another way to map these data is to calculate the average BMI for each suburb. While this does not explicitly measure overweight prevalence, it does provide a robust indicator of areas where children's weight status is markedly above or below the norm for this study population. This method of display also has the advantage of enabling the data to be displayed for more suburbs as the results are not so dependent upon the base number of children (see Figure 4.10). This greatly enhances the ability of the viewer to judge the variation in weight status across the entire study area. However, small numbers will still bias the result so only suburbs with more than 3 records have been included. The same process has also been used to map the average BMI for CDs (Figure 4.11). In both cases, males and females are mapped separately as un-standardised BMI scores are not comparable between the genders due to the different growth patterns. The same spatial patterning of higher average BMI scores in the north and west and lower scores in a south-east arc are apparent in these maps. For reference, the average BMI for the four statistical regions of Adelaide is also listed in Table 4-6.

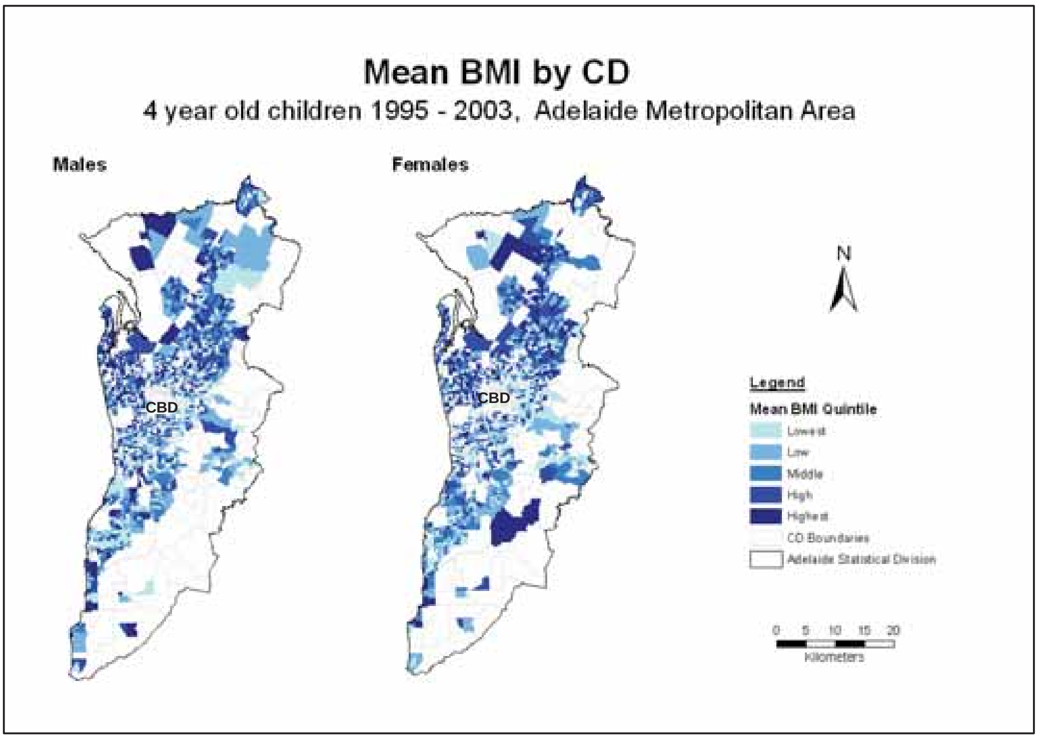
Visual inspection of these maps also suggests a possible relationship between distance from the city centre and increasing prevalence of overweight or mean BMI. This has been tested by both quintile of distance and straight correlation (results not shown) and no statistical relationship was found. The apparent patterning is most likely due to the visual influence of the larger CDs towards the outer boundaries of the city, which tend to overwhelm the colours of the smaller CDs. This is a good example of how the selection and representation of spatial units of analysis can have an unintended impact on map interpretation.

Figure 4.10 Average BMI by suburb



Source: CYWHS data 1995-2003

Figure 4.11 Average BMI by CD



Source: CYWHS data 1995-2003

4.3.2 Discussion

The apparent variation in the distribution of overweight children throughout metropolitan Adelaide indicates that overweight also varies spatially among this South Australian population and immediately raises the questions of why this is so, and if we can in some way measure these differences against possible contributors to overweight and obesity. Given the large numbers of children and the amount of supplementary data available for this area, it will be possible to firstly refine the identification of areas of high and low overweight prevalence and also to further interrogate this data set to determine whether the spatial variation is in any way correlated with socio-economic and environmental indicators.

The following chapters take up this challenge by considering both individual and area level correlates, and using more sophisticated mapping techniques to develop a clearer picture of the distribution of overweight in urban Adelaide. The ability to investigate this phenomenon outside of the constraints of standard administrative boundaries will provide a key insight into the drivers behind the overweight prevalence in different parts of Adelaide.

CHAPTER 5

Individual Children and Unique Characteristics: the who and why of overweight

5.1 Individual Variables

Underlying the prevalence of overweight in any location are the many influences on diet and lifestyle which are the main focus of this study. In this chapter, we begin to explore these by assessing both the individual variables provided with the data set and some physical environmental variables created from secondary data sources and matched to the urban subset of children based on their area of residence. This provides a broad background for the more focused socio-economic analysis which follows in later chapters.

Individual variables are those which have been measured directly for the individual children. The five variables presented here and listed in Table 5.1 are those that were supplied with the data set, and were recorded for each individual child during contact with CYWHS. As such, it is possible to hypothesize direct relationships between these factors and the prevalence of overweight and obesity among the children. Where such relationships are detected, they should be noted and accounted for, if possible, in any subsequent analysis.

A problem arises in that not all variables have been recorded for each child in this data set (see Table 5-1). While language group and indigenous status have been entered for the majority of the children, the number of visits to CYWHS services outside of the preschool check has been reliably recorded for just over one third. Birth weight and breast feeding (at 3 months of age) have only been recorded for approximately twenty percent of the research database. However these results are still important in that any relationships detected at an individual level provide both a link to previous research, much of which is of a similar nature, and a foundation on which to conduct the more extensive area-level spatial analysis which is the particular focus of this study. It is also important to consider these factors in the light of the location analysis presented in the previous chapter. It is possible that variation in one or more of these variables may contribute to some of the differences in overweight prevalence between different locations.

Table 5-1 Number of children for which individual variables have been recorded in CYWHS research database

	MALE		FEMALE	
	n	*%*	*n*	*%*
Total Children	**61526**		**59250**	
Birth weight	11812	19.2	11350	19.2
Indigenous	59363	96.5	57154	96.5
Breastfeeding	13092	21.3	12705	21.4
Language Group	60520	98.4	58295	98.4
CYWHS visits	23778	38.6	22725	38.4

Source: CYWHS data 1995-2003

This analysis has been carried out in SPSS 15.0, using cross-tabulation to obtain percentages with chi square testing and adjusted standardised residuals to check for statistical significance. All work has been reported separately for males and females to control for the gender differences as described in section 3.2.4. The entire state-wide data set, describing 120 776 individual children who attended a preschool check between 1995 and 2003, has been used.

5.1.1 Birth weight

An association between birth weight and later weight status has been identified in numerous studies from around the world (Eriksson, Forsen et al. 2001; Reilly, Armstrong et al. 2005; Rugholm, Baker et al. 2005; Blair, Thompson et al. 2007). Most authors have found that the risk of obesity at some later age increases as birth weight increases, although one study found no association between being either small or large for gestational age and the risk of overweight at age four (Jouret, Ahluwalia et al. 2007). However, there is also a body of literature which states that low birth weight – specifically, low for gestational age – is also associated with a greater risk of obesity in later life – but it is not clear whether the low birth weight *per se* is responsible, or whether the catch-up growth which so often follows somehow programs the body for later overweight (Druet and Ong 2008).

In order to substantiate the relationship with weight status in this database, birth weight was assessed in multiple ways using actual birth weight groupings, standard deviation groupings, high birth weight and low birth weight. In general, the higher the birth weight category, the greater the prevalence of overweight and obesity (Table 5.2 and Figure 5.1). Chi square testing showed all relationships were statistically significant or very closely approaching significance. Notably, for both males and females, those children whose recorded birth weight was more than one standard deviation above the mean had approximately double the prevalence of obesity compared to those whose birth weight was within one standard deviation of the mean.

When viewed graphically (Figure 5.1), it can be seen that the relationship between increasing birth weight category and percentage overweight/obese appears to be linear in nature, although with only three weight categories this is a limited observation.

Slightly more variation is evident in the graph of the birth weight standard deviations (five categories), but the overall trend is still strongly linear.

Table 5-2 Prevalence of overweight and obesity by birth weight

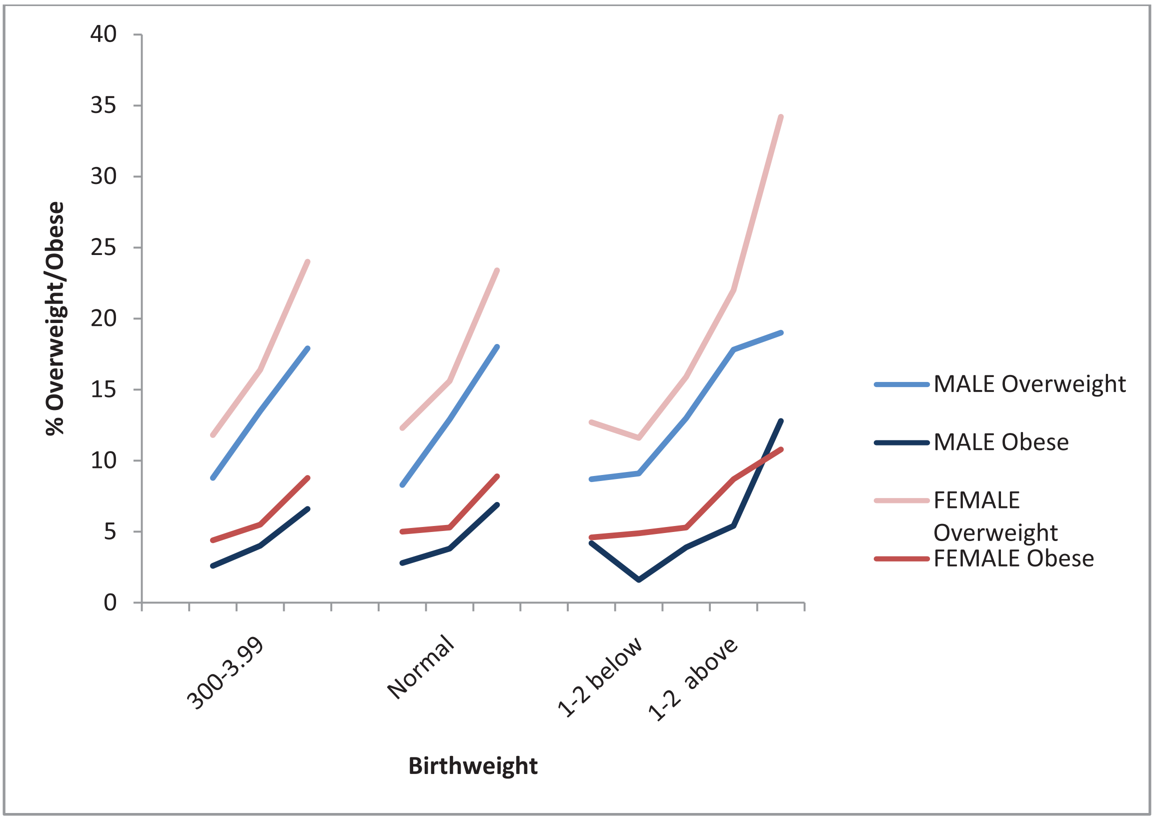
	MALE		FEMALE	
	Overweight	**Obese**	**Overweight**	**Obese**
	%	%	%	%
Birthweight (Kg)				
2.00-2.99	8.8**	2.6**	11.8**	4.4**
300-3.99	13.5	4.0	16.4	5.5
4.00-4.99	17.9**	6.6**	24.0**	8.8**
Birthweight Category				
Low	8.3**	2.8	12.3**	5.0
Normal	12.9**	3.8**	15.6**	5.3**
High	18.0**	6.9**	23.4**	8.9**
Birthweight SD				
>2 below	8.7**	4.2	12.7	4.6
1-2 below	9.1**	1.6**	11.6**	4.9
Within 1 SD	13.0	3.9	15.9	5.3**
1-2 above	17.8**	5.4**	22.0**	8.7**
>2 above[1]	19.0**	12.8**	34.2**^	10.8**^

*** P< 0.00*
^n=120

Source: CYWHS data 1995-2003

These results can also be used to explore the possibility of a relationship between low birth weight and increased likelihood of overweight at age four, as discussed above. Figure 5.1 shows a consistently lower gradient of obesity prevalence between the lower and middle birth weight categories than between the middle and higher categories; particularly for obesity and most evidently in the standard deviation categories where the prevalence of obesity in the very lowest category (more than 2 standard deviations below the mean) is almost the same as or higher than the prevalence in the next lowest birth weight category. This suggests that low birth weight is not as protective of obesity at age four *as might be expected*, with obesity levels in particular not much lower than those of normal birth weight children.

Figure 5.1 Birth weight category and prevalence of overweight/obesity



[1]*n=120 (females)*

Source: CYWHS data 1995-2003

Some caution should be used, however, in interpreting the results relating to low birth weight. Ideally, birth weight is assessed in relation to gestational age as a baby born prematurely may have a birth weight appropriate to the length of gestation, but this will of course be low compared to full term babies. Alternatively, a baby may be smaller than average due to such factors as maternal under nutrition or maternal smoking, among others (Kramer 1987) or to pregnancy-related factors such as placental insufficiency (Khong, Wolf et al. 1986; Bleker, Buimer et al. 2006). It has not been investigated how – if at all – these different contributors to low birth weight may individually influence later weight status. The lack of information on gestational age, in particular, means that these results can only be viewed as an *indicator* of a possible relationship between low birth weight and increased prevalence of overweight *over what might otherwise be expected* at age four.

5.1.2 Indigenous Status

Only 0.9% of both boys and girls in the data set were identified as being of Aboriginal and/or Torres Strait Islander descent – a total of 1 125 children. While there may be some problems with the identification of indigenous children when they present to CYWHS – either not reported as such by their carers or not recorded by the CYWHS nurse - this group is clearly under-represented in the database, with population statistics from both the 1996 and 2001 census indicating that indigenous peoples actually comprise approximately 1.6% of the total state population and 3.2% of those aged 0 – 4 (Australian Bureau of Statistics 1997b; 2002). Despite the low numbers, it is important to establish the prevalence of overweight and obesity in this group, as previous work has noted that indigenous peoples – particularly females – are likely to have a higher prevalence of overweight, and that the prevalence of overweight/obesity in this adult population has increased rapidly since 1995 (Australian Bureau of Statistics 2008c). Data from the 1990s found that indigenous children living in urban environments were taller and heavier than their remote or rural counterparts. However there was also a significant proportion of children who were underweight, and this may contribute to the finding that urban indigenous children were, on average, lighter than urban caucasian children (Australian Bureau of Statistics 1998; Mackerras, Reid et al. 2003).

In the CYWHS data set, the prevalence of both overweight and obesity is higher among indigenous males than other males, but the differences are not large. Indigenous females, however, are significantly more likely to be overweight than their non-indigenous counterparts although the obesity prevalence is almost identical (Table 5-3)

Table 5-3 Indigenous status and overweight

	MALE		FEMALE	
	Overweight	**Obese**	**Overweight**	**Obese**
	%	%	%	%
Indigenous	13.6	4.5	18.4**	5.0
Non-Indigenous	11.3	4.0	13.8**	5.1

** *p* < 0.005

Source: CYWHS data 1995-2003

It is interesting that overweight, rather than obesity, is the outcome most strongly related to indigenous status. If being of Aboriginal or Torres Strait Islander descent is very strongly related to low SES (Hugo 2003; Australian Institute of Health and Welfare 2006), then we would expect obesity prevalence to be higher in this population, as it is for many of the low SES indicators as seen in later chapters. At least among the indigenous children living in the less remote areas of South Australia captured by this data set, these results suggest a genetic, or even familial/environmental/cultural, contribution specifically to overweight that is not readily explained by other factors.

5.1.3 Language

> *"Culture influences every aspect of human development and is reflected in childrearing beliefs and practices designed to promote healthy adaptation. The influence of culture on the rearing of children is fundamental and encompasses values, aspirations, expectations, and practices."*
>
> *(Shonkoff and Phillips 2000b p25)*

The primary language of a person or family can be used as a proxy for ethnicity, which has a demonstrated relationship with overweight in both children (Booth, Michael L, Wake et al. 2001; Strauss and Pollack 2001) and adults (Zhang and Wang 2004). Ethnicity implies connection with a certain culture, which potentially has a very strong influence on child-rearing practices.

Language in the CYWHS database was coded according to the Australian Standard Classification of Languages (Australian Bureau of Statistics 1997a), and these were further grouped by region, as listed in

, to facilitate analysis. It is possible that some variation between, for example, Other Asian languages may have been masked by this grouping, but low numbers in some categories have precluded a finer break down.

Looking at Table 5.4 and Figure 5.2, it appears that children from Chinese and Other Asian language backgrounds are less likely to be overweight than English speakers, while children from Western European language backgrounds are more likely to be overweight and obese. However, the fact that people of Asian descent are overweight at a lower BMI than most other populations is of particular relevance here, and therefore this chart has been reproduced with the children from Chinese and Other Asian language backgrounds categorised as overweight or obese according to cut-off points (for age four years) published by Shang *et al*. (2005) which were derived from a reference population of Chinese children. The corresponding table and graph indicate that male children from Asian backgrounds are, in fact, more likely to be overweight and obese than English speaking children while females have comparable overweight prevalence and slightly higher obesity prevalence.

The application of ethnic-specific BMI cut-off points is relevant to this analysis as an indicator of the potential for underlying biological factors to influence the development of overweight in young children. However it is plausible to expect that the weight status of children from other ethnic backgrounds might also be more accurately assessed using cut off points from specific reference populations. Given that other ethnic BMI reference charts are not available, and that children identified as coming from either Chinese or Other Asian language backgrounds comprise less than 2% of the entire CYWHS data set, the application of this separate standard has been restricted to this section of the analysis.

While low numbers of children with both language and birth weight data preclude definitive analysis, a check of the relationship between these two variables indicates that there may be some correlation, with children of Chinese/Asian language backgrounds significantly less likely to have a high birth weight (data not shown). This suggests that the relationship between birth weight and overweight at age four may be different in children from Asian backgrounds, and that environmental factors might play a greater role in the development of overweight in this population.

The higher obesity prevalence found in boys from Asian language backgrounds is similar to that found by Balakrishnan *et al,* (2008), who also identified a higher prevalence of obesity in South Asian boys living in the UK. While there is a great deal of literature on the development of overweight following immigration in adults, (e.g. Wandel (1993) or Yang and Read (1996)), there is very little investigation involving children, particularly of this age group, who are being raised in migrant households and the mechanisms by which overweight might develop unevenly in these populations. (Li *et al.* (2008) do look at older children).

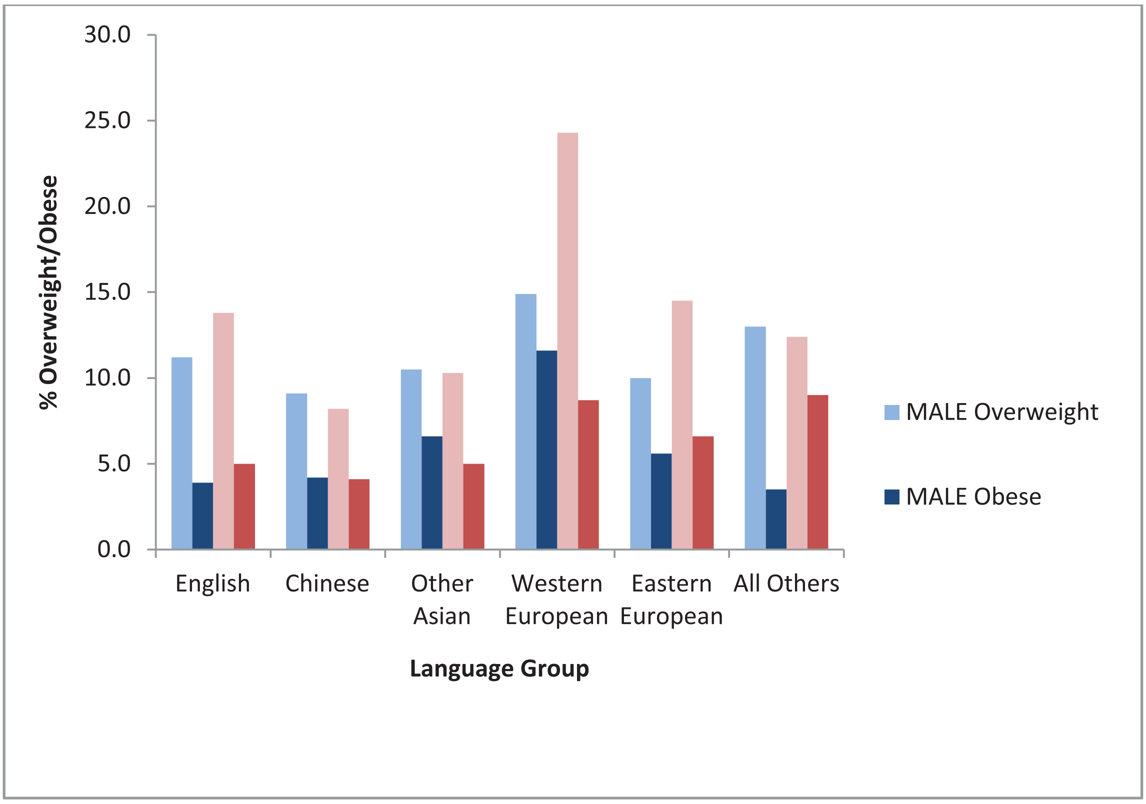
Table 5-4 Language background and prevalence of overweight/obesity

	MALE		FEMALE	
	Overweight	**Obese**	**Overweight**	**Obese**
	%	%	%	%
English	11.2	3.9**	13.8	5.0**
Chinese	9.1	4.2	8.2**	4.1
Other Asian	10.5	6.6**	10.3**	5.0
Western European	14.9	11.6**	24.3**	8.7**
Eastern European	10.0	5.6	14.5	6.6
All Others	13.0	3.5	12.4	9.0**

*** P < 0.005*

Source: CYWHS data 1995-2003

Figure 5.2 Language background and prevalence of overweight/obesity



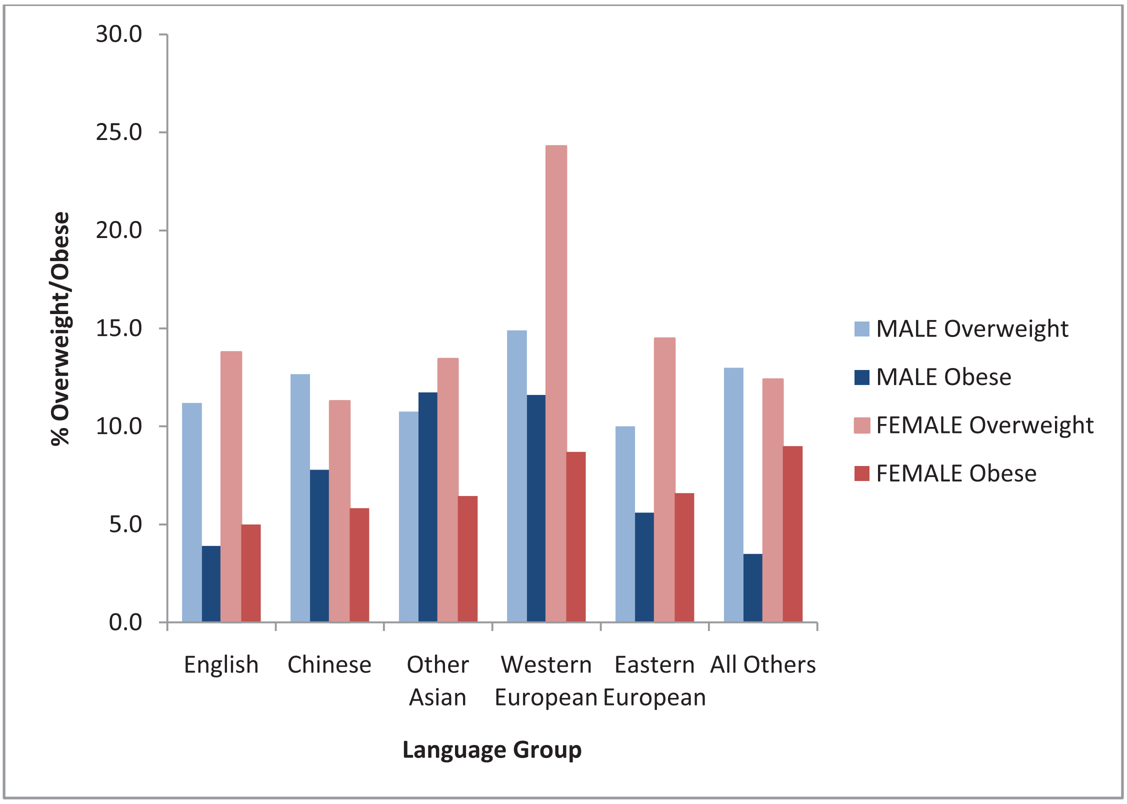
Source: CYWHS data 1995-2003

Table 5-5 Language background and prevalence of overweight/obesity – Chinese and Other Asian children assessed using BMI cut-off points for Asian children

	MALE		FEMALE	
	Overweight	**Obese**	**Overweight**	**Obese**
	%	%	%	%
English	11.2	3.9	13.8	5.0
Chinese	12.7	7.8	11.3	5.8
Other Asian	10.8	11.7	13.5	6.4
Western European	14.9	11.6	24.3	8.7
Eastern European	10.0	5.6	14.5	6.6
All Others	13.0	3.5	12.4	9.0

Source: CYWHS data 1995-2003

Figure 5.3 Language background and prevalence of overweight/obesity – Chinese and Other Asian children assessed using BMI cut-off points for Asian children



Source: CYWHS data 1995-2003

One possible explanation may be that this population is largely drawn from relatively recent immigrant communities where physiological responses to western dietary norms tend to predispose to weight gain, at least in adults (McKeigue, Shah et al. 1991; Yang and Read 1996; Misra and Ganda 2007), and it is possible that the same process operates in children. However a similar effect should also be evident in girls if this is the case. It may also be possible that these results are indicative of the generally low socio-economic status of South Australia's migrant populations, although some interaction with genetic and cultural factors could also be expected. These results illustrate the suspected complexity of the relationship between gender, ethnicity and overweight/obesity, which may be driven in part by heterogeneity within migrant groups which cannot be accounted for in this study.

5.1.4 Breastfeeding

Breastfeeding status at three months of age in the CYWHS database was reported by the care giver. Children who were reported as being breastfed at three months of age were significantly less likely to be obese at age four (Table 5-6), however there was no relationship observed between breastfeeding at three months of age and overweight (not including obesity) at age four. The relationship between breastfeeding and obesity was strongest in females, but still statistically significant in males. Given the competing claims for the protective effect of breastfeeding as discussed in Chapter 2 (p43 – 44), it is interesting to note that these results actually validate both claims – i.e. a strong relationship and no relationship at all – suggesting that the degree of overweight being assessed is a significant factor in any analysis and that the cut off points used may bias the results. The strong relationship detected here between breastfeeding at three months of age and lower obesity prevalence at age four indicates that, at least for this age group, breastfeeding in infancy can protect against the higher degrees of overweight.

These results, which compare both overweight and obesity as defined by the IOTF cut points, may help to explain the discrepancies in previous findings.

Table 5-6 Breastfeeding and overweight

	MALES		FEMALES	
	Overweight	**Obese**	**Overweight**	**Obese**
	%	%	%	%
Breastfed	12.4	3.5**	15.6	4.3**
Not Breastfed	13.1	5.0**	15.8	6.8**

*** P < 0.005*

Source: CYWHS data 1995-2003

5.1.5 Use of CYWHS Resources

Ideally, CYWHS has contact with South Australian children at multiple points in their infancy and childhood, ranging from within a few days of birth to the preschool check. The extent to which families utilise this resource could be an indicator of health and lifestyle behaviour, knowledge and resources which may be reflected in the weight status of children. Unfortunately, over 60% of the children in the database did not have any record of a visit to CYWHS other than the preschool visit. As there was no indication as to whether this was truly the case (unlikely), or whether the data were simply not recorded/transferred in some instances (Volkmer 2006), only children with at least one other consultation recorded were analysed. Even so, the quality of this data variable is undetermined and the results are presented here with the understanding that no firm conclusions can be drawn from this analysis.

Although there is a statistical relationship between female obesity and the number of times CYWHS services have been accessed (Table 5-7), there is no clear linear relationship. There is less obesity among those children who made six or more visits than among those who made between one and five visits. The recommended schedule of health checks offered by CYWHS includes five visits prior to the preschool check, so potentially this grouping is capturing predominantly children who have attended at least some of the routine checks.

Table 5-7 Obesity prevalence by number of CYWHS consultations

	MALES		FEMALES	
	Overweight	**Obese**	**Overweight**	**Obese**
# consults	*%*	*%*	*%*	*%*
1-5	12.6	4.6	15.6	6.0**
6-10	13.1	3.9	15.7	4.7**
11-15	13.4	4.0	15.3	5.0
>15	13.1	3.5	14.8	5.3

***P < 0.005*

Source: CYWHS data 1995-2003

The implications of this are unclear – presumably these are families who are doing the 'right' thing in this area and taking advantage of the resources offered to monitor their children's health and well-being. If that is the case; and routine attendance at CYWHS can be seen as a proxy for attention to, and knowledge about, children's healthy development; then it is surprising that this group exhibits a markedly higher prevalence of overweight and obesity. However, it is also possible that children who access services much more frequently have other particular health and/or behavioural concerns that intrinsically affect/limit the energy imbalance which leads to obesity.

5.1.6 Discussion

The strong statistical relationship between birth weight and both overweight and obesity at age four is very difficult to ignore. While it is possible that this is at least partially correlated with ethnicity, it seems that birth weight may perhaps be the single most influential factor in determining weight status at four years of age. However, not all high birth weight babies go on to become obese four year olds, and the reverse is also true. Therefore we need to look to the other variables to identify any moderating or contributing factors which further influence weight status.

Ideally birth weight would be included as a controlling factor in the analysis of each variable however the limited numbers of children for whom birth weight is available makes this difficult, (See Table 5-1), especially when it is considered that those children for whom birth weight is recorded are not necessarily the same ones for whom any of the other variables are recorded. This will become particularly problematic when considering the smaller samples used for subsequent analysis, and therefore has not been attempted. It is unfortunate that the two individual variables which have the strongest relationship with weight status at age four – birth weight and breastfeeding at three months of age – are the two which have been recorded for the lowest numbers of children.

In summary, all of the individual variables were found to have some relationship with overweight and/or obesity. Not all of these relationships are easily interpreted but the patterns are generally consistent and serve as an indication of a valid interaction. They are also generally consistent with the results reported in the literature and discussed in Chapter 2. The implications of these results are significant. The different interactions observed between gender and the individual variables, as well as inconsistent relationships between overweight and obesity and some variables, lead to speculation on two different hypotheses.

Firstly, it may be that obesity, rather than overweight, is the true indicator of dysfunctional energy balance in this population and this is why many variables relate most strongly to obesity. While it is possible that this is an artefact of the BMI cut off points used to distinguish obesity from overweight, this seems unlikely given that some authors have found that the Cole cut points, (used in this research), tend to under-estimate obesity prevalence compared to other definitions (Flegal, Ogden et al. 2001; Janssen, Katzmarzyk et al. 2005). Rather, it seems possible that the 'normal' weight status of children in this age group encompasses a wide range of BMI values which *may not be indicative of an energy imbalance of concern*. It would then follow that only those children with the highest BMI-for-age scores – i.e. those that have been classified as obese – are being influenced by factors over and above the 'average' environment of South Australian preschool children.

The second possibility is that the relationship between birth weight and overweight (not including obesity) at age four is so strong as to be the main predictor for this outcome, over-riding other influences and thus leading to the inconsistent and/or insignificant relationships with other variables and overweight as seen here. If this is the case, then the health and nutrition knowledge and practices of women of child-bearing age could become an area of great importance in the prevention of obesity, with the aim of limiting excessive birth weight in the next generation.

Either scenario is plausible, and if this tendency can be confirmed then it may lead to a rethinking of the ways in which we define and research energy imbalance in young children. The search for the presence of similar patterns in children of different ages would also be imperative to validating these hypotheses. In light of the observations which have been made for this data set, including those of many other cross-tabulations not reported here, obesity only, rather than overweight, will be the focus of further investigation of this data set in an attempt to elucidate the true nature of the contributors to energy imbalance.

5.2 Assigned variables for individuals

Although these next sets of variables are applied to individual children, they have been derived from supplementary data sets rather than being collected by CYWHS during client contact. They are not census statistics, but environmental characteristics which relate directly to the children's residential locations. They have also been applied only, unless stated otherwise, to the urban subset of data which comprises the records of 21 766 children, collected in 2000, 2001 and 2002 and chosen due to the correspondence of this time period with much of the supplementary data and with the Australian Census of Population and Housing undertaken in August 2001. They measure aspects of the children's environment which, if a relationship is found with obesity prevalence, may be potentially modifiable. Even if it is not appropriate or possible to modify these environments directly, they may serve as indicators to help identify children at risk of obesity.

5.2.1 Housing

Neighbourhood and individual housing quality has been identified as a contributor to health inequalities (Poortinga, Dunstan et al. 2008; Jacobs, Wilson et al. 2009). While the associations between conditions like asthmas and housing attributes such as ventilation are quite direct, it is possible that there is also an underlying link with chronic conditions such as obesity.

It is also true that the type of housing occupied by an individual or family is very much a choice which is dictated not only by personal preference but also by economic considerations. If the factors which lie behind these choices are similar to those which influence the weight status of four year old children, it is possible that housing –

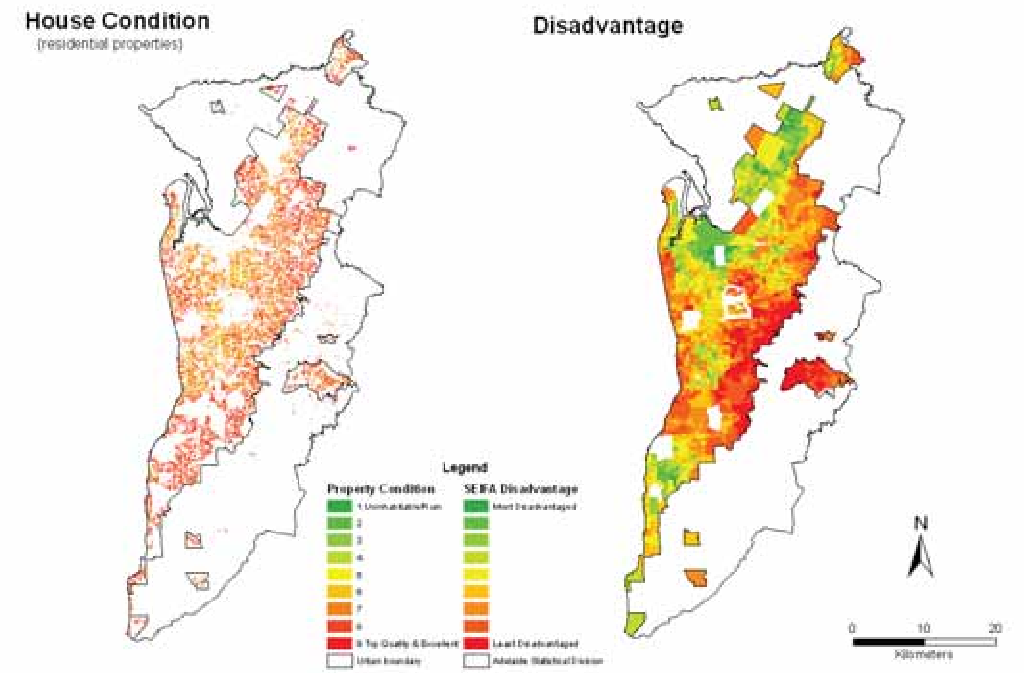
particularly neighbourhood norms – could be used to identify families and communities where children are at increased risk of obesity.

5.2.1.1 Condition and Value

As part of the property valuation process in South Australia, information on the condition and capital value of housing stock (among many other property attributes) is collected by the State Valuation Office, a unit of the Land Services Group (LSG). These data, when integrated with the digital cadastral database (DCDB) provide a spatially referenced source for property and dwelling information in South Australia. Both the DCDB and valuation information was made available for this project from the LSG through the Department of Environment and Heritage (DEH). Each geocoded record is located within a single residential parcel, which enabled the valuation data from 2004 for those specific properties to be joined to the data records. This resulted in a housing condition code and a capital valuation figure for the property of residence for all but a few of the children.

The housing condition code is subjectively assigned by the individual valuation assessors, and there is likely inconsistency between assessors and some fuzziness in the boundaries between categories. However, this variable still provides a useful indication of the quality of South Australian housing stock. The nine original housing condition values as reported in Table 5-8 were subsequently reclassified according to the natural breaks in the data, as very few properties actually fall into the lower condition categories and over 50% of the children's residences were classified as 'Very Good'. When examined visually, (Figure 5.4), the distribution of poor quality residences can be seen to be closely aligned to the areas of higher disadvantage within urban Adelaide.

Figure 5.4 Comparison between residential house condition and disadvantage, Adelaide



Source: Property valuation data LSG 2004 and ABS SEIFA 2001

Table 5-8 Housing condition codes as derived from the valuation data, and the proportion of children in the database whose residences fall into these categories

NOTE:
This table is included on page 122 of the print copy of the thesis held in the University of Adelaide Library.

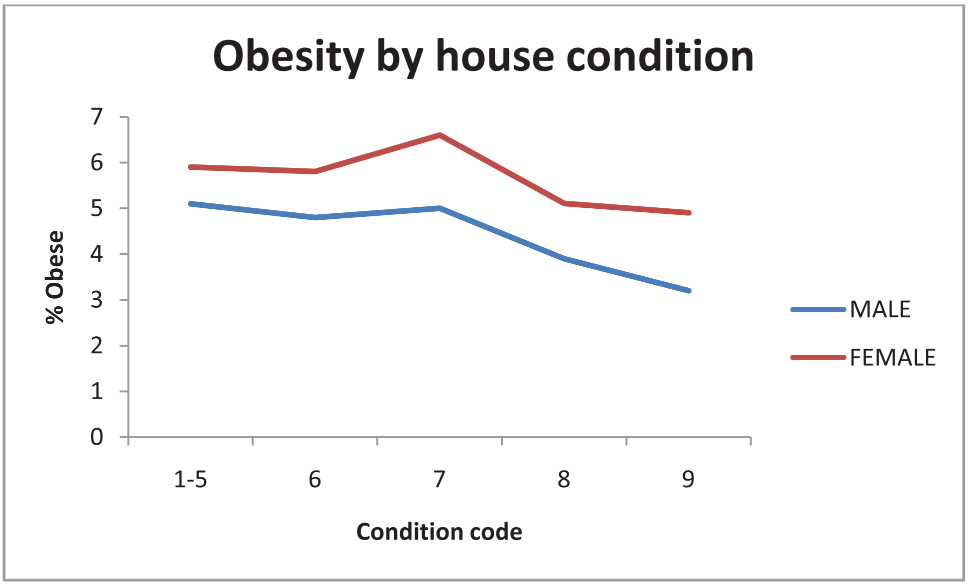
Source: Housing Valuation data, Office of the Valuer-General, LSG, 2004

When obesity prevalence is compared by house condition category, the results show a predictable relationship between housing quality and child obesity (Figure 5.5), where obesity prevalence generally decreases as housing condition improves. This trend approaches statistical significance and the relationship is slightly stronger for males. The upward deviation in obesity prevalence at category 7 (Good) for both males and females is an interesting pattern. While it may be due to chance, it is also possible that this category is reflecting families who have enough assets to participate in the obesogenic environment yet not enough knowledge or physical and social resources to ameliorate its influence as effectively as families living in higher quality housing.

When obesity prevalence is assessed by the capital value of properties (grouped by quintile), a similar pattern of decreasing obesity prevalence with increasing property value is observed (Figure 5.6). The relationship is statistically significant for both genders, and boys in particular living in high value properties have a markedly lower prevalence of obesity.

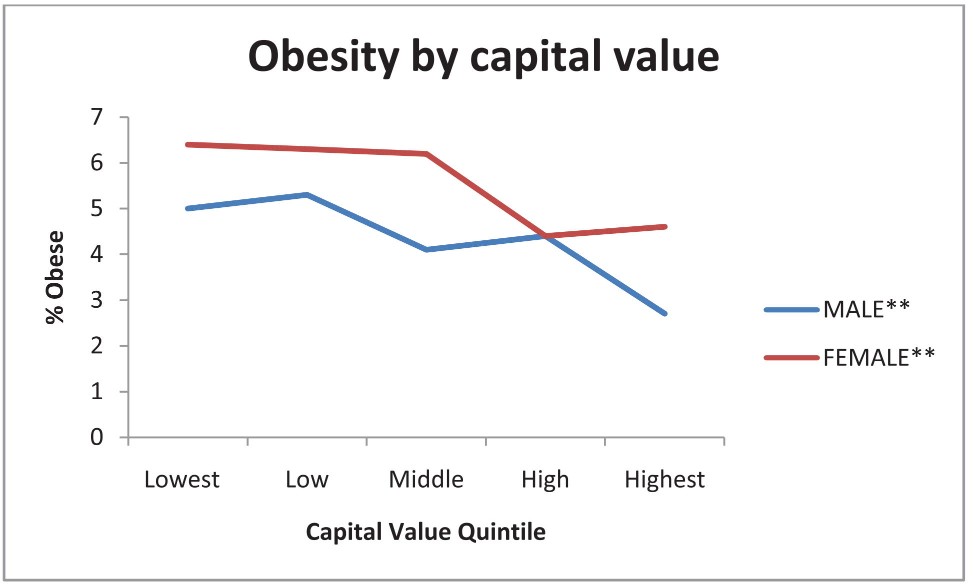
This analysis was repeated using property values derived from a smoothed density surface of the residential property values in Adelaide in order to test whether neighbourhood property value was a better predictor of obesity prevalence than individual values. The results (not shown) were very similar which implies that an area or neighbourhood measure of property values would be a valid proxy for this type of analysis when information on individual residences is not available.

Figure 5.5 Obesity prevalence by housing condition code



Source: Property valuation data, LSG 2004 and CYWHS data 2000-2002

Figure 5.6 Obesity prevalence by quintile of capital valuation of properties



***P < 0.005*

Source: Property valuation data, LSG 2004 and CYWHS data 2000-2002

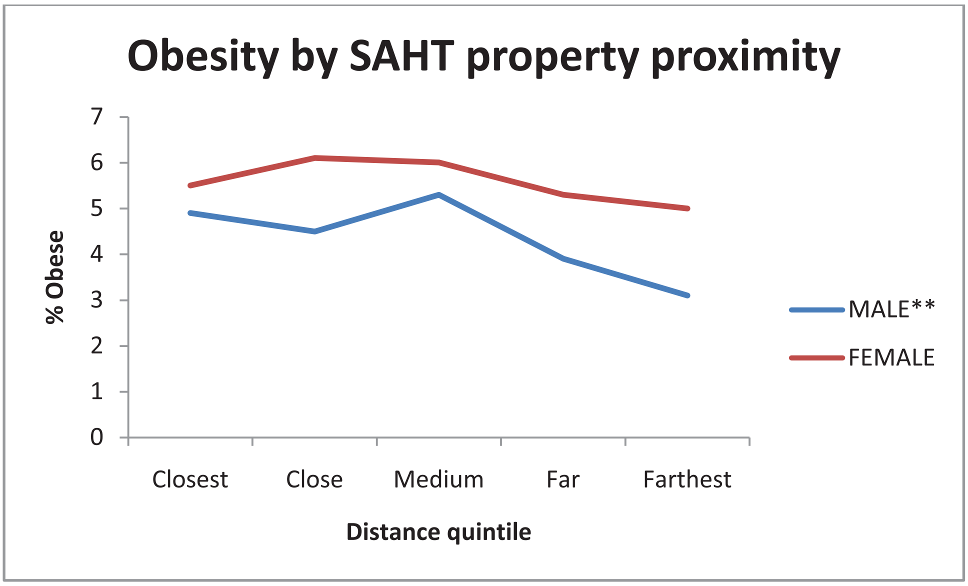
5.2.1.2 South Australian Housing Trust

Ownership information included with the valuation data for South Australia enabled the identification of properties owned by the state's public housing authority, the South Australian Housing Trust (SAHT). Residence in an SAHT dwelling or the presence of SAHT stock in the residential area could be viewed as indicators of individual or neighbourhood disadvantage. By its very nature, such public housing tends to promote the concentration of socially and economically disadvantaged households. Badcock (1997) describes how this has occurred in a South Australian context.

The distance from each child's residence to the nearest SAHT property was derived in ArcGIS by measuring the point distance from each residential location to the nearest SAHT property. The children were then grouped by quintile of distance to SAHT stock, and obesity prevalence was calculated for each quintile. The results are presented in Figure 5.7. Similarly, a surface representing the distribution of SAHT properties across the urban area was constructed using kernel density techniques, and the resulting density value at each child's point of residence was used to construct quintiles for obesity comparison (Figure 5.8).

Both the distance to and density of SAHT stock are significantly related to obesity prevalence in males, and the pattern is very similar for females although not statistically significant. As SAHT density is almost certainly correlated with proximity, and the results are very similar, the density of public housing stock in an area could conceivably be used as an indicator of neighbourhood disadvantage in relation to obesity.

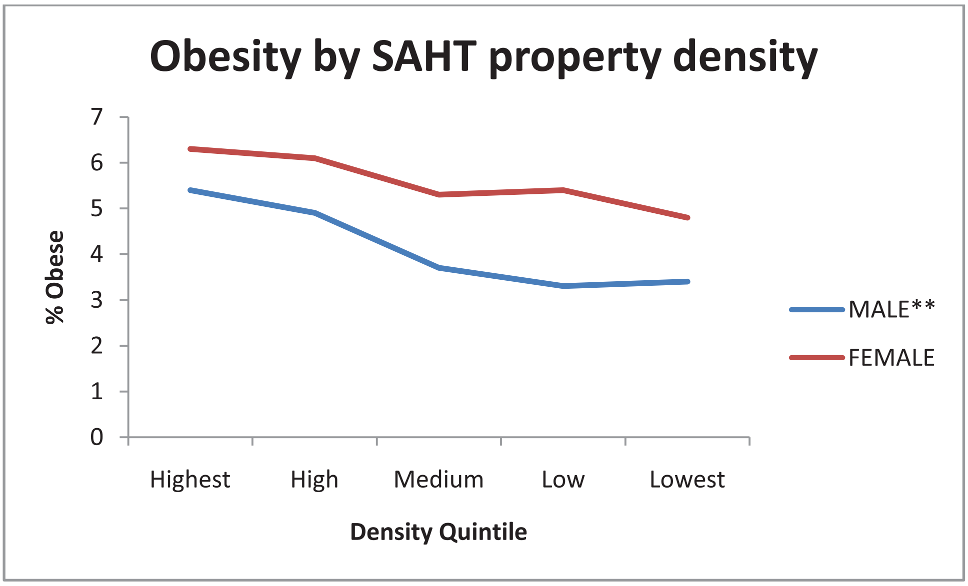
Figure 5.7 Obesity prevalence by quintile of distance to nearest public housing property



***P < 0.005*

Source: Property valuation data, LSG 2004 and CYWHS data 2000-2002

Figure 5.8 Obesity prevalence by quintile of public housing density



***P < 0.005*

Source: Property valuation data, LSG 2004 and CYWHS data 2000-2002

5.2.1.3 Discussion

While these results suggest weight status is influenced by housing considerations, it would be naive to assume that poor quality housing leads directly to obesity. In reality, it is likely that it is the socio-demographic forces which drive families to live in particular neighbourhoods with a certain type of housing which underlie the observed obesity prevalence. However, as housing condition and value are accurate reflectors of economic status, the correlations between housing stock and obesity can serve as a means to identify families at risk for the development of obesity in their young children.

5.2.2 Fast Food Outlets

A great deal of media attention has been given to the role of fast food in the development of obesity, particularly in children (Associated Press 2008; Hale and Naug 2008). Although it is not possible to determine the fast food consumption of children in this study, it was considered essential to ascertain whether the physical location of fast food restaurants shows any relationship with obesity prevalence in the study population.

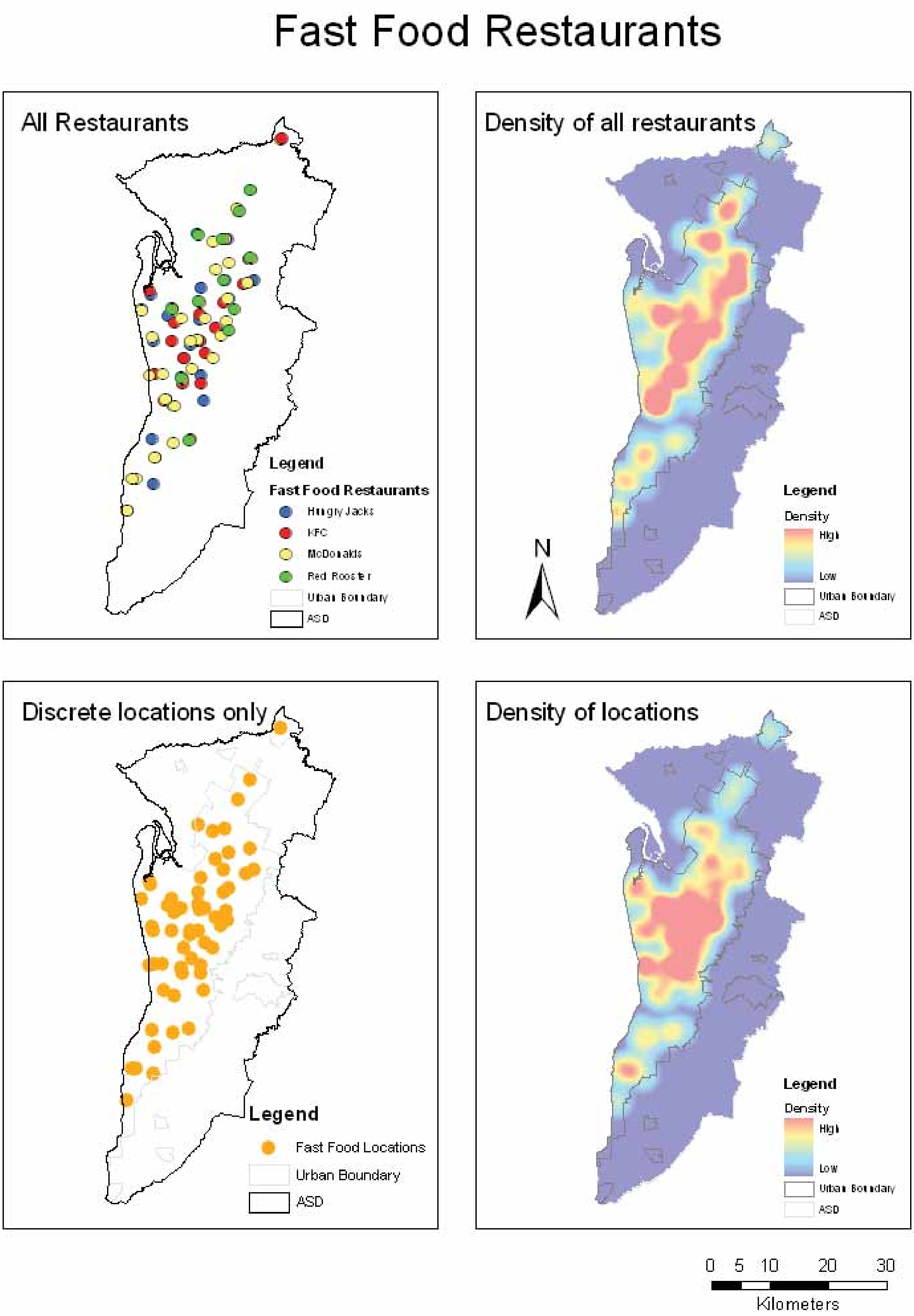
For the purposes of this study, four major fast food chains have been included in the analysis. McDonalds®, Hungry Jacks®, KFC® and Red Rooster® were identified as key retailers of 'traditional' fast food meals – primarily hamburgers and fried chicken. A conscious decision was made to exclude pizza restaurants - partly due to the different dynamics introduced by the popular home delivery option and partly because of the proliferation and popularity of both franchise and individual stores reducing the impact of a single brand. Another major player, Subway®, was also excluded as the menu focus is towards fresh sandwiches rather than the deep fried offerings more commonly associated with fast food.

The street address of the restaurants belonging to each of the four chains was obtained from the electronic white pages, and these locations were geocoded within ArcGIS where the distance from each child's residence to a fast food restaurant was then calculated using point distance techniques. A density surface representing the distribution of these restaurants across the urban area was also constructed using kernel density techniques and these density values extracted for the children's place of residence.

At some locations, a clustering of fast food outlets was observed where two or more restaurants were either co-located or sited very close to one another. Those areas where restaurants were less than 500m apart were identified and the distances and density calculations as described above were repeated using these cluster locations as single, discrete points instead of counting the individual restaurants. The distribution of both individual restaurants and grouped locations is illustrated in Figure 5.9.

There is no relationship evident between increasing proximity quintile to, or density quintile of, the four fast food restaurant chains used in this analysis and the prevalence of obesity in children. This is true for both males and females and the results do not change appreciably if the grouped locations only are used in the calculations. These results were supported by further data exploration which confirmed no relationship between the children's BMI scores and the distance to or density of the fast food restaurants (results not shown). These findings mirror those of Crawford *et al.* (2008) and Jeffery *et al.* (2006), who also found that exposure to fast food outlets in the neighbourhood of residence did not increase the risk of obesity. This is probably not surprising given the modern, highly mobile society in which families who desire to consume fast food can easily access it. Distance does not really become an access issue unless the residence is outside of the metropolitan area.

Figure 5.9 Distribution of fast food restaurants, Adelaide 2004

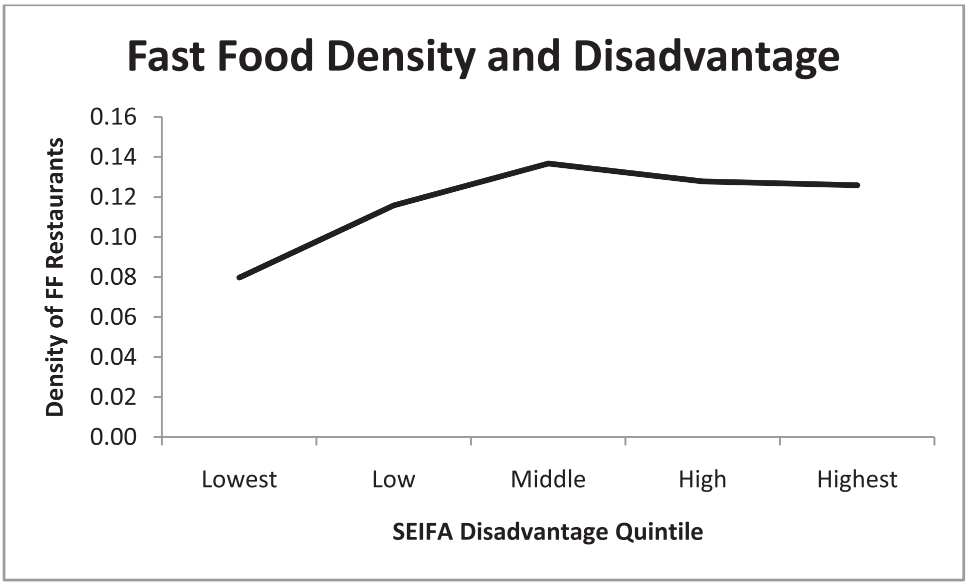


Source: Restaurant locations obtained from electronic white pages, 2004

There is, however, a relationship between the density of fast food restaurants and the SEIFA disadvantage score for CDs (Figure 5.10), such that CDs with lower SEIFA scores (i.e. more disadvantaged) tend to be located in areas of higher fast food restaurant density. A similar result was obtained by Reidpath *et al.*(2002) using the median income of postal areas as the measure of SES. This finding is important, as it is already established that children in the more disadvantaged areas are more likely to be overweight (see Table 4-6 and

Figure 6.1); so although there is no direct relationship between weight status/BMI and fast food restaurant distribution in this study, perhaps fast food locations form a part of the overall environment of disadvantage in which the healthy choice is not always the easiest choice.

Figure 5.10 Density of fast food restaurants by CD disadvantage quintiles



Source: ABS SEIFA 2001 and Electronic White Pages 2004

In any discussion of these results, it is important to remember that the choice of fast food restaurants used in the calculations may influence the outcomes. If, for example, Subway® restaurants or the major pizza chains had been included the results may have been quite different. As the effects of different types of fast food – as opposed to convenience food – upon body weight, especially in young children, are not at all well understood it is difficult to design a more meaningful analysis.

5.2.3 Recreational Facilities

Access to recreational facilities, particularly open space, has been implicated as a potential influence on weight status (Giles-Corti, Macintyre et al. 2003; Wilson, Ainsworth et al. 2007; Veugelers, Sithole et al. 2008). There are a broad range of places/services which can be defined as recreational facilities and it seems unlikely that many of them could be directly used by four year old children. However it is conceivable that families with good access to recreational space may find it easier to lead healthier lifestyles and this may have an effect on the weight status of even young children. It is also true that parks and playgrounds can provide a place for active play and perhaps proximity to these places may be reflected in the children's weight status.

In a GIS environment, the spatial relationships between different data sets can easily be processed and quantified, even for very large databases. Measurement of straight line distance between the features in one layer (in this case, the location of individual children), to the nearest features of interest in any other layer is accomplished quickly and accurately using simple commands. While road distance might be considered a more accurate measure of accessibility, straight line distance provides a precise measure of the proximity of these features to each other and is much less computationally intensive, making it an ideal tool to detect and assess any associations.

5.2.3.1 Recreational Trails

The recreational trails data set supplied by the South Australian Office for Recreation and Sport contains a digital representation of all of the major, and many of the minor, walking and cycling trails within South Australia. The availability of these spatial data means that the influence of designated recreational walking/cycling corridors on children's weight status can be investigated. Trail use has been shown to have an impact on levels of adult physical activity (Librett, Yore et al. 2006; Wilson, Ainsworth et al. 2007), but geographic accessibility has not been assessed short of presence or absence in a defined neighbourhood. Trails are of interest for this study because they are free – so the results are not complicated by issues of financial access – and are places where people are likely to take their young children, even if only for short walks. For many people, the main barrier to using a recreational trail will be whether they are able to access one easily.

Recreational trail accessibility was assessed by measuring straight line distance from each child's residential location to the nearest trail. This analysis shows no relationship between quintile of distance to trails and obesity prevalence, nor is there any evidence of a relationship between individual children's BMI and the distance to trails (data not shown). These results are perhaps not unexpected, as four year old children are really too young to utilise recreational trails at any level which might conceivably influence BMI. Similarly to fast food, it is probable that those families who are likely to utilise trails as a part of a healthy lifestyle will have the mobility to access them even if they are not nearby.

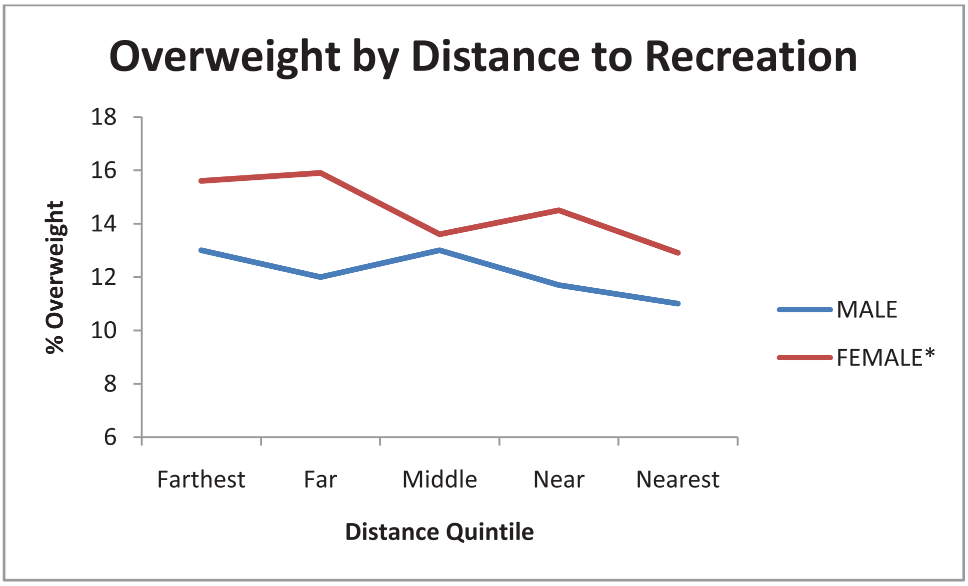
5.2.3.2 Recreational Land Use

While trails are a relatively specialised type of recreational space, further analysis including all types of recreational land may be more appropriate to detect any health benefits of recreational accessibility. It has been shown that accessibility to recreational facilities is associated with increased physical activity in adults (Giles-Corti and

Donovan 2002), and that children living in neighbourhoods with greater access to parks and playgrounds were more likely to be active and less likely to be overweight (Veugelers, Sithole et al. 2008).

For this study, recreational space was identified from the cadastre-based land use data supplied by PlanningSA. Using two parameters – the straight line distance from children's residences and the density of recreational space (calculated using a kernel density surface based upon each 25m² of recreational land) at each residential location – there is no relationship apparent between quintile of distance or quintile of density and obesity prevalence in four year old children (results not shown). However in this case there is some correlation with *overweight* prevalence, with the relationship between female overweight and recreational distance quintile (Figure 5.11) reaching statistical significance and the same pattern evident for males and reflected, less strongly, in recreational density (Figure 5.12)

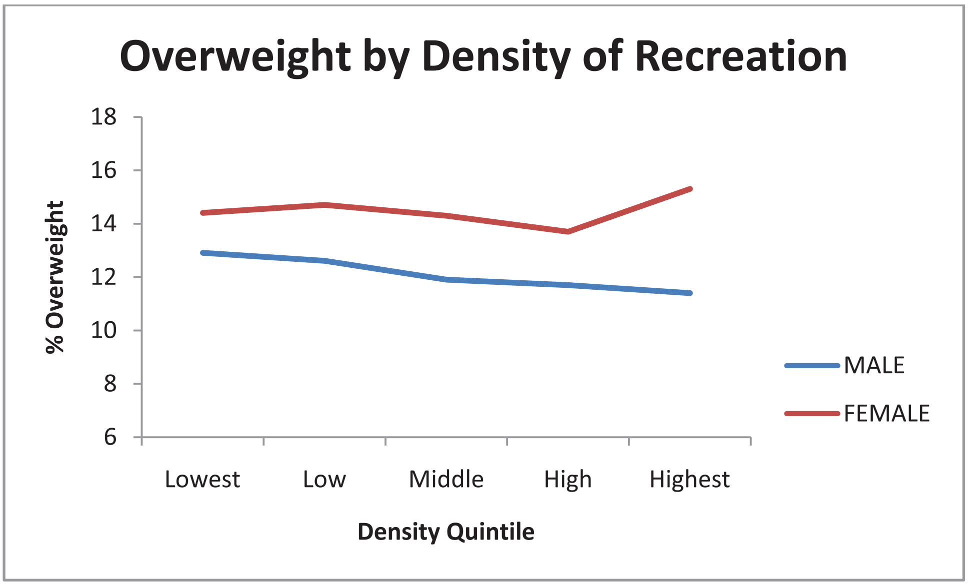
Figure 5.11 Overweight prevalence by quintile of distance to recreational space



$*P < 0.03$

Source: Land use data, PlanningSA 2004 and CYWHS data 2000-2002

Figure 5.12 Overweight prevalence by quintile of density of recreational space



Source: Land use data, PlanningSA 2004 and CYWHS data 2000-2002

These results imply that proximity to freely accessible recreational space is reflected in the overweight status of four year old children, although it does not appear to relate to the more marked energy imbalance which manifests as obesity. It is also uncertain exactly how this proximity moderates overweight – while it may be as simple as families who live near recreational areas taking their children there more often so they get more exercise, it is also possible that there is more recreational space in higher SES areas where children are less likely to be overweight anyway, or that families who enjoy healthy lifestyles are more likely to consciously choose to live near recreational areas. A recent study has shown that the quality (amenity/facilities) of public open space varies with area SES (Crawford, David, Timperio, Giles-Corti et al. 2008) and this finding may help to explain the results further.

5.2.4 Walkability

The theory of walkability incorporates the notion that the physical aspects of neighbourhoods may influence walking behaviour. Objective measures have been developed using such attributes as street connectivity and land use mix to categorise residential areas according to their level of walkability, and these concepts have been explored in both American, (Saelens, Sallis and Frank 2003) and Australian contexts (Leslie, Coffee et al. 2007). In Adelaide, GIS techniques have been used to derive an index of walkability for the urban CDs. This index (illustrated in Figure 5.13) has been developed using GIS to precisely measure and combine such features as dwelling density, street connectivity, land use attributes and retail destinations for each CD (Coffee 2005; Leslie, Coffee et al. 2007).

Visual examination of this map shows that walkability tends to decrease as the distance from the CBD increases. This is partly a function of the sloping terrain in the ranges on the eastern edge of the city where high street connectivity is difficult to attain; but is also partly due to the fact that newer residential areas which have been developed as the city expanded are more likely to be built with cul-de-sac type street patterns and low land use mix. Although this index is only available at the CD level as opposed to the previous variables in this section for which unique values for each child could be extracted; it is included here as it also measures an aspect of the structural environment which may influence physical activity.

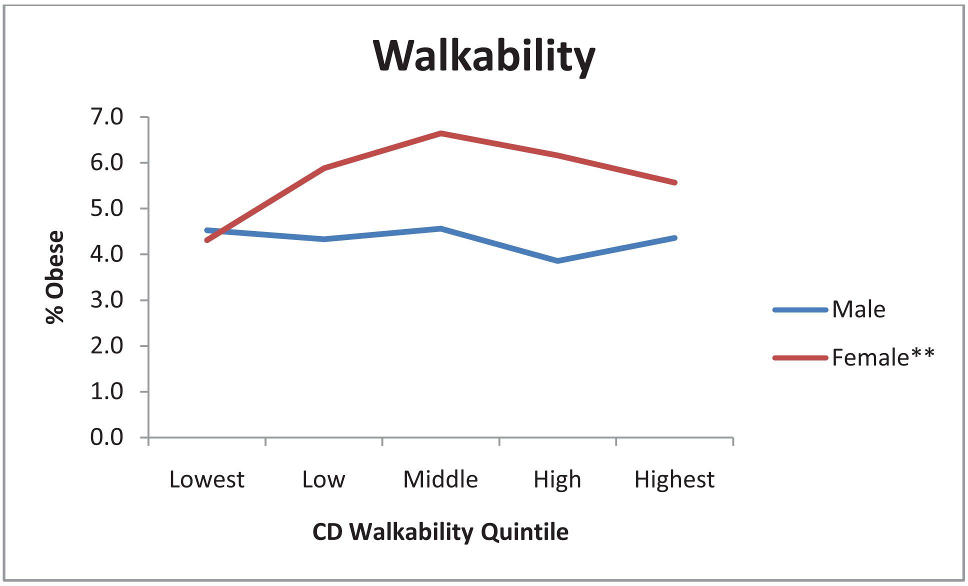
For this analysis, the urban CDs were categorised according to quintile of walkability, and obesity prevalence among the children residing in those CDs was calculated (Figure 5.14). The results are ambiguous – there is no relationship evident between walkability quintile and obesity in boys, while for girls there is a strong, but non-linear, statistical relationship. Obesity prevalence is highest amongst the children living in CDs of the middle quintile of walkability for both genders, but the reasons for this and for the inverted 'U' shape of the line for females are unknown. It seems likely that the walkability of neighbourhoods does not impact obesity prevalence in the study population.

Figure 5.13 Walkability Index for Urban Adelaide by CD, 2005

NOTE:
This figure is included on page 135 of the print copy of the thesis held in the University of Adelaide Library.

Source: Coffee 2005

Figure 5.14 Obesity prevalence by CD quintile of walkability



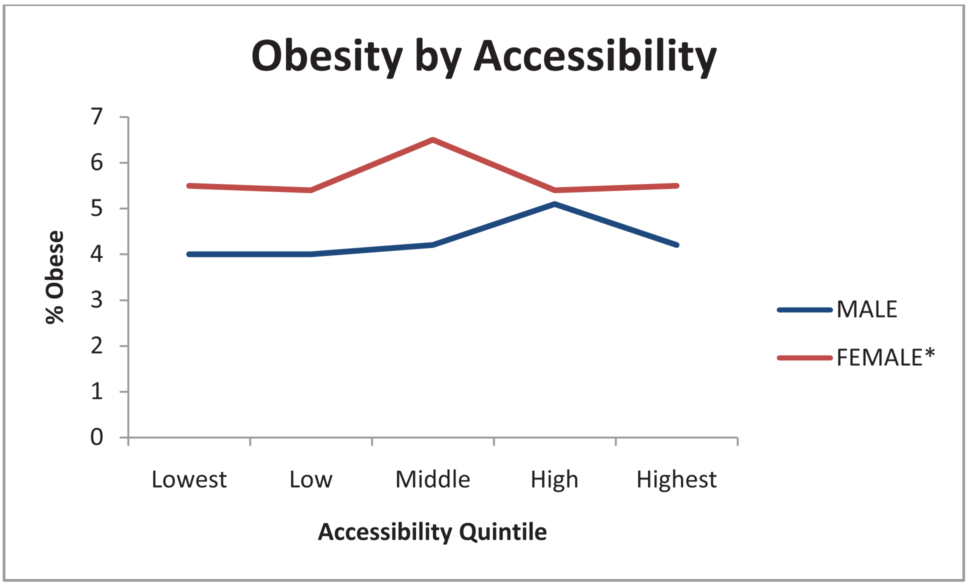
**P < 0.005*

Source: Walkability data 2005 and CYWHS data 2000-2002

5.2.5 Accessibility

Lack of accessibility to services and organisations such as health, education, financial and retail is a potential indicator of disadvantage and may even have a detrimental effect on overall health status (Pearce, Witten et al. 2006a). These variables are components of the Metropolitan Accessibility and Remoteness Index for Adelaide (MARIA), which was constructed by GISCA at the University of Adelaide using road network distance from each property to the various locations of interest (GISCA 2002). Using these data, it is possible to measure physical accessibility against the obesity prevalence of the children in the database. The results show an increase in obesity prevalence in the middle accessibility quintile for females, and the high quintile for males (Figure 5.15). The relationship is statistically significant for females. The implications of this are unclear, but it may also be in some way correlated to distance from the Central Business District (CBD) of Adelaide.

Figure 5.15 Obesity prevalence by MetroARIA (accessibility) quintile



**P* < 0.05*

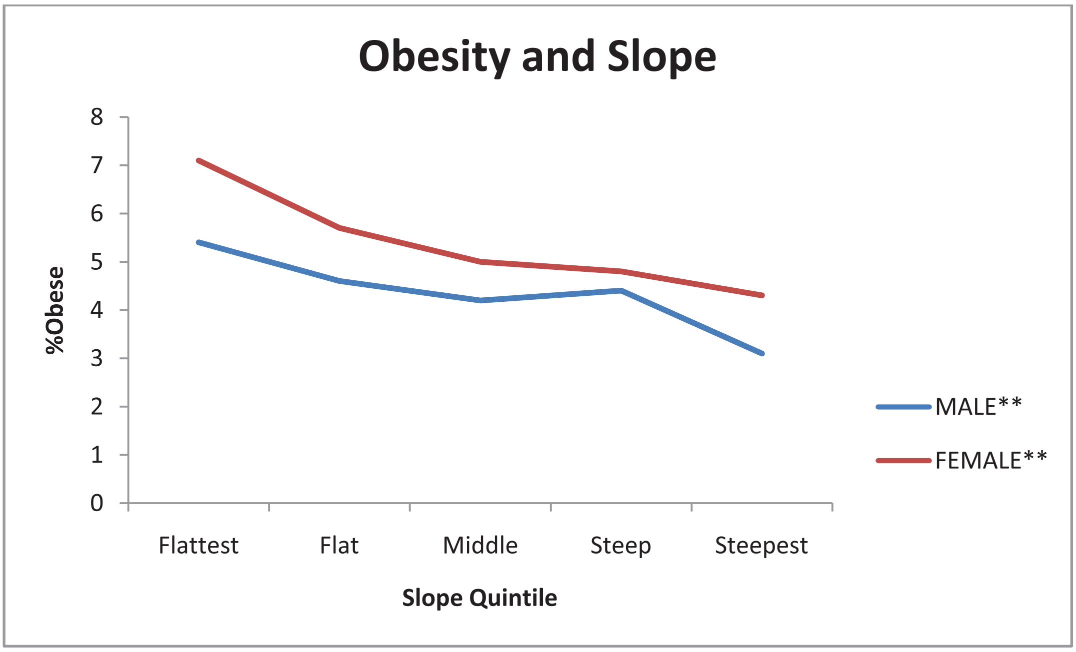
Source: MetroARIA data, GISCA 2002 and CYWHS data 2000-2002

5.2.6 Topography

Slope is a characteristic of the landscape which has not usually been considered in obesity studies and this research provides a unique opportunity to do so; with the availability of the large, spatially referenced CYWHS data set and a high quality digital elevation model developed from GeoScience Australia topographic data. The simple fact that more energy is expended to move up an incline is central to the (rather simplistic) theory that living in a steep environment might be protective of obesity by increasing energy expenditure. As the slope of the land does not change within any but the longest time frames or exceptional circumstances, the entire geo-coded urban data set of children has been used for this analysis, rather than only those from the 2001 census period.

This analysis shows a strong statistical relationship between obesity and slope for both males and females (Figure 5.16), such that children living in the flattest areas have a higher prevalence of obesity. However, to assume that four year old children living in undulating areas expend enough energy walking uphill to lower their likelihood of obesity would be a prime example of the ecological fallacy. In reality, areas with undulating terrain are generally considered more attractive and desirable as residential areas in Adelaide, and these places have higher land values and are predominantly high SES neighbourhoods (Pearson's Correlation 0.029 (p=0.000)) – with the associated lower prevalence of obesity.

Figure 5.16 Obesity prevalence by quintile of the degree of slope in the landscape



***P = 0.000* **Source: GeoScience Australia topographic data 2004 and CYWHS data 1995-2003**

5.2.7 Discussion

This selection of assigned variables relate primarily to the physical environment in which the children are living. There are many more facets of the environment which would be interesting to explore in relation to obesity, but for which data are not presently available. These could include such things as the presence of footpaths, crime rates or child abuse statistics.

Of the variables which have been investigated in this study, housing factors emerge as strong predictors of the level of child obesity. The association between public housing and higher obesity prevalence has most likely been driven by the tendency in recent years for the SAHT to provide primarily welfare housing rather than market entry-level housing for young couples, as was initially the case (Badcock 1997). It is particularly informative from an intervention/prevention perspective, as this is something which could easily be measured in any urban environment and used to identify populations at risk.

Relationships between the other variables and obesity are generally nil or indeterminate – except for slope, which has been discussed in detail above – and this is likely because the geographical distribution of these variables in Adelaide is driven by factors which do not relate to obesity in young children. It is probably also a reflection of the level at which four year old children can be expected to actively participate in the physical environment. A similar study conducted among older children or adults might show quite different results.

CHAPTER 6

Census Statistics and Obesity

6.1 Area Level Variables

This chapter contains an analysis of obesity prevalence in relation to census variables, and has been undertaken using socio-demographic statistics for small areas as derived from the 2001 census and categorised by quintile. The urban subset – the records of the 21 766 children measured by CYWHS during 2000, 2001 and 2002 and subsequently geocoded successfully - is once again the focus of this analysis. These records have been aggregated to the CD of residence and obesity prevalence has been calculated for each variable according to quintile CD groupings. The results from this type of ecological analysis serve as an indicator of the type of social and economic environments within which obesity flourishes, rather than identifying direct causes of obesity.

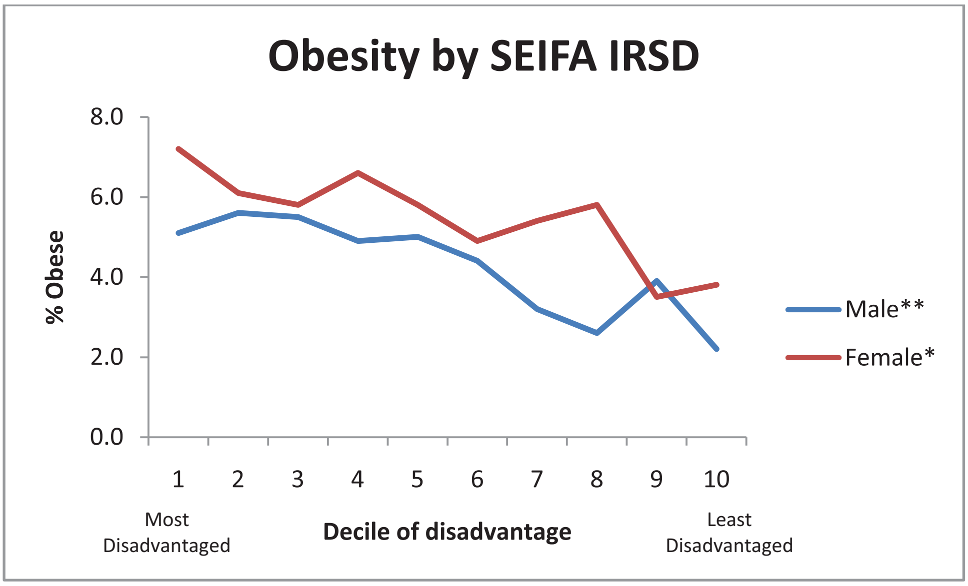
The application of area level census variables – most of which are measured for adults only, and not restricted to those adults who are raising young families - to individual children can be problematic if it is not clearly understood that because a child lives in an area with, for example, a high unemployment rate this does not mean we can assume that particular child is directly affected by unemployment in their own household. However, this type of socio-economic information is simply not available at the individual level, and any information about the specific population groups among which obesity prevalence is higher or lower is valuable in terms of increasing understanding of the mechanisms which promote energy imbalance and suggesting public health initiatives to combat and prevent this phenomenon.

6.2 Aggregate Measures of Disadvantage

The five yearly Australian Census of Population and Housing ('the census') conducted by the Australian Bureau of Statistics (ABS) collects a variety of social and demographic information for individuals and households in Australia. As well as the data generated by discrete census questions, the ABS also compiles a series of indices which attempt to quantify the socio-economic status of CDs relative to each other. These are known as the Socio-Economic Indexes for Areas (SEIFA). In particular, the Index of Relative Socio-Economic Disadvantage (IRSD) incorporates attributes such as low income, low educational status, high unemployment and other variables which reflect disadvantage, while the Index of Relative Socio-Economic Advantage/Disadvantage (IRSA) gives a high weighting to areas with higher incomes and a more skilled workforce (Australian Bureau of Statistics 2003).

For this analysis, SEIFA IRSD (disadvantage) scores were divided into deciles to approximate the relative disadvantage of each CD and decile numbers have been attributed to individual children according to the CD in which the children reside. The resulting comparison clearly shows that children living in CDs with IRSD scores in the lowest deciles (more disadvantaged) are significantly more likely to be obese than those in less disadvantaged CDs (Figure 6.1). This pattern supports the findings of the many other authors who have reported a negative relationship between obesity prevalence and socio-economic disadvantage (e.g. Kinra, Nelder et al. 2000; Janssen, Boyce et al. 2006; Wang, Youfa and Beydoun 2007)

Figure 6.1 Obesity prevalence by decile of disadvantage



**P < 0.01   **P < 0.000*

Source: ABS SEIFA 2001 and CYWHS data 2000-2002

As there has also been some speculation in the literature about polarisation of communities affecting health and social outcomes over and above the levels of disadvantage, (Shouls, Congdon et al. 1996; Diez-Roux, Link et al. 2000; Robert and Reither 2004) it was decided to also examine the CDs according to the difference in the IRSD (disadvantage) decile vs. the IRSA (advantage) decile. The implication is that the greater the difference between deciles then the less homogenous the population of the CD; i.e. the CD may have relatively high numbers of both advantaged *and* disadvantaged people. Low numbers in the category Decile Difference >2 precludes statistical significance, but there is a suggestion that, for boys only, there is a positive relationship between the diversion of advantage/disadvantage decile categories and increasing prevalence of obesity (Figure 6.2).

Figure 6.2 Obesity prevalence according to CD advantage/disadvantage comparison

Source: ABS SEIFA 2001 and CYWHS data 2000-2002

6.3 Key Census Variables

The SEIFA IRSD score is a construct derived from a number of the unique census data items collected for each CD. It is possible that different socio-demographic variables may have a unique relationship with obesity prevalence, and their effect may be masked by, (or not included in), the generalised IRSD. The variables presented in the following sections have mostly been reported in the literature as possibly contributing towards overweight and obesity, although they have usually been measured at an individual level rather than the area level used here. Assigning these values at an area level could generate misleading conclusions if the ecological fallacy is not considered; therefore the emphasis in this investigation is on context rather than cause. Due to the paucity of studies involving young children, variables which have been shown to have an influence for any age group have been considered for inclusion here.

6.3.1 Socio-Demographic Measures

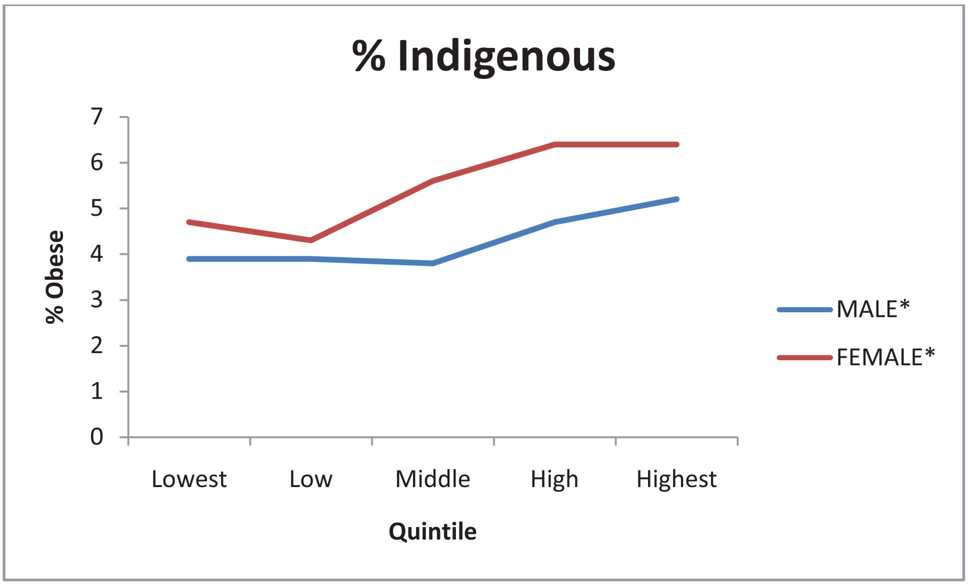
The population of a given area is often described in terms of basic demographic characteristics like age and ethnicity – variables which can readily be calculated at the CD level from the census data. These characteristics of population underlie and possibly interact with all of the socio-economic indicators which are explored in the following pages; therefore it is important to establish if there is any association between these particular measures and the prevalence of child obesity.

6.3.1.1 Age, Population Density and Ethnicity

There is no relationship detected between obesity prevalence and the population density of CDs, nor is the age structure – measured as the percentage of the population 15 years and younger and the percentage of the population 65 years and over – significant (data not shown). However the ethnic make-up of CDs is correlated with obesity prevalence. This is not unexpected given the relationships between ethnicity and weight status which were observed in the individual level analysis.

Children living in CDs with higher percentages of indigenous people are more likely to be obese, a trend which is statistically significant and slightly stronger for females (Figure 6.3). Likewise, CDs with higher percentages of people born overseas (Figure 6.4) or speaking a language other than English (Figure 6.5) also have a higher prevalence of obesity. These relationships are statistically significant, and strongest when speaking another language at home is the characteristic against which obesity is measured. Particularly notable is the steep increase in obesity prevalence between the ‘high’ and ‘highest’ quintiles of speaking another language (Figure 6.5).

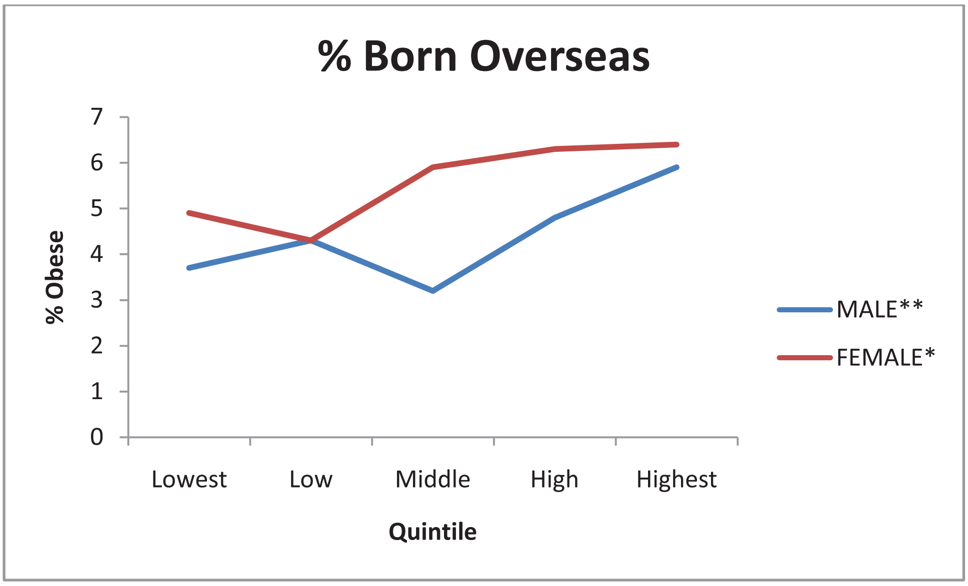
Figure 6.3 Obesity prevalence by quintile of Indigenous population



**P <0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

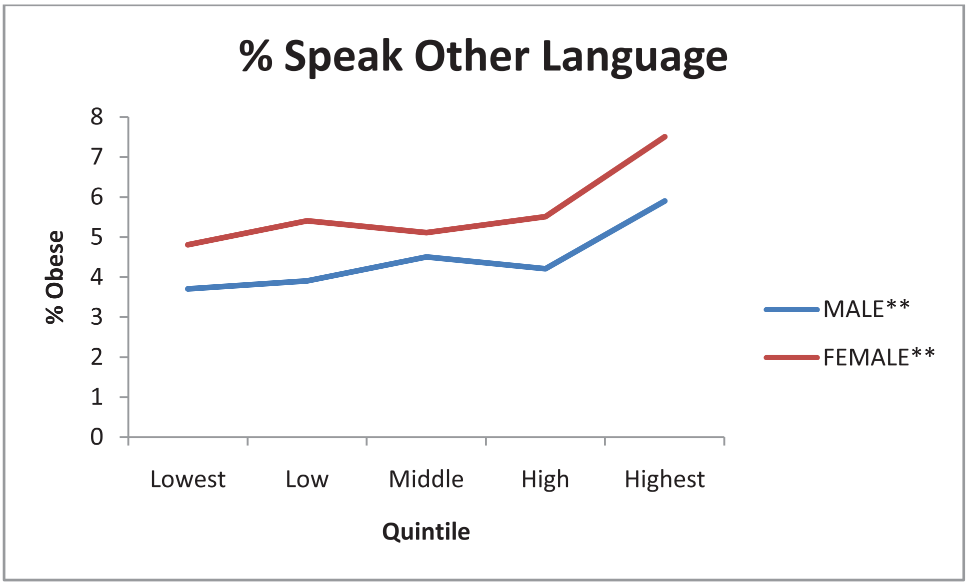
Figure 6.4 Obesity prevalence by quintile of population born overseas



**P < 0.05 **P = 0.000*

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.5 Obesity prevalence by quintile of population who speak a language other than English at home

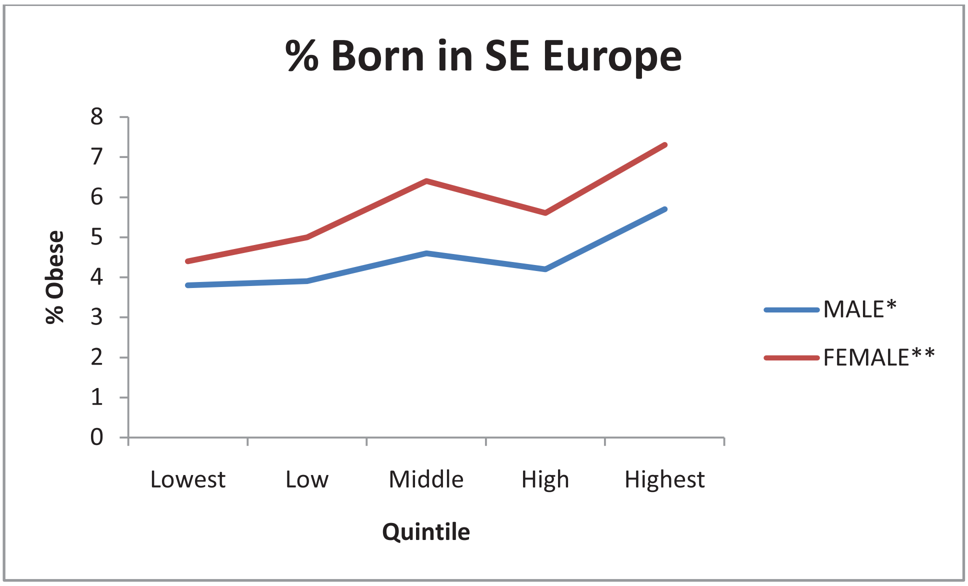


$**P < 0.005$

Source: ABS census data 2001 and CYWHS data 2000-2002

Two regions of origin – South East Europe (Figure 6.6) and South East Asia (Figure 6.7) - show a particular relationship with obesity such that the prevalence in both genders increases as the percentage of people born in these regions increases. This trend is significant for all except males in the South East Asia category. However, it is likely that a higher percentage of the children from Asian language backgrounds also live in the CDs where there is a high percentage of people born in south-east Asia, and if these children's weight status had been defined according to the Asian cut-offs (see Chapter 5, Section 5.1.3) then the prevalence of obesity in these CDs would likely be even higher and the statistical significance would probably increase, especially for males.

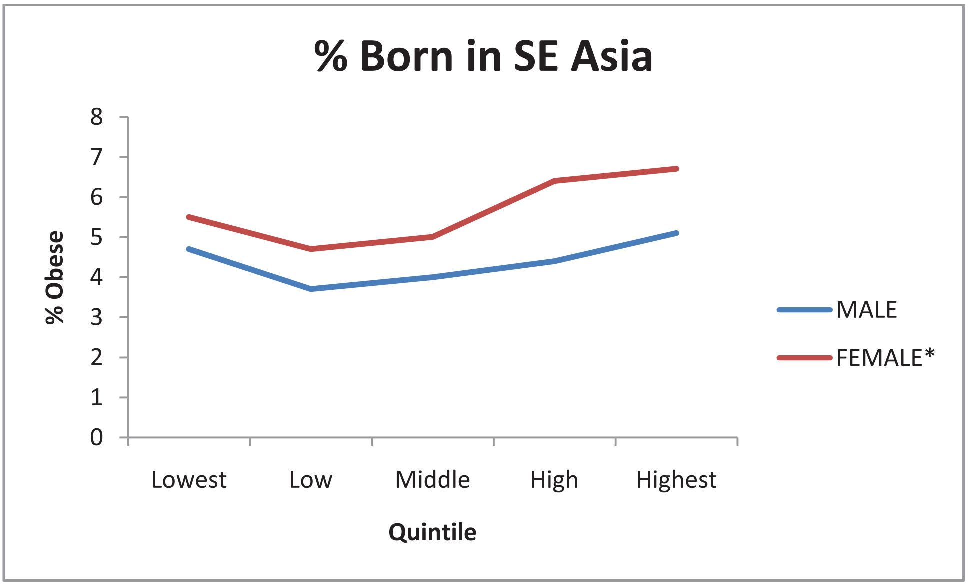
Figure 6.6 Obesity prevalence by quintile of population born in south-east Europe



**P* < 0.05 ***P* = 0.000*

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.7 Obesity prevalence by quintile of population born in south-east Asia



**P* < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

There is no statistical relationship between the percentage of the population born in North West Europe and the prevalence of obesity (data not shown), which is initially surprising given that children from Western European language groups had a high prevalence of both overweight and obesity in the individual level analysis (see section

5.1.3). However, this discrepancy can be explained in light of the different countries included in the two different categories. The census category of North West Europe includes Great Britain, which is English speaking, but children from this background have been included in the English language background category of the CYWHS data and the two are not comparable in this sense. It is also possible that associations with obesity may vary between individual countries, a trend which would be disguised by this aggregation into regions[8].

These results confirm the association between ethnicity and child obesity in this population which was identified in the individual level analysis in Chapter 5; and this suggests that area level data can be used to predict outcomes for children when individual data are unavailable. What cannot be quantified from these outcomes is how ethnicity actually influences obesity – whether due to genetics/biology, cultural or socio-economic influences. It does, however, suggest that populations with a high proportion of indigenous or non-English speaking people could be appropriate targets for interventions aimed at preventing/reducing child obesity.

6.3.1.2 Marital Status

> *"Unequivocally, children do best when they are living with 2 mutually committed and loving parents who respect and support one another, who have adequate social and financial resources, and who are actively engaged in the upbringing of their children." (American Academy of Pediatrics 2003 p1542)*

While there has been limited research directly linking the marital status of parents with the weight status of their offspring, one study did report a lower incidence of obesity among children whose parents were married compared to those who were single or co-habiting (Whitaker, Phillips et al. 2007). As single parent families are more likely to

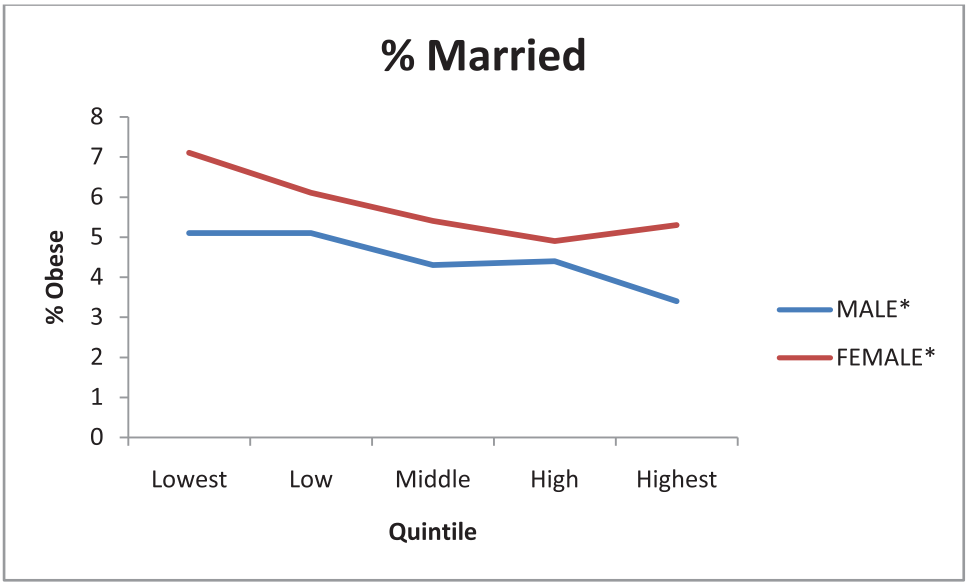
[8] A good example of the Modifiable Areal Unit Problem

suffer socio-economic stress (Lichter and Eggebeen 1994; Loshkin and Popkin 1999; Grinstein-Weiss, Yeo et al. 2008), this is not a surprising outcome. Separation or divorce of parents has also been demonstrated to negatively affect parenting skills and can have repercussions for the children's mental health and functioning (Cherlin, Furstenberg Jr. et al. 1991), which might conceivably have consequences for their weight status. This mechanism may be responsible for the finding that parental marital status was related to the incidence of attrition from a treatment program (Israel, Silverman et al. 1986), which has implications for intervention strategies.

In the current study, a greater percentage of married people within a CD is associated with a lower prevalence of obesity for both males and females (Figure 6.8). Similarly, a higher percentage of separated or divorced persons is associated with a higher prevalence of obesity (Figure 6.9), although the relationship appears to be more complex with the key differential being the sharp increase in obesity prevalence from the middle to high quintiles for both genders. This is suggestive of a threshold effect, where the number of divorced/separated persons in the CD does impact obesity prevalence, but only above a certain level. Of course, these CD level census statistics do not differentiate between adults with or without children, and this may be partly responsible for the degree of ambiguity in the Separated/Divorced category, where the presence of single parent families is not necessarily implied by the presence of separated or divorced persons.

This analysis can be further refined by considering the structure of families rather than simply the marital status of individuals. The two variables chosen for exploration are the percentage of couple families with children and the percentage of one parent families. These represent both the ideal and perhaps less than ideal family scenarios in which children can be raised, and potentially reflect neighbourhood stability and advantage.

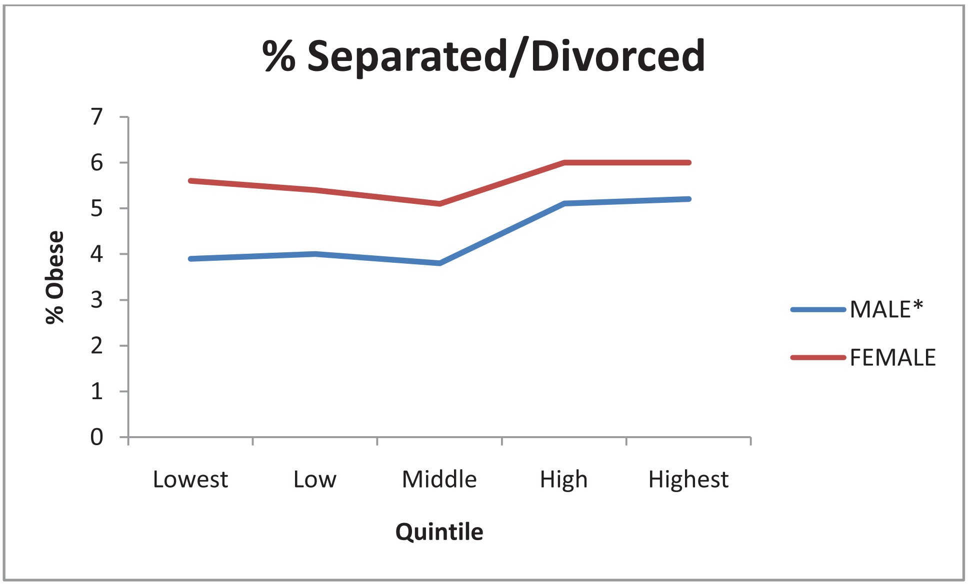
Figure 6.8 Obesity by quintile of married persons



**P < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.9 Obesity by quintile of separated or divorced persons

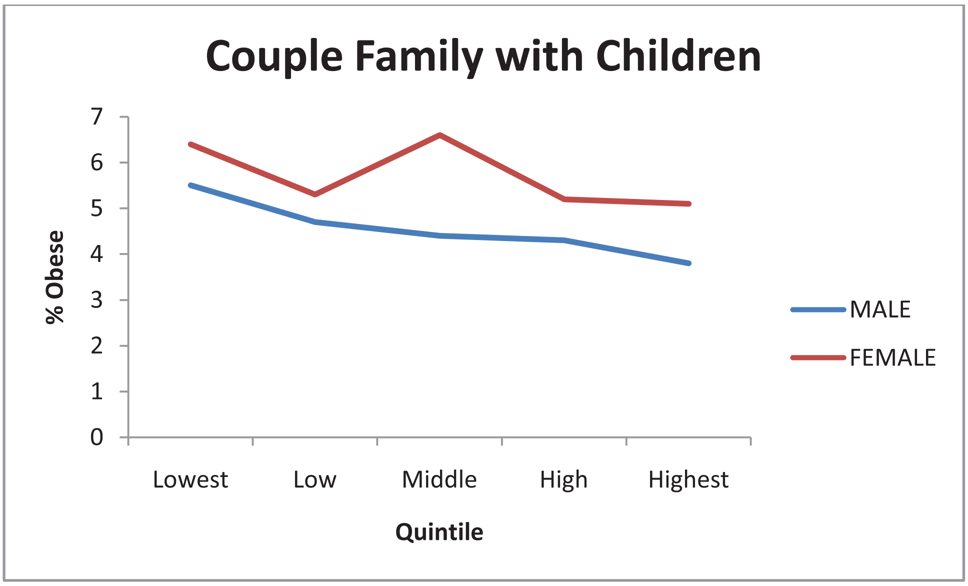


**P < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

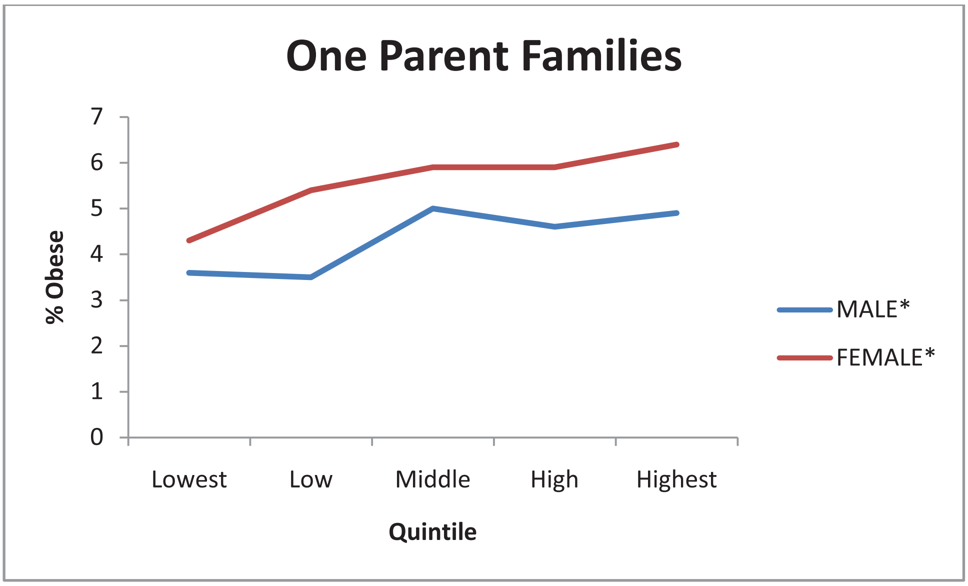
Although there is a trend towards decreasing obesity prevalence with increasing numbers of couple families with children (Figure 6.10), this relationship does not approach statistical significance. The sharp increase in obesity prevalence of girls living in CDs in the middle quintile is notable, but difficult to explain, and it would be interesting to see if this finding could be supported by qualitative research. On the other hand, the percentage of single parent families is positively related to obesity prevalence (Figure 6.11), with higher obesity prevalence evident in CDs with a higher percentage of one parent families.

Figure 6.10 Obesity by quintile of couple families with children (traditional family structure)



Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.11 Obesity by quintile of single parent families



**P < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

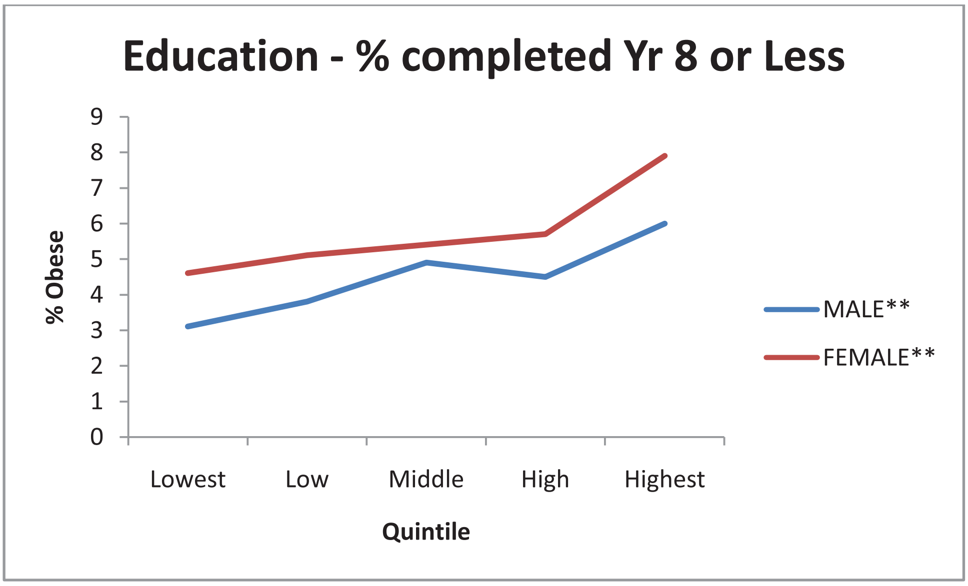
These results signify that the family structure of an area could be reliably used as an indicator of children at risk for obesity. A high percentage of one parent families would certainly identify an area where children may be at risk and, although the relationship is not as strong, the concentration of married people in an area may contribute to an overall environment of stability and socio-economic advantage which ameliorates the tendency towards obesity in young children.

6.3.1.3 Education and Qualifications

Education is one of the most commonly used indicators of SES (Wamala, Wolk et al. 1997; Ball and Crawford 2005; Chen and Paterson 2006) and parental education in particular has been shown to be related to child overweight in that children with more educated parents are less likely to be overweight/obese (Baughcum, Chamberlin et al. 2000; Campbell, Karen, Crawford et al. 2002b; Lamerz, Kuepper-Nybelen et al. 2005). The census measures education in various ways and the results from two particular statistics are presented here: the percentage of the population which completed year 8 or less and the percentage which completed year 11 or 12. These represent respectively the lowest and the highest levels of high school education in South Australia.

Chi square testing identified a statistically significant increase in obesity prevalence among children who live in CDs where a greater percentage of people did not complete high school (Figure 6.12), and decreased obesity prevalence in CDs where more people completed the final years of high school (Figure 6.13). These results support the literature which identifies a link between higher educational attainment in parents and decreased likelihood of overweight in children; they further indicate that the high school education levels of an area can potentially identify child populations with differential obesity risk.

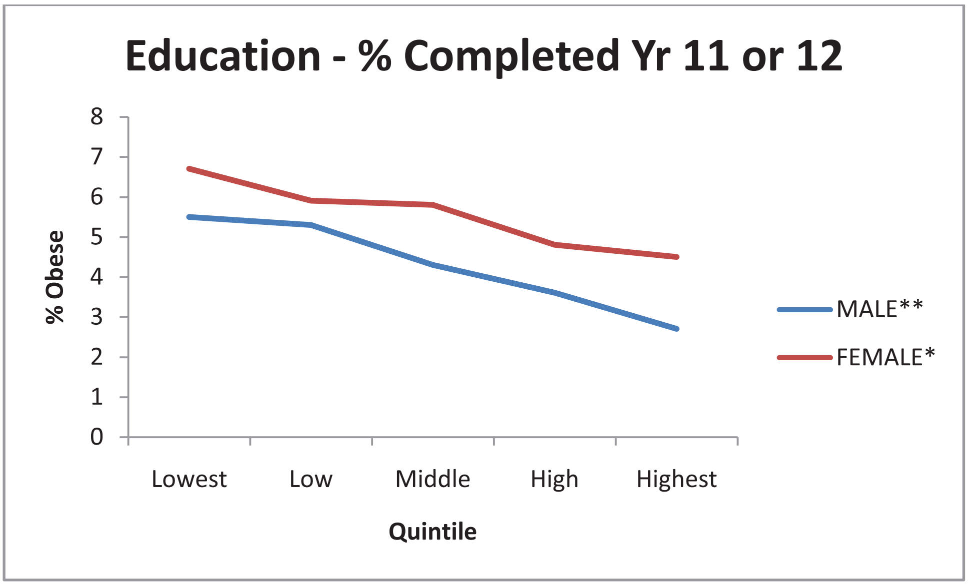
Figure 6.12 Obesity by quintile of population who completed year 8 or less (low level of high school education)



$**P < 0.005$

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.13 Obesity prevalence by quintile of population who completed yr 11 or yr 12 (high level of high school education)



**P < 0.05 **P < 0.005*

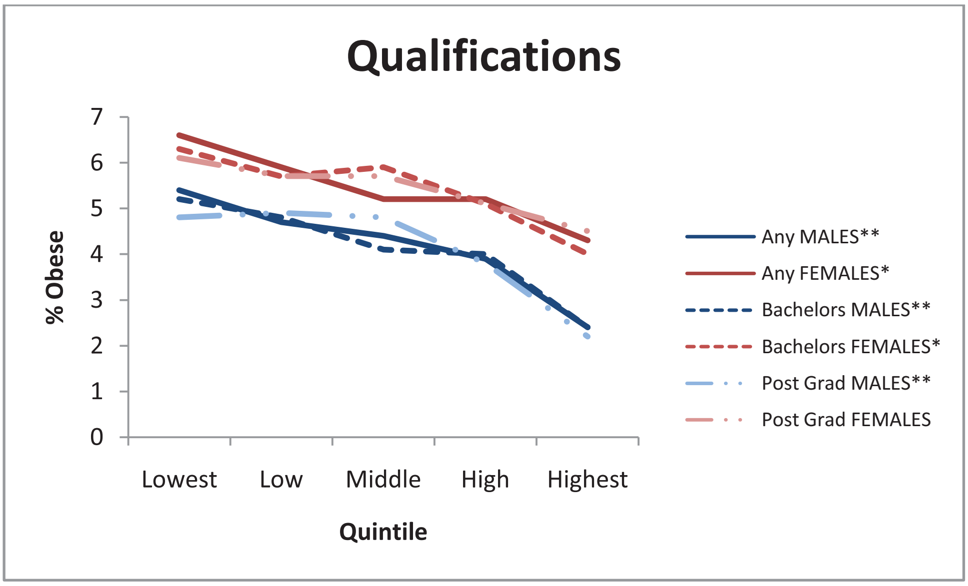
Source: ABS census data 2001 and CYWHS data 2000-2002

Because some studies have particularly identified maternal education as a risk factor for child obesity (Baughcum, Chamberlin et al. 2000; Lamerz, Kuepper-Nybelen et al. 2005), female's education level was also assessed as a discrete variable (data not shown). The relationship between obesity prevalence and female education quintile was almost identical to that shown (above) in Figure 6.12 and Figure 6.13 for all persons. This indicates that, while this variable could still be used to identify child populations at risk, the contribution of area-level female education status is either not as strong as, or comparable to, the established relationship between maternal education and child weight status for individuals.

Post-school qualifications represent an extension of education and could be considered to furnish the link between education and income. As a high school education is needed to access most formal further education, this variable can be expected to show very similar results to high school education. However not all people with a high school education go on to undertake further training, and it is instructive to see if the strength of the relationship between qualifications and obesity is as strong as the relationship between high school education and obesity.

The relationship between qualifications and obesity was assessed using three categories of qualification – any post school qualification (including diploma, certificate and trade qualifications), bachelor's degree only and post-graduate degree only. In general, children living in areas with the highest percentage of people with qualifications are less likely to be obese and vice versa (Figure 6.14) – supporting the high school education results as expected. Interestingly, the statistical relationship is stronger for boys in all categories and the relationship between qualification quintile and obesity in girls does not reach statistical significance in the postgraduate degree analysis. Once again, almost identical results were observed if female qualifications only were assessed (not shown).

Figure 6.14 Obesity by quintile of post-school qualifications



*$P < 0.05$ **$P < 0.005$*

Source: ABS census data 2001 and CYWHS data 2000-2002

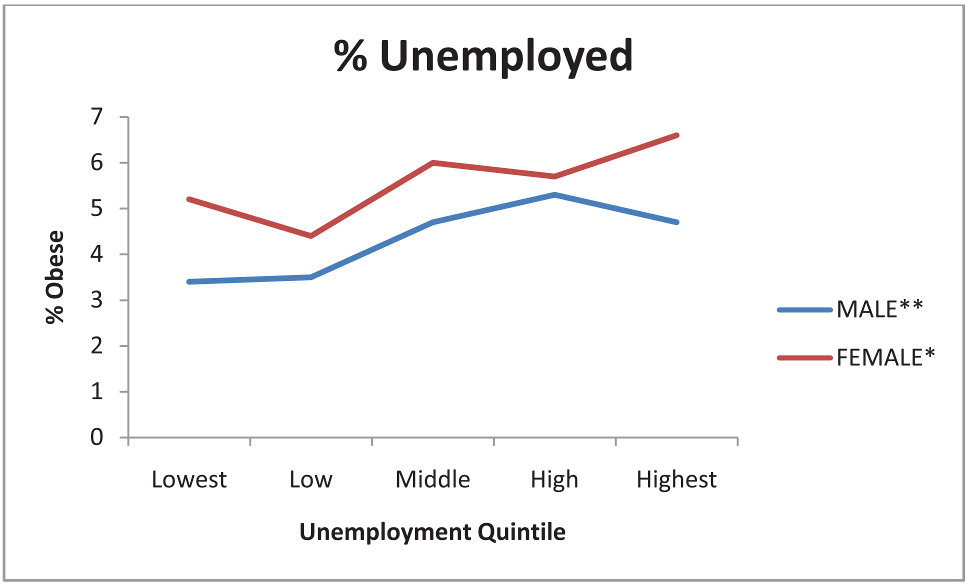
These results appear to confirm that education – whether high school or beyond – is indeed an important component of the socio-economic relationship with obesity in this age group. Exactly how area level adult education achievement influences child obesity rates is not clear, but it is reasonable to assume that success in education, as well as improving employment and therefore income prospects, underlies the development of things like life skills and health literacy, thereby forming the basis for an informed and intelligent parenting community (Kickbusch 2001; Bennett, Robbins et al. 2003; Lurie and Parker 2007).

6.3.1.4 Employment

Employment status is related to both education and income, and is therefore another commonly used indicator of SES. The relationship with obesity in the CYWHS data set was assessed using the percentage of people employed, unemployed and not in the labour force (NILF).

Those children living in CDs with the highest unemployment rates are more likely to be obese than those living where unemployment is lower, and this relationship is significant for both males and females but stronger in males (Figure 6.15). If percentage employed is the measure against which obesity prevalence is calculated then the inverse pattern is evident, however this relationship is not statistically significant at all for girls (Figure 6.16).

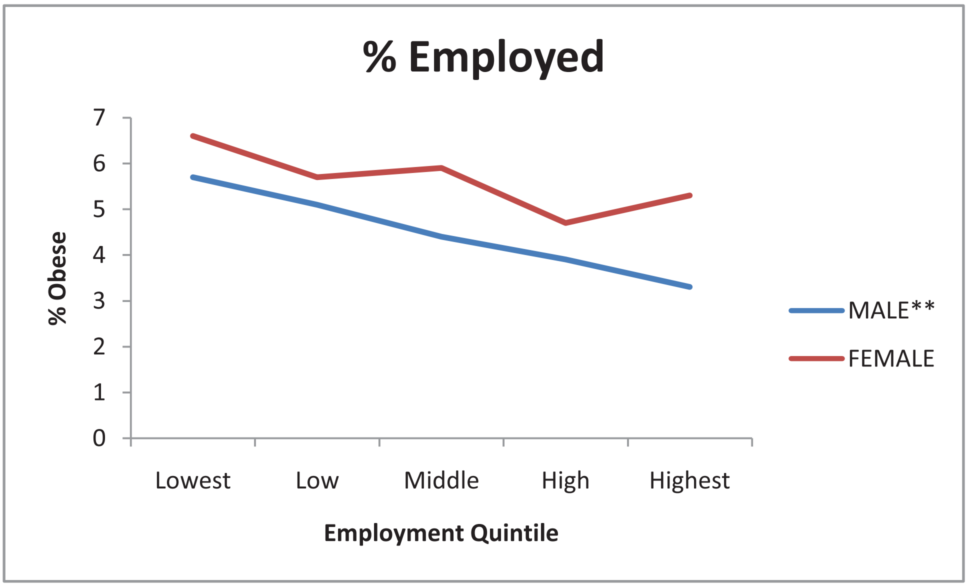
Figure 6.15 Obesity prevalence by quintile of unemployment



**P < 0.05 **P < 0.005*

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.16 Obesity prevalence by quintile of persons employed

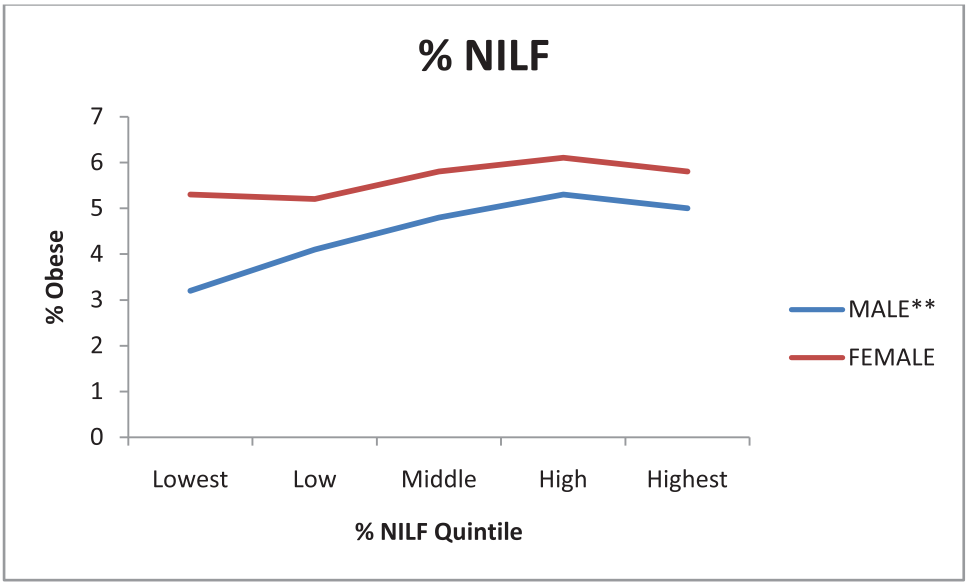


***P < 0.005*

Source: ABS census data 2001 and CYWHS data 2000-2002

The 'not in labour force' (NILF) category captures people who are not employed and not seeking to be employed. This can included people who are on sickness, disability or other benefits (including the age pension) through to those whose accumulated wealth or other household income enables them to choose not to work. As such, the percentage of people NILF could represent either advantage or disadvantage and it is difficult to interpret the relationship with obesity (Figure 6.17). Although the spatial distribution of NILF quintiles is very similar to that of disadvantage (Figure 6.18) it is certainly not identical, and this may help to account for the fact that the observed relationship is not statistically significant for girls, although there is a significant association between male obesity prevalence and NILF quintile (Figure 6.17).

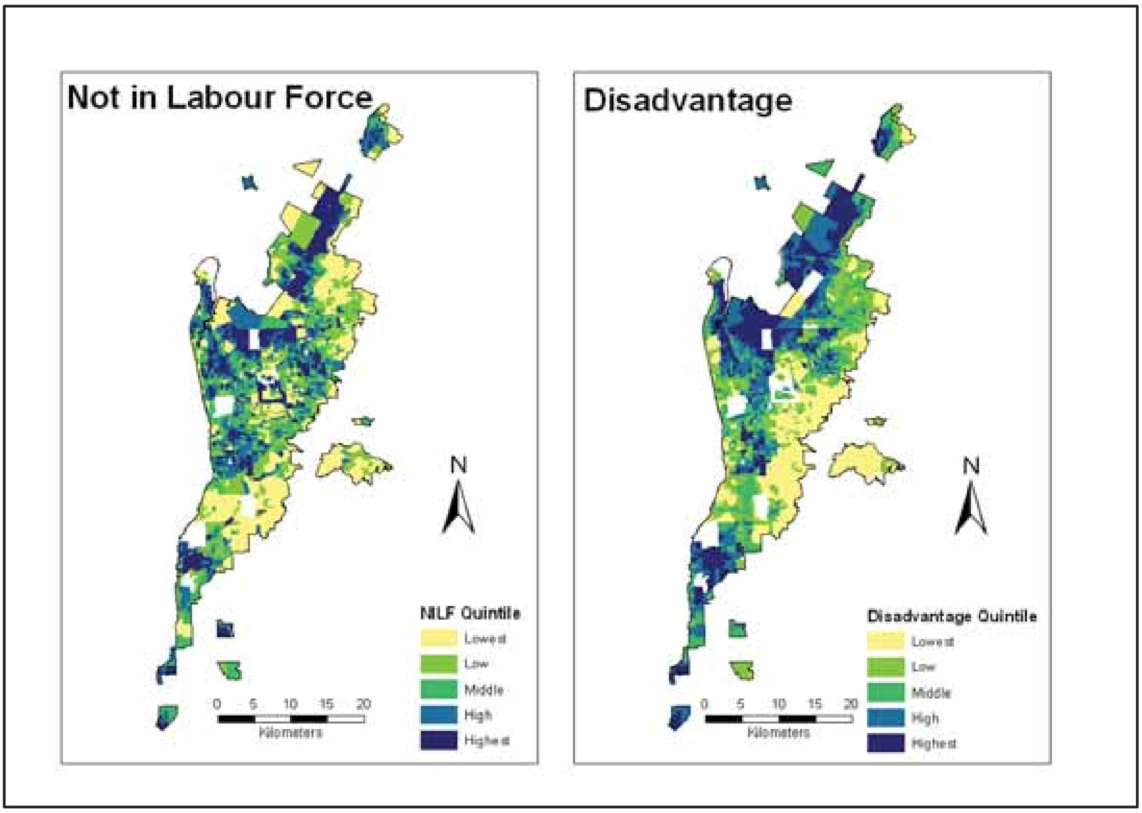
Figure 6.17 Obesity prevalence by quintile of persons not in the labour force



$^{**}P < 0.005$

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.18 CD level comparison of NILF and SEIFA disadvantage, urban Adelaide, 2001



Source: ABS census data and SEIFA 2001

These results indicate that area level employment patterns are related to the prevalence of obesity in four year olds, although once again these relationships are strongest for boys. Because of the correlation between education/qualifications and employment status it is not possible to assess what contribution each factor makes individually, but it is evident that area level employment status could be accurately used to identify groups of children at risk of higher obesity prevalence.

6.3.1.5 Female Employment

In some studies, mothers' hours of work has been related to their children's weight status with increased hours of maternal employment being associated with greater likelihood of child overweight, especially among higher income families (Anderson, Butcher et al. 2003; Hawkins, Cole et al. 2008). Interestingly, one study has also found that limited attendance at formal childcare (up to 15 hours per week) is associated with a decrease in overweight compared to children receiving either more or less hours of care (Lumeng, Gannon et al. 2004). Although this may be explained by the underlying socio-economic status of the family, it is also possible that this is in some way related to the mother's hours of work, rather than time in childcare per se.

Although this relationship cannot be confirmed directly with the data available for this study, it is possible to measure obesity prevalence against the percentage of women working full time, part time or NILF. In this instance there was no relationship between quintile of female full time employment and child obesity (data not shown), however obesity in both boys ($P = 0.02$) and girls (near significant at $P = 0.08$) decreased as the percentage of women working part-time increased. In contrast, the prevalence of obesity among both boys ($P = 0.00$) and girls (not significant) increased with increasing percentage of women identified as NILF (data not shown).

It is unclear what these results are actually measuring – there are potentially many factors which influence women's need/choice to work part time or not to work at all and there is a possibility that these statistics could be indicative of both advantage and disadvantage depending on individual circumstances. Any interpretation is further complicated by the fact that it is all women, not just mothers of young children, who are included in the census statistics. For these reasons, it would be not be prudent to hypothesise a relationship between the area-level employment status of women and child obesity prevalence and it is not possible to either support or refute the work of previous researchers who have found associations at the individual level.

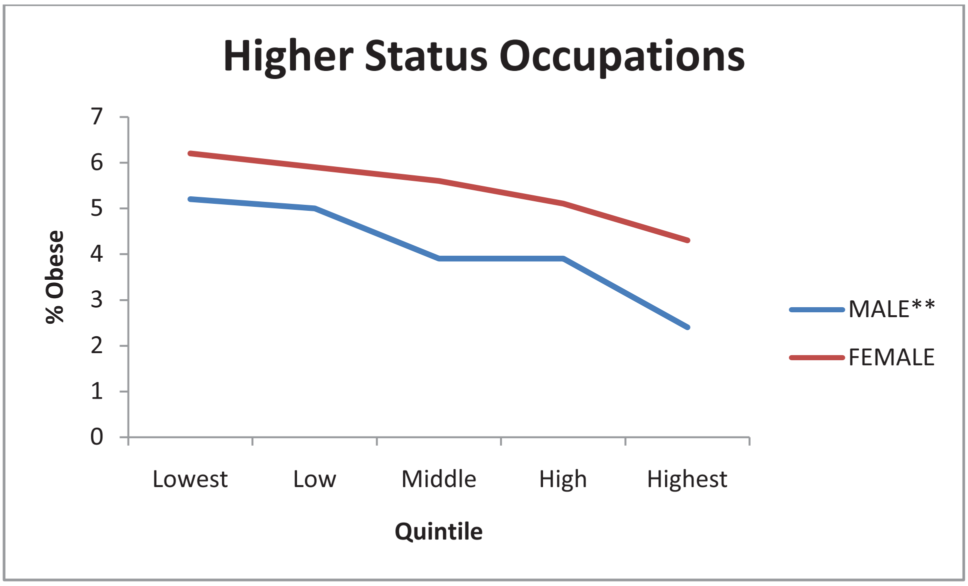
6.3.1.6 Occupation

Also related to education and income is occupation. Occupation rank has been reported to be associated with many aspects of health (Macintyre 1986; Macleod, Davey Smith et al. 2005; Rajaratnam, Burke et al. 2006) and with overweight in particular (Romon, Duhamel et al. 2004; Lamerz, Kuepper-Nybelen et al. 2005; Chen and Paterson 2006). Occupation rank is a concept which has long been embodied in the notion of 'white collar' and 'blue collar' workers; while more recent classification systems have concentrated on actual job titles, and the tasks performed, to group similar occupations together (Australian Bureau of Statistics and Statistics New Zealand 2006). The ranking of occupations embodies the notion of status, which is an expression of such factors as training required, responsibility assumed and remuneration received.

For simplicity of analysis, the occupation groups defined by the ABS (Australian Bureau of Statistics and Statistics New Zealand 2006) have been further amalgamated into four categories which rank occupations in terms of status. The higher status occupations include managers and administrators, professionals, and associate professionals while the lower status occupations encompass elementary clerical and sales workers, and labourers and related workers. Both the highest and lowest status categories are compared here with the obesity prevalence of children in the CYWHS research database.

Obesity prevalence among four year olds increases as the percentage of people with higher status occupations decreases (Figure 6.19), and vice versa (Figure 6.20). Once again, the relationship is strongest in boys and the relationships for both genders are stronger when it is the lower SES variable against which obesity prevalence is measured.

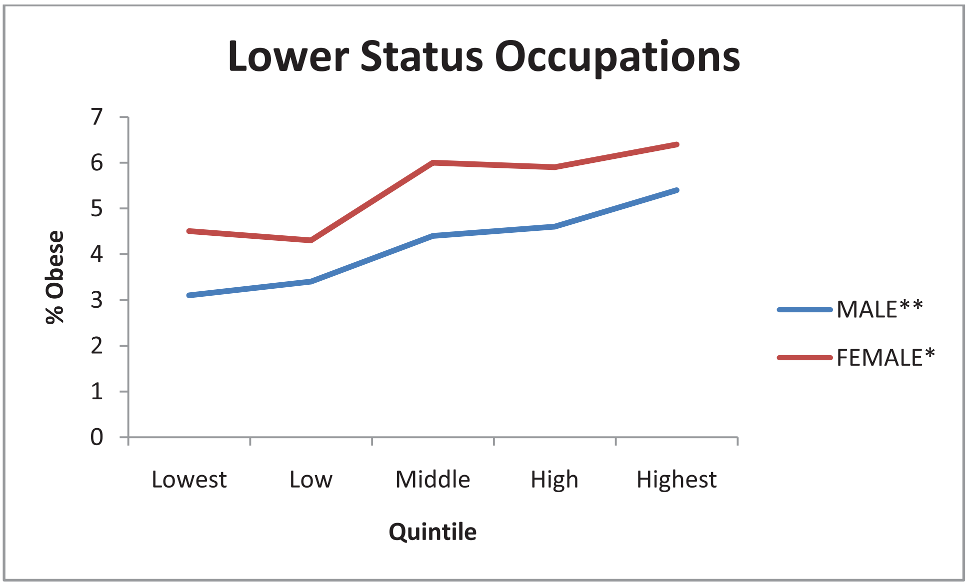
Figure 6.19 Obesity prevalence by quintile of high status occupations



$**P < 0.005$

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.20 Obesity prevalence by quintile of low status occupations



$*P < 0.05$ $**P < 0.005$

Source: ABS census data 2001 and CYWHS data 2000-2002

6.3.1.7 Industry of employment

Similar to occupation rank, industries can be perceived in terms of status. The percentage of people working in different industry categories was also investigated, with a higher percentage of people in the manufacturing/trade/wholesale sector being associated with higher prevalence of obesity in both genders (Figure 6.21). Conversely, higher percentages of people in property/finance (Figure 6.22) - significant only for males - and education (Figure 6.23) were associated with lower levels of obesity. Analysis of other industry categories did not show any particular relationships.

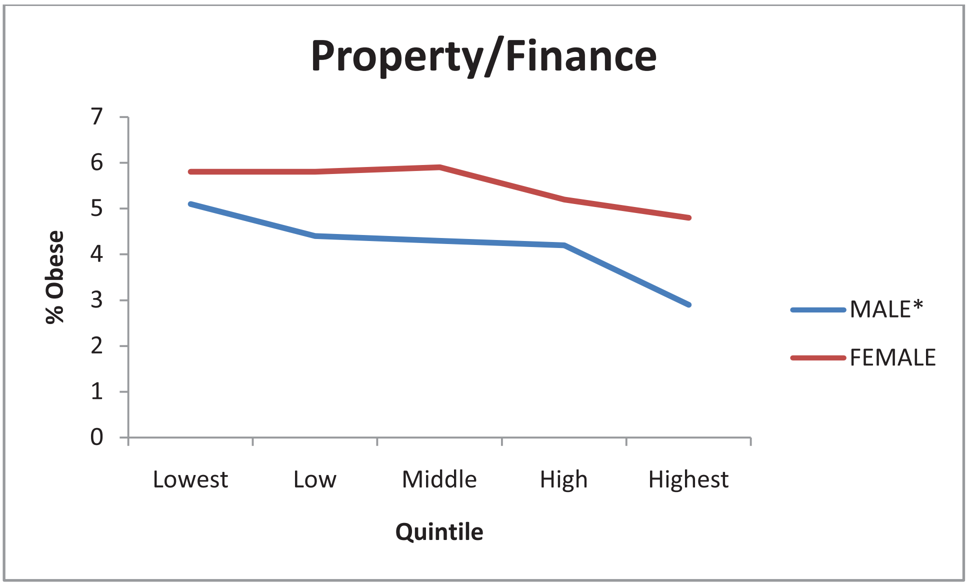
These results reflect both the status and wealth of certain industries – e.g. property/finance vs. manufacturing/wholesale/trade – and the education levels required to participate in them. The relationships seen here are very similar to those reported for other variables which measure aspects of wealth and/or education.

Figure 6.21 Obesity prevalence by quintile of employment in lower status industries

**P* < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

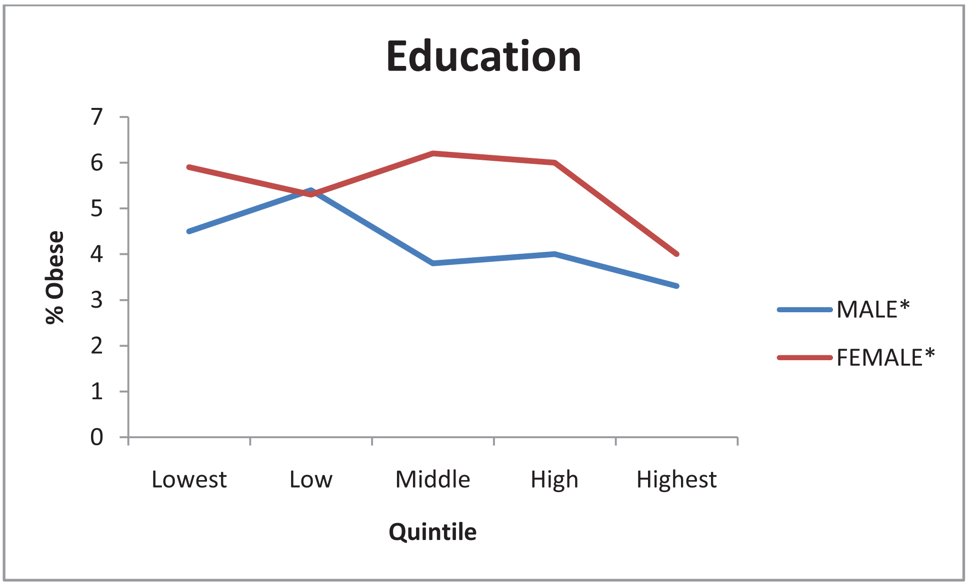
Figure 6.22 Obesity prevalence by quintile of employment in property and finance (high status)



**P < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.23 Obesity prevalence by quintile of employment in the education industry (mid-high status)



**P < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

6.3.1.8 Income

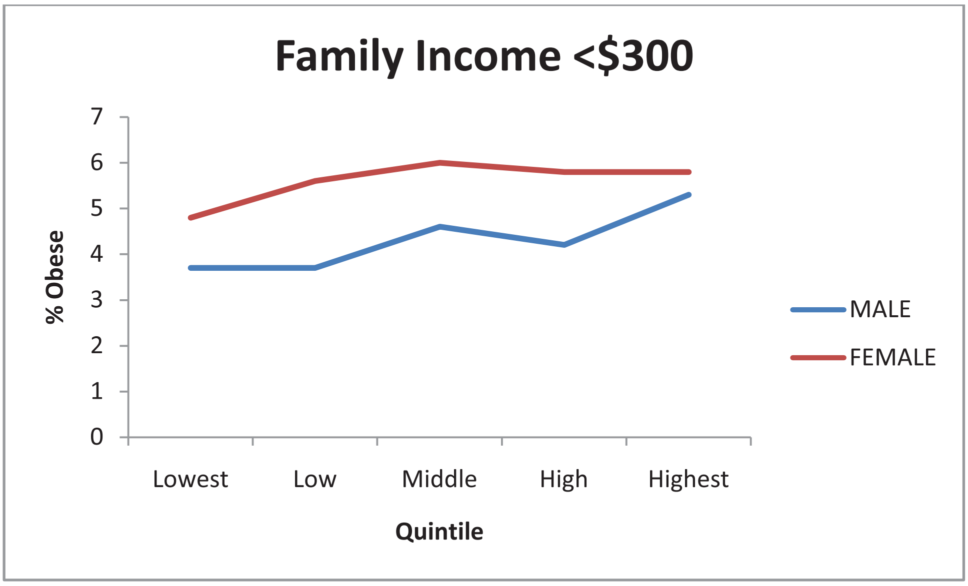
Income can be considered as an expression of education, occupation and employment status such that CDs in the higher quintiles of those variables would also be likely to be in the higher quintiles of income. Similar relationships with obesity prevalence would also be expected and these have certainly been detected at an individual level (Strauss and Pollack 2001; Wang, Youfa 2001; Dickenson and Johnstone 2005).

In general, the expected relationships between CD income quintiles and obesity prevalence have been identified in this analysis, with the obesity prevalence among four year olds increasing as the percentage of high income families or individuals decreases (Figure 6.24, Figure 6.25, Figure 6.26, Figure 6.27). However, the relationships are not always as clear or as strong as might be anticipated. The relationship between low family income (<$300/week) and obesity (Figure 6.24) does not reach statistical significance for either gender and is particularly poor for girls, while if high family income (>$1500/week) is used as the comparison variable (Figure 6.25) then the relationship is still only significant for boys. This is a contrast to the previous socio-economic variables analysed, where the measure of lower SES has consistently shown the strongest relationship with obesity.

If individual incomes are used as the comparison variables (Figure 6.26, Figure 6.27), the statistical relationships are much stronger than those for family incomes, which is unexpected given that four year old children live in family environments and would presumably be more affected by the money available to the family unit. Once again, the statistical relationships are also stronger when the high income variable (Figure 6.27) is analysed. It seems that in low income neighbourhoods, other factors may be more influential in the development of obesity in children than the actual income levels;

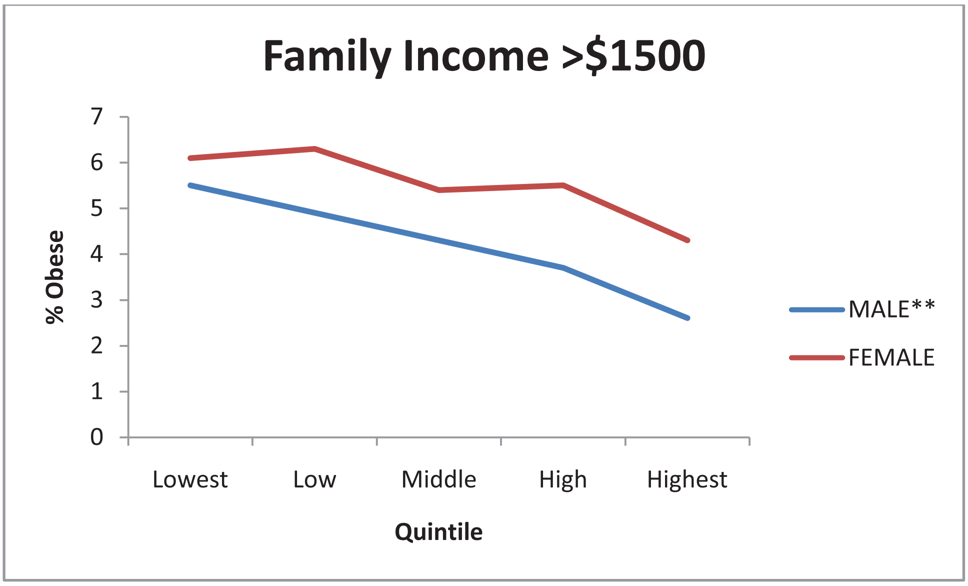
while in high income neighbourhoods the income levels may be more representative of the protective effect of high SES on the development of obesity.

Figure 6.24 Obesity prevalence by quintile of low income families



Source: ABS census data 2001 and CYWHS data 2000-2002

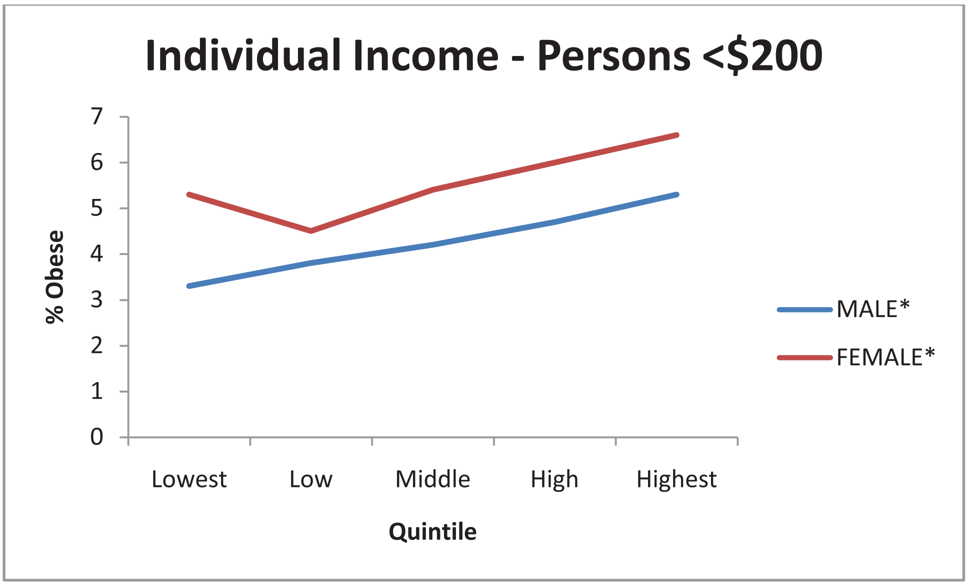
Figure 6.25 Obesity prevalence by quintile of high income families



***P < 0.005*

Source: ABS census data 2001 and CYWHS data 2000-2002

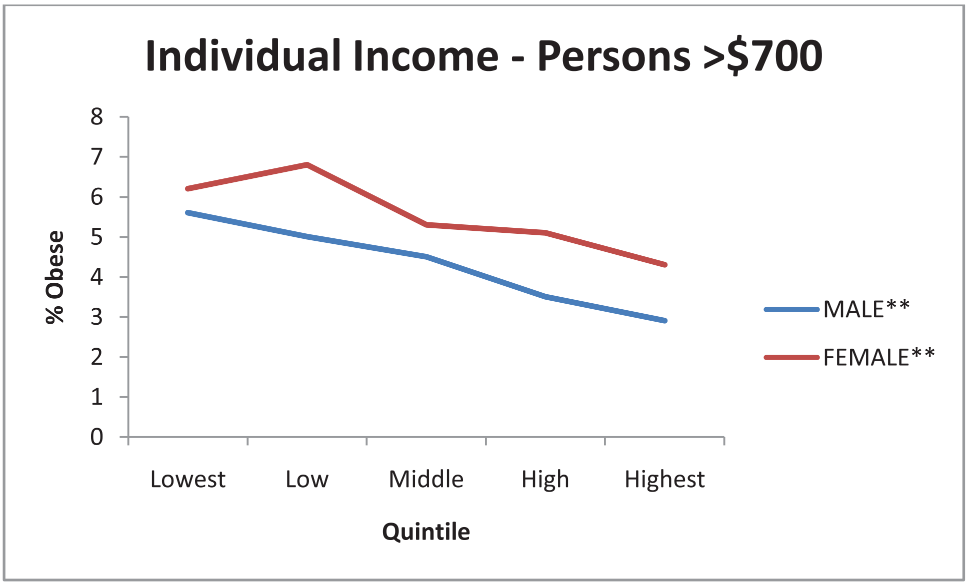
Figure 6.26 Obesity prevalence by quintile of low income (individuals)



$P < 0.05$

Source: ABS census data 2001 and CYWHS data 2000-2002

Figure 6.27 Obesity prevalence by quintile of high income (individuals)



**$P < 0.005$*

Source: ABS census data 2001 and CYWHS data 2000-2002

6.3.2 Other Indicators of Disadvantage

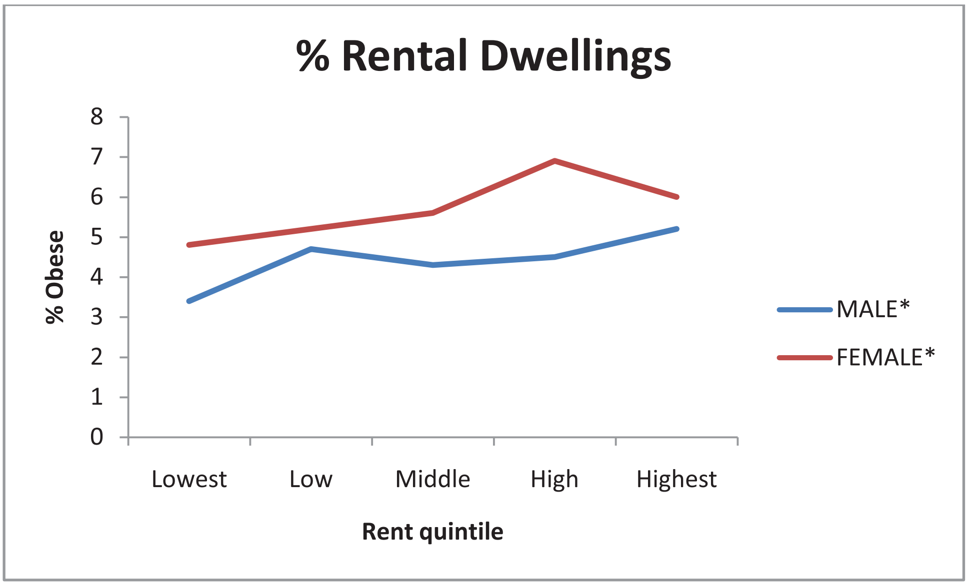
Disadvantage can manifest in multiple ways apart from the core indicators already described above. As such, neighbourhoods may exhibit other characteristics which can be associated with child obesity. The remaining variables explored in this section tend to reflect wealth – or the absence of wealth – and are investigated here to determine if their relationship with obesity prevalence goes beyond the over-arching correlation with disadvantage.

6.3.2.1 Dwelling Type and Tenure

Obesity prevalence increases as the percentage of dwellings classified as separate houses decreases (data not shown), but this relationship does not reach statistical significance. Neither is there any apparent relationship between the percentage of dwellings classified as flats/units and the incidence of obesity (data not shown). It is likely that while living in a detached dwelling generally requires a certain level of financial resources to either rent or purchase, this may not always be the case, (e.g. public housing stock includes many separate houses), and similarly living in apartment-type accommodation may be a deliberate – and not necessarily cheap – lifestyle choice for many people. Once again this is a limitation of the data available in that the census statistics do not differentiate between households with young children and all other households. In the absence of supplementary information on the underlying population, these variables do not provide a good indication of communities where children may be risk of obesity.

The percentage of rental dwellings in a community may be more indicative of disadvantage as those people – especially families – who can afford to purchase a home usually do so. This analysis does indeed show a relationship with obesity, such that obesity prevalence is higher in areas with a higher percentage of rental dwellings (Figure 6.28).

Figure 6.28 Obesity prevalence by quintile of homes being rented



**P < 0.05*

Source: ABS census data 2001 and CYWHS data 2000-2002

Table 6-1 Obesity prevalence of children living in CDs with or without public housing stock

	MALE**	FEMALE*
	%	%
no SAHT	3.6	4.7
SAHT	4.8	6.2

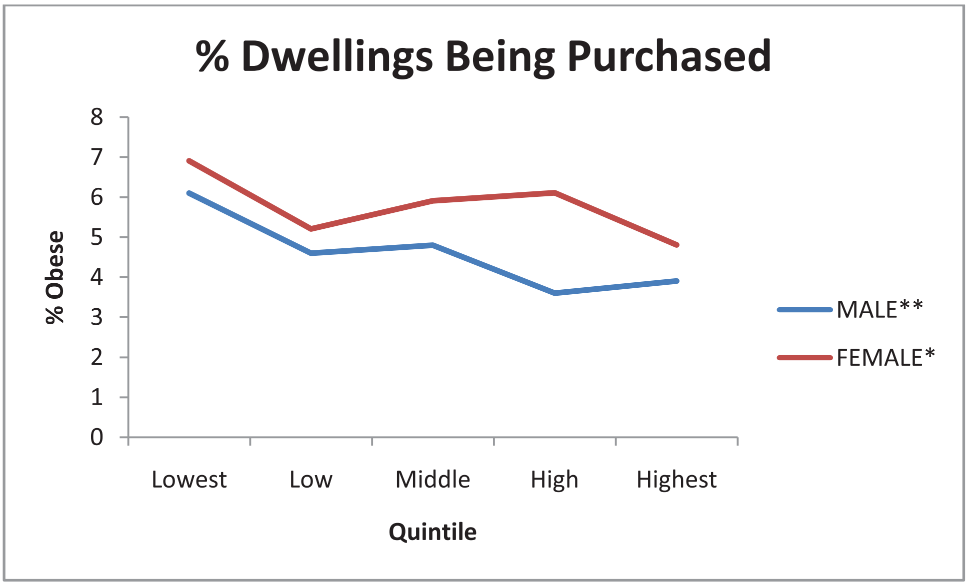
**P < 0.05 **P < 0.005*

Source: ABS census data 2001 and CYWHS data 2000-2002

This analysis can be further refined by considering only properties which are rented from the public housing authority, especially as proximity to and density of such properties was a strong predictor of obesity in the individual level analysis (see section 5.2.1). Because of the nature of the data and the phenomenon being measured (primarily, the many CDs without any SAHT stock), this variable is more suited to a binary analysis which simply compares children living in CDs with and without SAHT rental dwellings. Table 6.1 shows that there is a very strong relationship, with both males and females significantly more likely to be obese if they live in a CD in which any dwellings are owned by the SAHT.

Ownership is another aspect of dwelling status which presumably reflects SES and may therefore show a relationship with obesity. Two variables were investigated – the percentage of homes being purchased, and the percentage of homes which were fully owned at the time of the census. Children who live in CDs where higher percentages of dwellings are being purchased are less likely to be obese (Figure 6.29). This relationship is statistically significant for both genders, and stronger for boys than for girls. In contrast, there is no apparent relationship between the percentage of dwellings fully owned and the obesity prevalence of the children (data not shown). Although this initially seems surprising, it is likely that full home ownership does not necessarily mirror the demographic of families with young children and this has obscured any relationship which may exist.

Figure 6.29 Obesity prevalence by quintile of dwellings being purchased



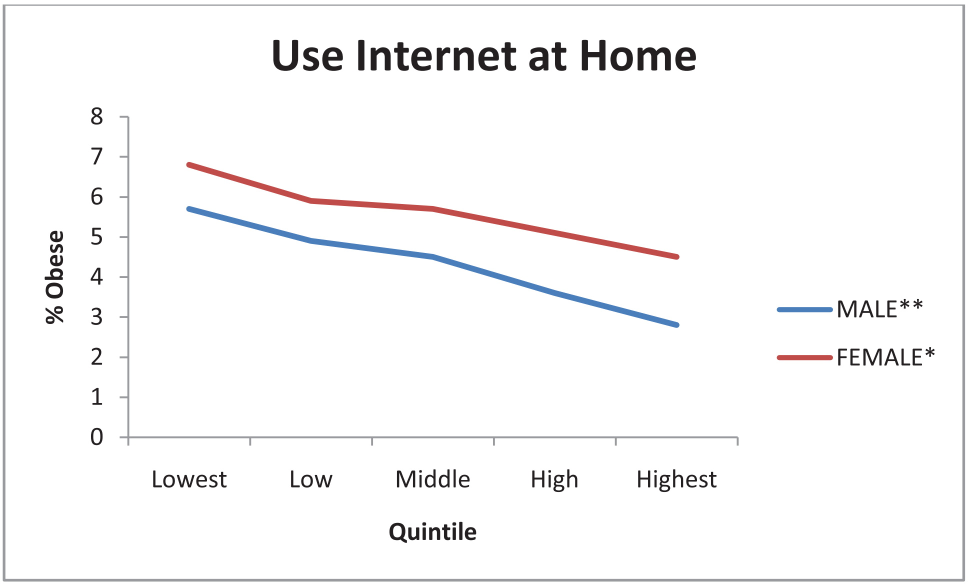
**P < 0.05 **P < 0.005*

Source: ABS census data 2001 and CYWHS data 2000-2002

6.3.2.2 Internet Use

Perhaps one of the most pervading influences of modern times is the explosion of electronic media, particularly the internet (Madden and Savage 2000). Lack of access to this technology indicates some level of disadvantage in Australian society (Curtin 2001) and access to the internet in the home would presumably signal either a certain level of wealth and/or a decision to direct resources towards participation in the modern communications and information revolution. As such, internet use statistics may be a strong indicator of advantage or disadvantage in communities which might also show a relationship with obesity prevalence in young children, and this appears to be the case for this study population (Figure 6.30).

Figure 6.30 Obesity prevalence by quintile of internet use



**P < 0.05 **P < 0.005*

Source: ABS census data 2001 and CYWHS data 2000-2002

The analysis shows that there is a significant relationship, especially for males, between the percentage of people who use the internet at home (Figure 6.30) or who use the internet at all (data not shown) and the prevalence of obesity among four year old children. These results suggest that internet access is indeed a measure of advantage which also has implications for education and information distribution, which may manifest as health consequences when sub-optimal participation in the digital revolution is apparent.

6.3.3 Discussion

The exploration of obesity prevalence in association with area level census data has yielded results which are largely supportive of the previously established correlations between SES and weight status. These results indicate that some neighbourhood characteristics can certainly be used to identify child populations at particular risk for the development of obesity.

This analysis has also yielded some new insight into the interaction between these variables and the obesity prevalence in the study population. The variables presented in this section and their statistical relationships with obesity prevalence are summarised in Appendix 1. Although girls consistently exhibit a higher prevalence of obesity, the statistical relationship between the quintile of the census variables and obesity prevalence was distinctly stronger for boys in many cases. This pattern was not evident in the analysis of individual variables (Section 5.1), where statistical relationships were more likely to be stronger for girls. The consistency of this pattern, and the fact that it is evident in the analysis of obesity prevalence by decile of SEIFA IRSD (section 6.2) – an aggregate measure of area level disadvantage – suggests that it is more than merely a data artefact or an unexpected result of the particular analysis method. This research suggests that neighbourhood socio-economic status has a stronger effect on obesity prevalence among boys than among girls. It is unclear why such area level factors would impact one gender more than another, and this is unlikely to be determined without further, qualitative, multi-disciplinary research to both confirm this finding and explore the underlying reasons for it.

The other detail of interest to emerge from this analysis is the observation that, when both a ‘high’ and ‘low’ indicator has been analysed for a particular variable category (e.g. education), it is often the low SES indicator which is likely to exhibit the strongest statistical relationship with obesity prevalence. The limited number of categories which have been analysed in this way preclude a definitive conclusion, nevertheless it is interesting to note that a high quintile of disadvantage seems to be a stronger predictor of increased obesity prevalence than a low quintile of advantage.

6.4 Conclusions

This chapter has explored many interactions between the weight status of four year old children and the socio-demographic environment in which they live. While individual data has shown that birth weight, breast feeding and ethnic measures are all strongly related to obesity, the social environment as measured by aggregate census data also appears to influence the prevalence of obesity in the study population. Aspects of housing, ethnicity, family structure, education, employment and income are particularly important for their statistical relationship between the CD quintiles and the obesity prevalence of the children living in those same quintiles. These measures of socio-economic status are also easily quantified from existing data, and can be used by health professionals to identify communities where intervention and prevention efforts could most usefully be focused to ensure that these strategies are actually reaching a population at risk.

However, there is also a suggestion that the areas with the highest levels of disadvantage do not necessarily exhibit the highest prevalence of obesity, with the most disadvantaged CD quintiles often having an obesity prevalence which is actually lower than the next most disadvantaged, or that the gradient between the most and next most disadvantaged quintiles is less than that between the higher advantage categories. As Chapter 7 will show, it may not be an efficient use of resources to target anti-obesity measures simply towards the most disadvantaged communities in metropolitan Adelaide.

CHAPTER 7

Analysis Outside of the Square

7.1 Introduction

This chapter follows up on the work presented in earlier chapters by further investigating the distribution of overweight children within the urban Adelaide area and how area level census variables relate to specific locations. Chapter 4 explored the prevalence of overweight children and average BMI scores using both suburbs and CDs as the units of investigation. However, with the capabilities of GIS and spatial statistics we are not confined to these somewhat arbitrary administrative boundaries with which we usually try to make sense of the world. A much more revealing visualisation technique is to create a continuous surface which illustrates the distribution of values across the study area.

Using these surfaces, the distribution and weight status of the urban subset of children is quantified in a way which reveals the underlying spatial variation in this phenomenon unconstrained by considerations of boundaries and base population. This technique enables the identification of a number of discrete areas where the children's weight status shows evidence of significant variation from the average. These areas are used to further explore the associations between obesity prevalence and the socio-demographic indicators which have shown outcomes of interest in the previous chapters, such that it is possible to determine whether these relationships remain robust when assessed for smaller groups of children in specific neighbourhood environments.

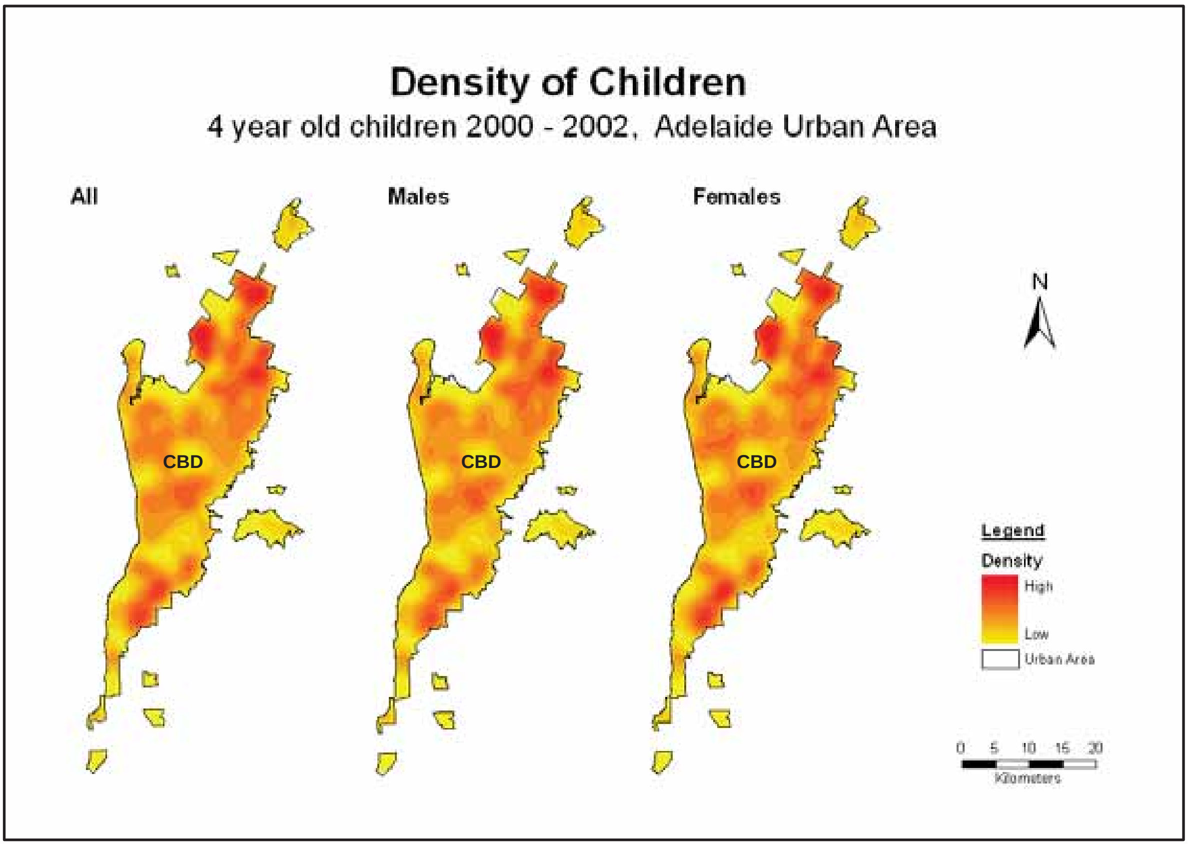
The maps and subsequent analysis in this chapter rely on the use of kernel density estimation techniques to ’spread’ the values from the point locations to create a continuous value, smoothed surface across the study area. Kernel density estimation uses a quadratic distance-weighted function to determine the values at each location on the surface, with points close to each location being weighted more heavily in determining the final value than those further away (O'Sullivan and Unwin 2003). This technique has previously been used as a visualisation tool in health-related research (e.g. Sabel, Gatrell et al. 2000; Spencer and Angeles 2007), and is particularly appropriate for this study due to the large number of point locations of both affected (obese) and non-affected (not obese) children.

The choice of parameters – particularly bandwidth - in this type of spatial statistical investigation is important, as the degree of smoothing is determined by these figures. Too much smoothing will mask all but the very broadest trends, while too little smoothing will emphasise local variation at the expense of a regional interpretation (Sabel, Gatrell et al. 2000). For this study, experimentation with various bandwidths has established 2500m as an appropriate search radius, and 150m² as an appropriate cell size for the output grid, and these parameters have been used for all of the density calculations described below.

7.2 Distribution of Children

This analysis uses the urban subset of children to examine the distribution of this population within the urban area of Adelaide, and the patterns of obesity across this area. It is first necessary to visualise the distribution of the children as a population (Figure 7.1), as this provides a basis for the comparison of obesity distribution. Boys and girls are presented separately due to the correlations between gender and weight status. These maps show that the distribution of boys and girls is very similar overall, with some minor variations visible in the western and inner southern suburbs. As analysis of weight will be stratified by gender, these minor differences will not affect any results.

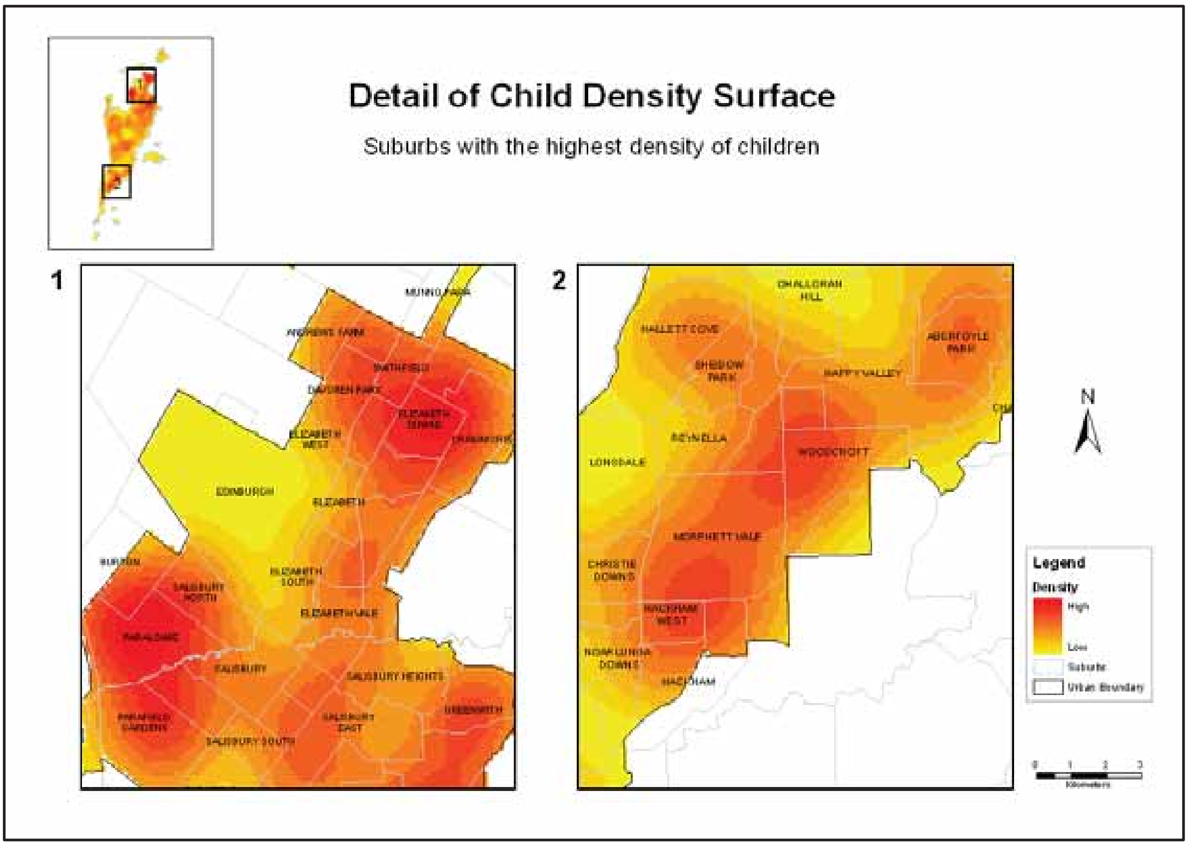
Figure 7.1 Density of children in the Adelaide urban area, 2000 - 2002



Source: CYWHS data 2000-2002

More detail of the higher density areas is presented in Figure 7.2, which shows that the highest densities of children are found in the northern suburbs of Paralowie and Elizabeth Downs and extending into the neighbouring suburbs. Another high density pocket is evident in the southern suburbs of Woodcroft, Morphett Vale and surrounds, with high numbers also present in the Aberfoyle Park area. (Refer to the location maps in Chapter 1, p17-20, for an overview of the study area). Other pockets of moderate density also occur in the suburbs directly south of the CBD and in the outer north-eastern suburbs (detail not shown). This distribution can largely be attributed to the concentration of new housing developments and the subsequent attraction of young families to these areas, however it should also be noted that many of these suburbs comprise relatively low-SES populations. These maps provide visual support for the findings reported in Hugo and Franzon (2006) that fertility levels in South Australia are higher among low SES populations.

Figure 7.2 Suburbs with the highest densities of children, 2000 - 2002



Source: CYWHS data 2000-2002

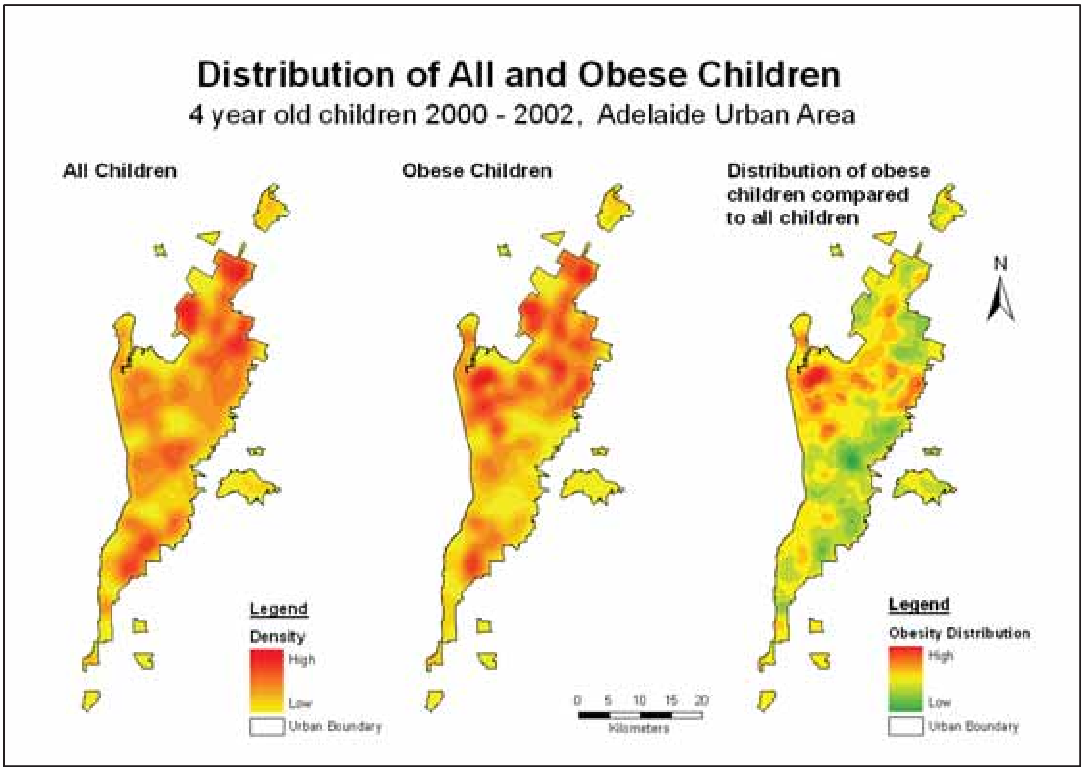
7.2.1 Distribution of Obese Children

The distribution of obese children within this population has also been extrapolated using the same methodology as for the density surfaces of all children. Because the kernel density technique does not rely on the base number of children in a given area to produce meaningful results – unlike the small-area based statistics presented in Chapter 4 – it is possible to focus on obesity only in this analysis.

The first two maps in Figure 7.3 show the density surface of all children alongside the density surface of obese children only. Although these two surfaces can be compared visually and conclusions drawn about where there appear to be more or less obese children than might be expected, it is desirable to quantify these comparisons where possible. This has been done by initially reclassifying both surfaces so that the highest densities have a value = 9 and the lowest densities a value = 0, with an equal distribution of values 1 – 8 in between. The surface of all children was then mathematically subtracted from the surface of obese children. The resulting surface, (the third map in Figure 7.3), has negative values where the density of obese children is lower than the density of all children, and positive values where the density of obese children is higher. This surface has been smoothed for more meaningful display. The darkest reds and darkest greens are the areas of most interest, as they represent an obvious disparity between the concentration of obese children and the underlying density of all children. The western suburbs clearly show up as an area of higher obesity, while the southern and eastern suburbs have lower obesity than the underlying distribution of children might suggest.

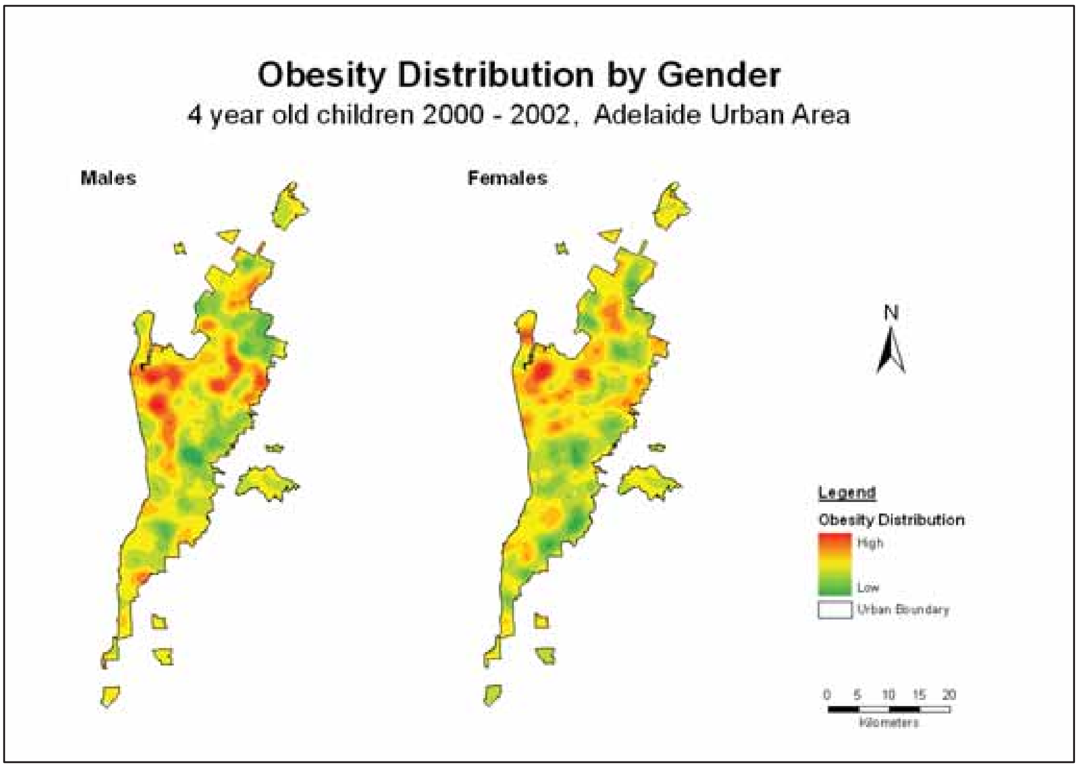
The same process was used to create obesity distribution surfaces of boys and girls separately, and Figure 7.4 shows that there are some evident gender differences with obesity ‘hot spots’ evident in the western, inner northern and (to a lesser extent) northern suburbs for females, while males show a more generalised pattern with focus areas distributed in the western suburbs and the middle northern suburbs. Both males and females show a ‘cool area’ ranging from the eastern to the southern suburbs, although this differs in intensity at different places between the genders. There is also a notable cool area in the northern suburbs for males which is not as prominent for females. However, there are also general similarities between the two distributions.

Figure 7.3 Distribution of all and obese children, urban Adelaide, 2000 - 2002



Source: CYWHS data 2000-2002

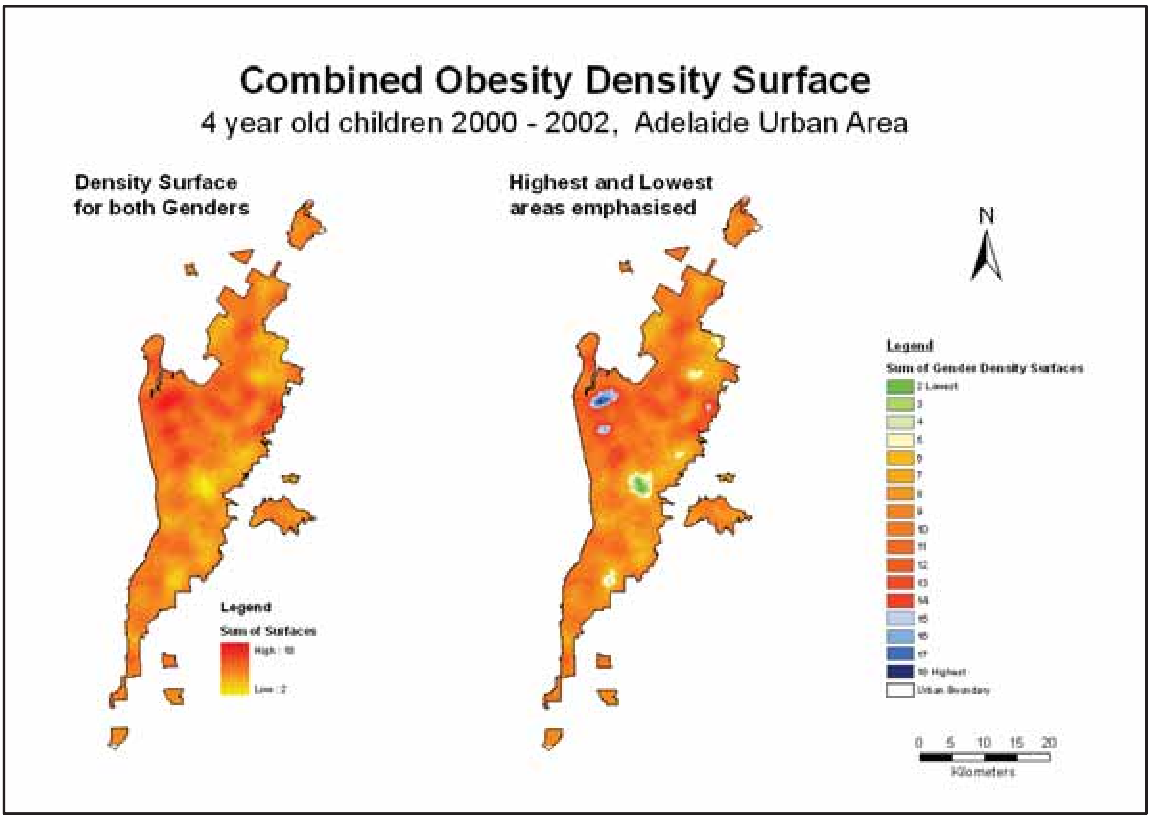
Figure 7.4 Distribution of obese children by gender, urban Adelaide, 2000 - 2002



Source: CYWHS data 2000-2002

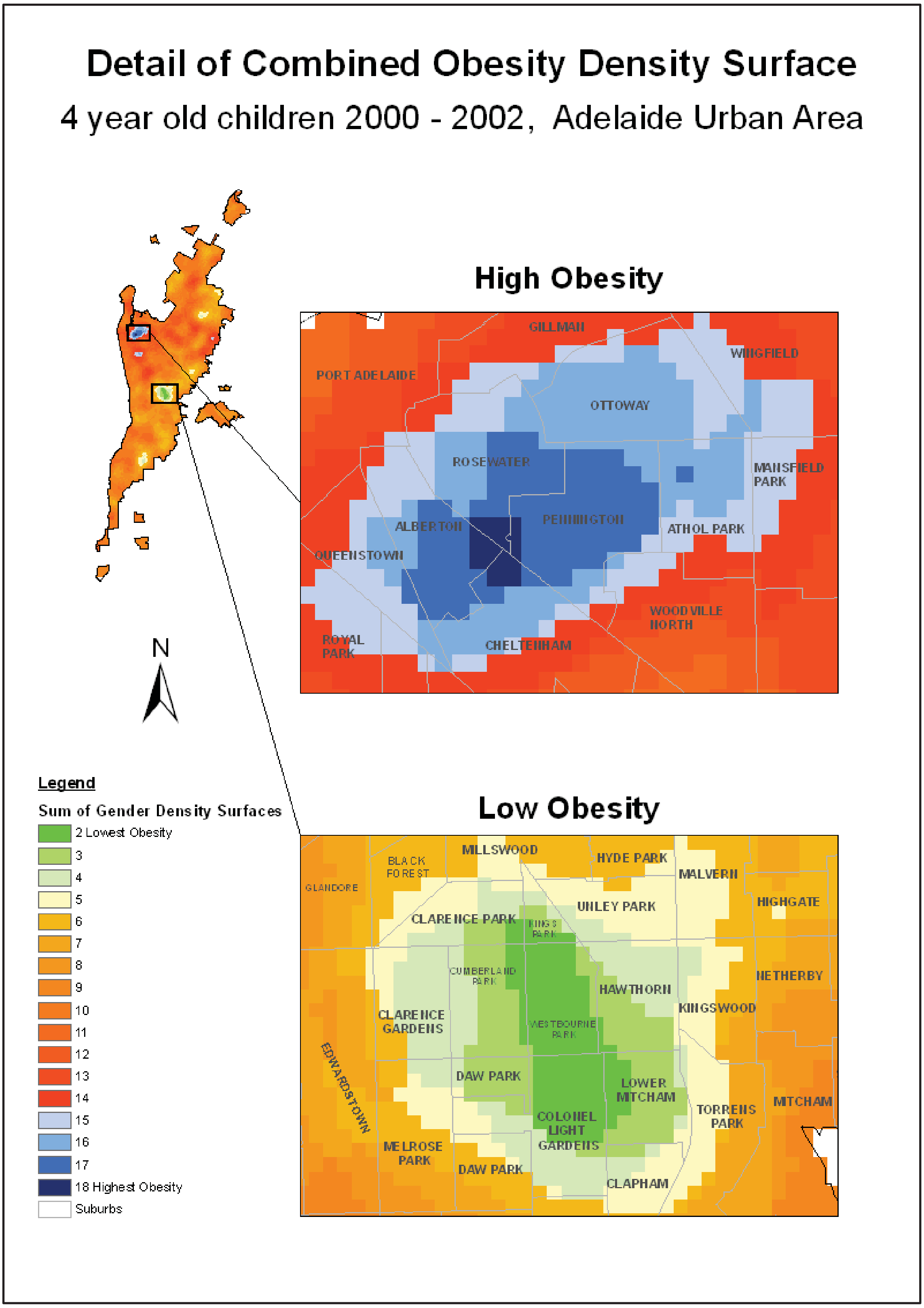
In order to conduct further analysis, it is important to identify areas where the prevalence of obesity is either high or low for both genders. This was done by once again reclassifying both gender surfaces so that the areas of lowest obesity density were = 1 and areas of highest density = 9, with values equally distributed in between. Adding these two surfaces together then gives values ranging from 2 (lowest obesity prevalence for both genders) through to 18 (highest prevalence for both genders). The resulting surface identifies these areas of interest (Figure 7.5) with the areas of lowest obesity prevalence picked out in greens and the highest in blues. Two areas immediately stand out – one each of high and low obesity prevalence, (detail shown in Figure 7.6). These areas should clearly be a focus for further investigation.

Figure 7.5 Concentration of obesity – males and females combined



Source: CYWHS data 2000-2002

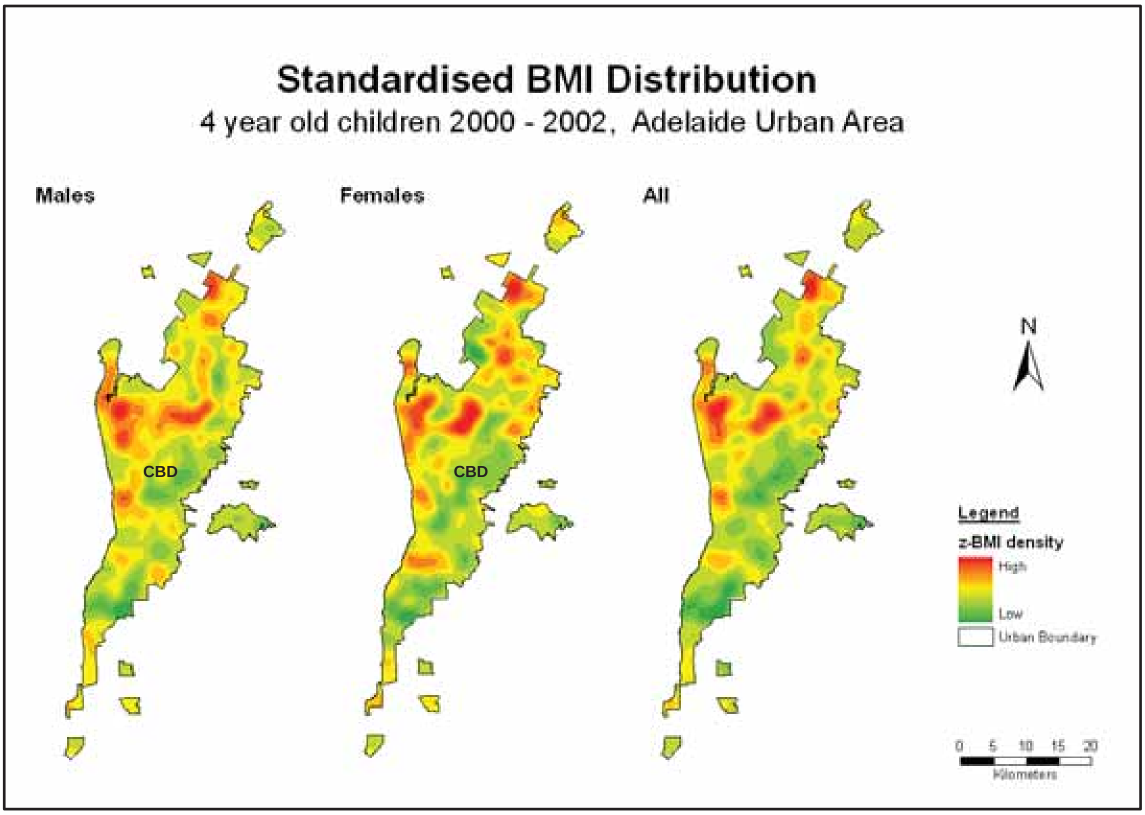
Figure 7.6 Areas of high and low obesity concentration, urban Adelaide, 2000 - 2002



Source: CYWHS data 2000-2002

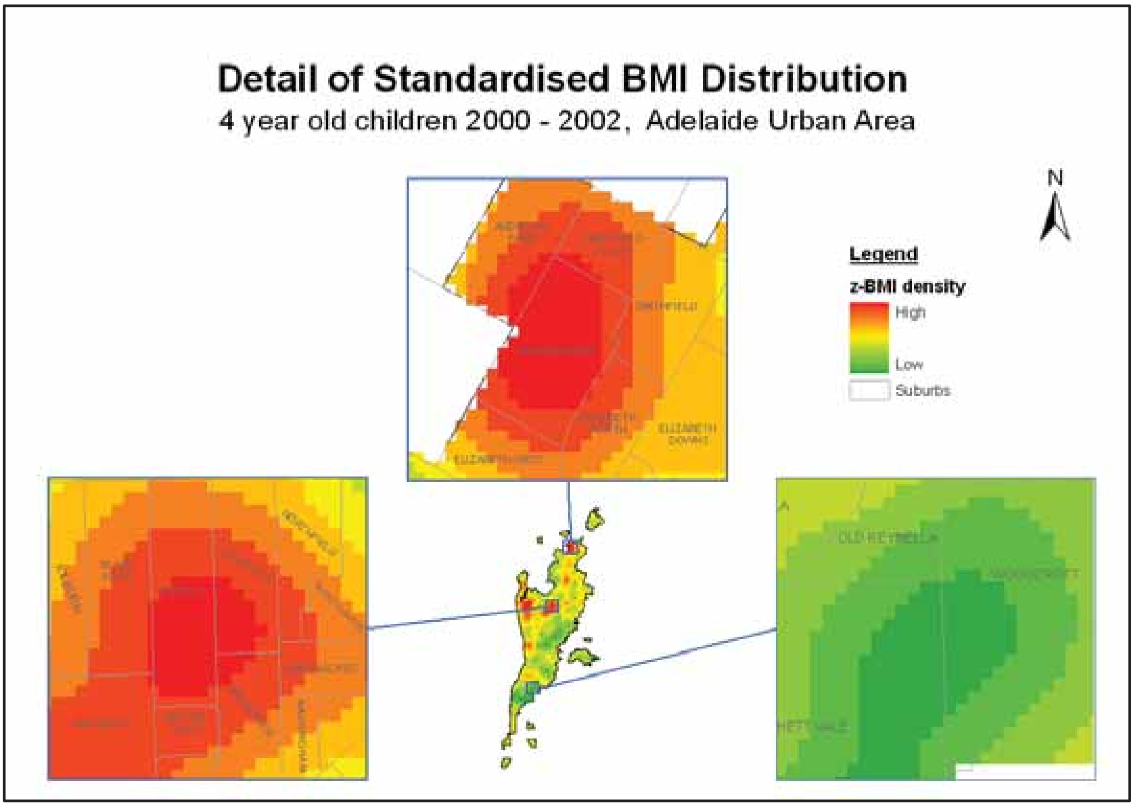
Standardised BMI scores can also be used to create a density surface which identifies areas where children's BMI tends to be either in excess of, or less than, the mean for this population. Although this does not specifically identify areas of high and low obesity prevalence, it is a useful guide to the distribution of lighter and heavier children throughout the study region. Kernel density techniques as described above were again used to create these surfaces, but with the standardised BMI score (z-BMI) used as a weighting factor for each child. The use of standardised BMI scores allows both males and females to be considered together. The resulting surfaces (Figure 7.7, with detail shown in Figure 7.8) identify further areas of interest where z-BMI scores are appreciably above or below the norm.

Figure 7.7 Distribution of z-BMI scores, urban Adelaide, 2000 - 2002



Source: CYWHS data 2000-2002

Figure 7.8 Areas of high and low z-BMI concentration, urban Adelaide, 2000 - 2002



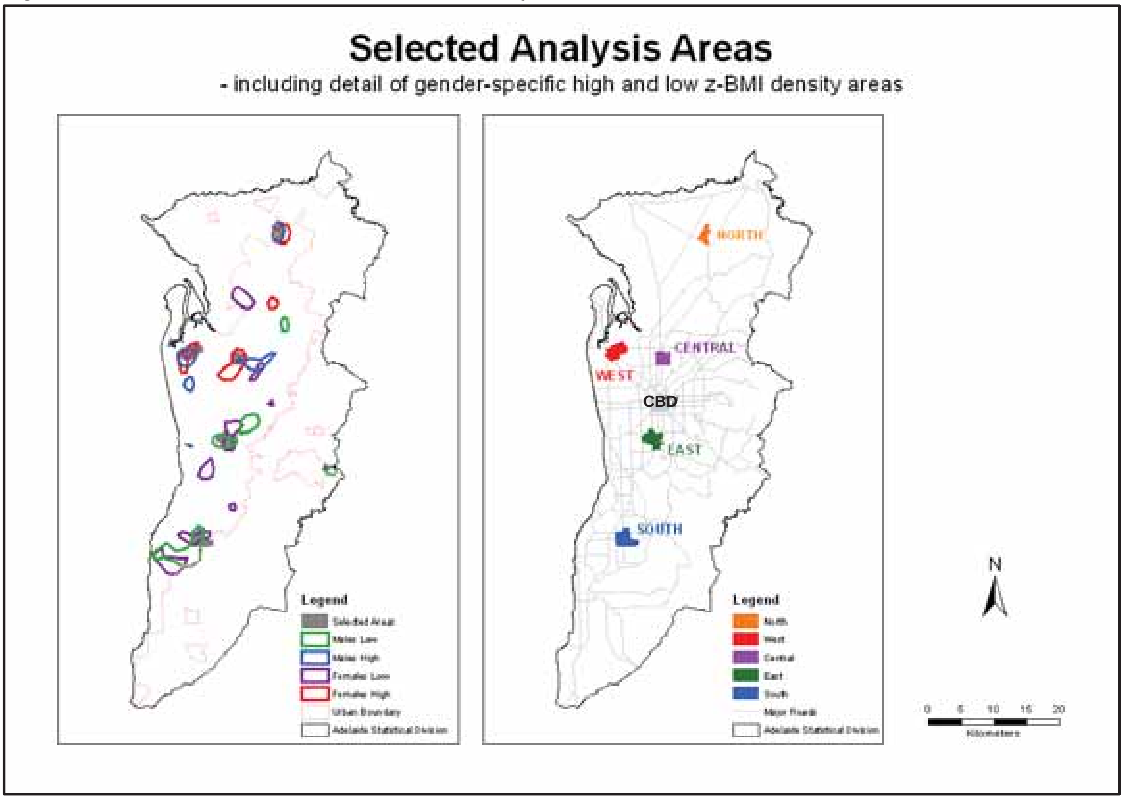
Source: CYWHS data 2000-2002

7.2.2 Areas for further study

Using both the obesity density surface and the surface of standardised BMI distribution, five discrete areas have been identified for further investigation. The first two areas are centred around the highest and lowest obesity prevalence areas as illustrated in Figure 7.6. Three further areas have been selected using the highest and lowest z-BMI density as illustrated in Figure 7.8 as a guide. In selecting these three areas, consideration was given to whether the values were high or low for both genders – i.e. overlap in gender-specific hot spots - and whether a core area encompassing more than 100 – and preferably more than 200 – children could be identified. These three areas are also discrete from the two areas already selected using the highest and lowest obesity prevalence surfaces.

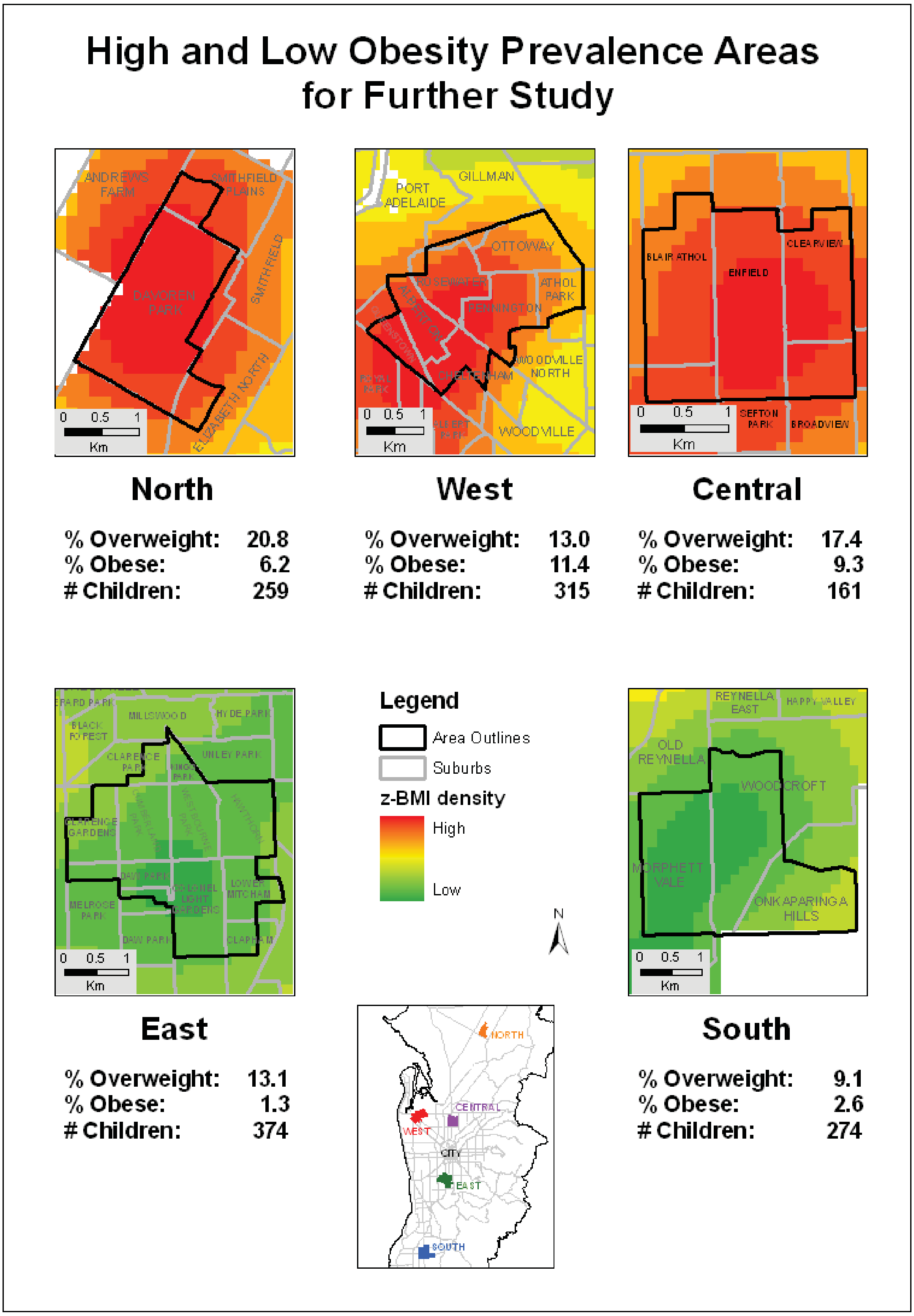
While it would be ideal to delineate the specific areas based solely on the density surfaces, the reality is that the census data against which the obesity prevalence will be compared is available in administrative units, the smallest of which is the Census Collection District. Therefore, contiguous CD groupings which approximate the five areas of interest have been selected as illustrated in Figure 7.9, and the children which fall within those boundaries have been identified as the study population for each area. For all areas, the inclusion and exclusion of CDs at the edges of the area was guided by the amount of the CD included in the central area (darkest colour) of the hot/cold spot; the distribution of children within the CD and, in a final check, the effect of the inclusion of the children in that CD on the obesity prevalence. All other things being equal, if the inclusion of the CD population decreased the obesity prevalence in a 'high' area (or vice versa) then that CD was excluded. These areas are presented in detail in Figure 7.10.

Figure 7.9 Location of small areas for further analysis, urban Adelaide



Source: CYWHS data 2000-2002

Figure 7.10 Detail of small areas for further analysis, urban Adelaide



Source: CYWHS data 2000-2002

The identification and delineation of these areas requires acknowledgement of the modifiable areal unit problem as discussed in Section 3.3.2. Any change in the number of CDs included in a given study area will alter the overweight/obesity prevalence observed in that area. In this instance, the researcher has made every effort to identify meaningful study areas and has been guided by the data in the delineation of final boundaries. This is the best possible outcome given the insolubility of the modifiable areal unit problem.

The inconsistent relationship between overweight prevalence and obesity prevalence among the four locations is worth further discussion. While the Western area has the highest prevalence of obesity[9] at 11.4%, which is more than double the overall prevalence for the urban area and almost nine times greater than that in the Eastern area, the overweight prevalence in this area is almost identical to that for the total population and to the high-SES, very low-obesity East. The Central area has both high obesity and high overweight, while the North has the highest overweight prevalence (20.8%) but at 6.2% the obesity prevalence is not greatly above the 4.9% of the total population. In contrast, the South has a lower prevalence of both overweight and obesity and is the only area to be markedly below the 13.3% total population prevalence for overweight. These figures support the hypothesis made in Section 5.1.6 that overweight and obesity may be manifesting as two separate conditions, and validate the decision made to concentrate further analysis for this study on obesity only.

It is clear from these figures that the issue of overweight and obesity is far more complex than a simple analysis of population can reveal. As data about the individual

[9] The true prevalence of obesity in this area is probably even higher, given the high proportion of children with an Asian language background (see Table 7-1).

children in these small study areas are limited to that presented in Table 7-1, (where birth weight and breast feeding status statistics are not shown due to the low numbers of children in the small areas for which these variables were actually recorded), the researcher must turn to area-level variables in an attempt to identify the elements of the physical and social environment which may explain the differences in obesity prevalence between the five areas.

Table 7-1 Statistics derived from the CYWHS data set, urban and selected sub-areas, 2000 – 2002

	All	West	Central	North	South	East
% Overweight	13.3	13.0	17.4	20.8	9.1	13.1
% Obese	4.9	11.4	9.3	6.2	2.6	1.3
Mean z-BMI	0.001	0.256	0.269	0.232	-0.161	-0.148
Indigenous %	1.1	2.6	3.2	2.0	0.7	0.3
Asian Lang. %	3.5	24.4	12.6	1.6	0.7	1.1
European Lang. %	1.7	5.8	1.3	0.8	3.0	0.8
Other Lang. %	0.8	1.0	1.9	0.0	1.1	1.3

Source: CYWHS data 2000-2002

7.3 Statistics for small areas

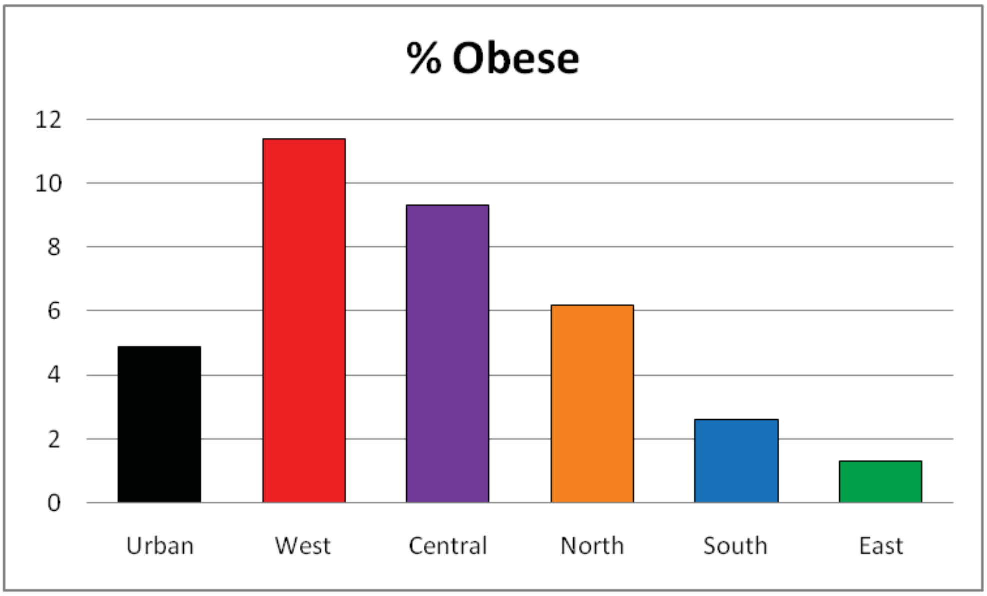
As the five focus areas have been defined using ABS CD boundaries, it is possible to compare area-level census statistics with the prevalence of obesity in each population. There is a danger involved in relating area values back to individuals, (see discussion of the ecological fallacy – p69), and it should be stressed that this is an exploratory look at the obesity prevalence of each study population in relation to the census statistics and does not purport to identify risk factors for individuals beyond the observation that areas with identified socio-demographic characteristics may contain a child population at particular risk for obesity.

To obtain these statistics, each CD grouping has been defined as a unit of geography and the census data for each variable of interest linked to that geography by CD code.

The percentage values for each area have then been calculated from the sum of the CD statistics. It should be noted that while these areas are quite small, even they may not be totally homogenous and the percentage value for the whole area may potentially be skewed if there is clustering of population characteristics in particular CDs.

Figure 7.11 provides a graphic illustration of the obesity prevalence in the five areas plus the urban area as a whole. It can easily be used for reference throughout the following discussion, as the same colour scheme and arrangement is used consistently throughout this chapter to represent the areas.

Figure 7.11 Obesity prevalence by urban and selected sub-areas, 2000 - 2002



Source: CYWHS data 2000-2002

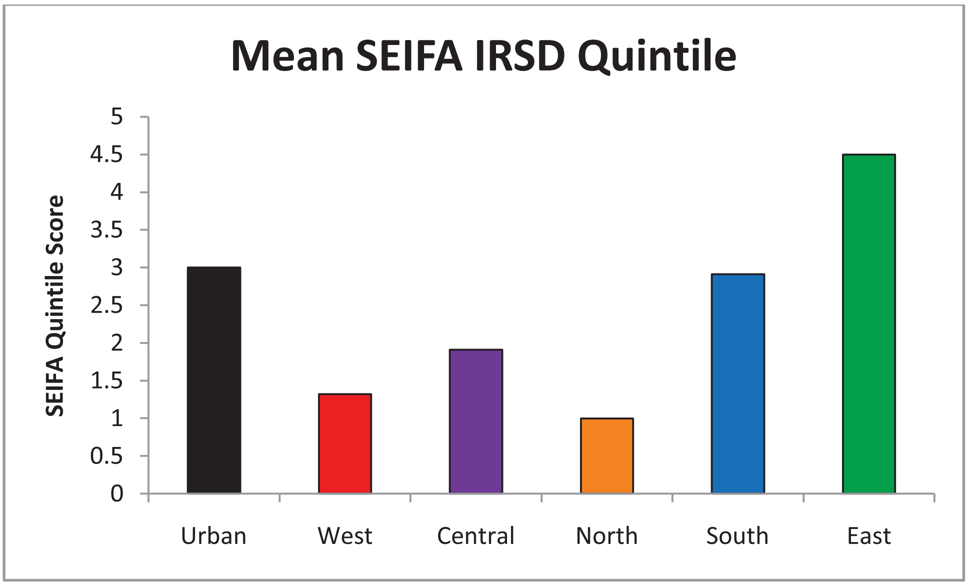
7.3.1 Census Variables

The area level variables derived from the census data for each area – aggregated from the individual CDs which comprise those areas – provide a snapshot of social and economic dynamics within each area. While actual statistics are given, the descriptive analysis which follows in sections 7.3.1.1 through 7.3.1.9 emphasises comparisons between the areas rather than absolute numbers. For all variables, the statistic for the entire study area is also provided as an indicator of the average values against which the small area statistics should be compared. It should also be remembered throughout this discussion that the census statistics are collected from the entire relevant population of each CD. This is generally the adult population and includes all people – not just those who are raising young children.

7.3.1.1 SEIFA

As an aggregate measure of disadvantage, the SEIFA Index of Relative Socio-economic Disadvantage provides a good overview of general disadvantage levels in the five areas. Figure 7.12 shows that disadvantage is greatest in the north and west (SEIFA quintile score close to 1) and lowest in the east (SEIFA quintile score close to 5). If there was a simple relationship between obesity prevalence and disadvantage, we would expect to see a graph which is the inverse of Figure 7.11, however this is clearly not the case. It appears that the link between obesity in four year olds and area-level disadvantage is not clear cut, at least for the selected study areas, and it is therefore desirable to investigate some of the discrete aspects of disadvantage to try and explain this discrepancy.

Figure 7.12 Average SEIFA disadvantage quintile, urban Adelaide and selected sub-areas, 2001

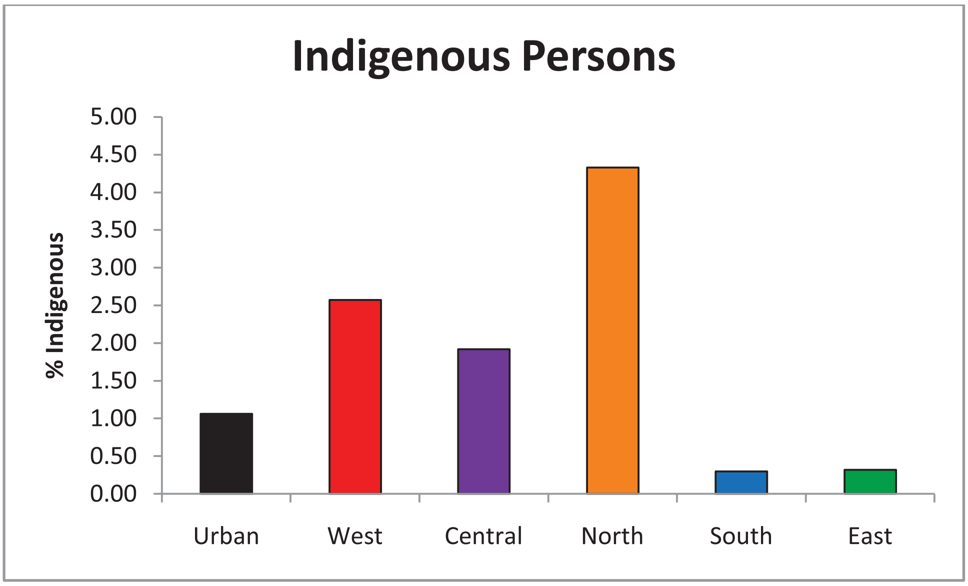


Source: ABS census 2001 and CYWHS data 2000-2002

7.3.1.2 Indigenous Persons

The percentage of Indigenous people (Figure 7.13) and the prevalence of obesity (Figure 7.11) in the five areas would appear to be a close reflection of each other if it were not for the Northern area, which has a markedly higher proportion of the population identified as indigenous but only a moderate level of obesity. This finding in the North runs contrary to the statistically significant relationship between indigenous population and obesity prevalence found in Chapter 6 (section 6.3.1.1) and suggests that either the proportion of indigenous persons in an area is not a direct contributor to obesity prevalence in young children, or that in the Northern area some other factor is modifying the effect of the large indigenous population.

Figure 7.13 Proportion of population indigenous, urban Adelaide and selected sub-areas, 2001



Source: ABS census 2001 and CYWHS data 2000-2002

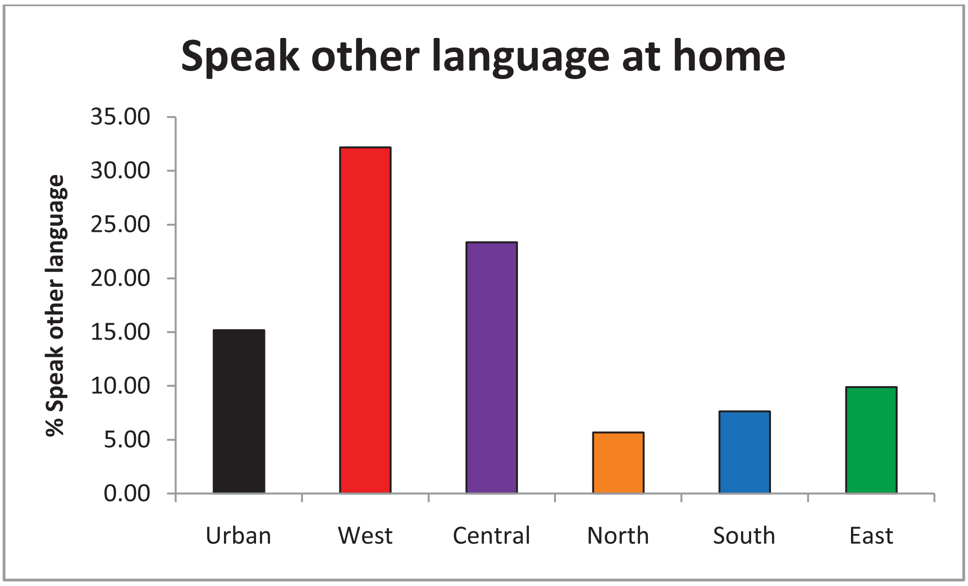
Essentially, though, the areas with an Indigenous percentage higher than the urban average do have higher obesity prevalence, while the South and East, with smaller indigenous populations, have much less obesity. Given the lack of relationship between obesity and indigenous status at the individual level (section 5.1.2) it does seem likely that this is not a direct association but rather that the presence of higher numbers of indigenous persons is an indicator of some form of area level disadvantage which contributes to the risk of obesity in young children. In the Northern area, this may be reflected more in the very high percentage of overweight children (20.8%) rather than in the obesity statistic.

7.3.1.3 Ethnicity

The percentage of people in the community who speak another language (Figure 7.14) is also reflected in the obesity prevalence of the areas, with the prevalence of obesity in the West and Central areas decreasing in line with a decrease in the proportion of other language speakers. However the proportion of other language speakers in the North is very low and, although still low, is slightly higher in the South and West where obesity prevalence *decreases*. From these observations, it seems possible that a large ethnic population may be an overarching risk factor for child obesity at the population level, however this could either be ameliorated by advantage – as in the South and East – so that obesity prevalence is lower than expected; or negated by disadvantage – as in the North – where obesity prevalence is raised despite a very low percentage of other language speakers.

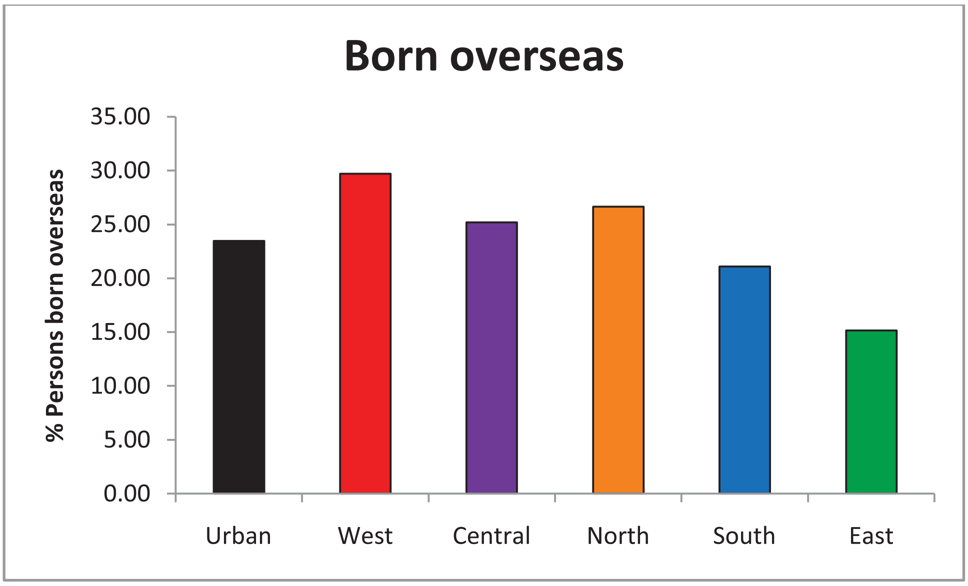
The relationship with ethnicity is much more stable when the percentage of persons born overseas or persons with two parents born overseas is used as the variable of comparison (Figure 7.15 and Figure 7.16). These graphs indicate decreasing obesity prevalence in the child population as the percentage of overseas born decreases. In general, the areas above the urban average for persons born overseas have obesity prevalence above the average, while those below have lower obesity prevalence.

Figure 7.14 Proportion of population who speak another language, urban Adelaide and selected sub-areas, 2001



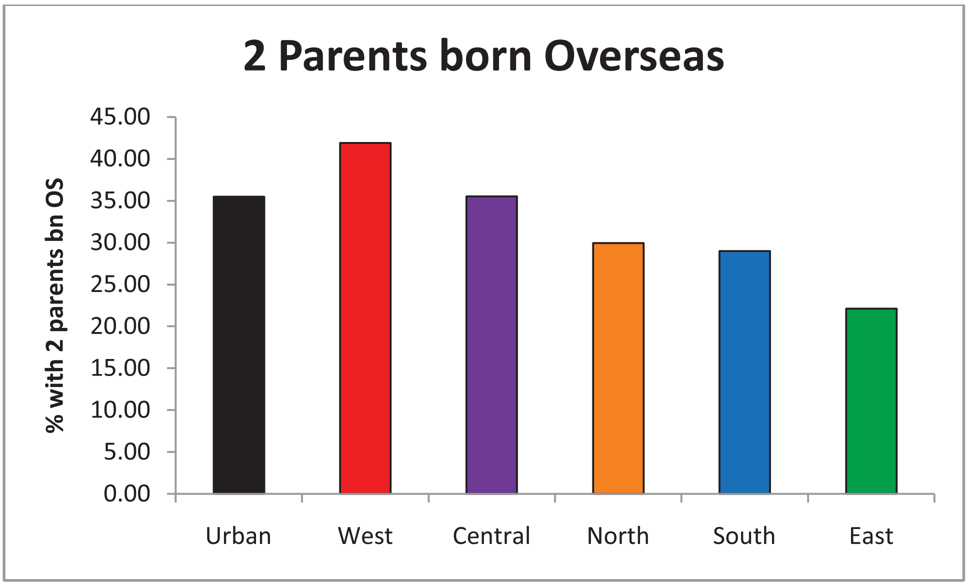
Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.15 Proportion of the population born overseas,



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.16 Proportion of the population with 2 parents born overseas

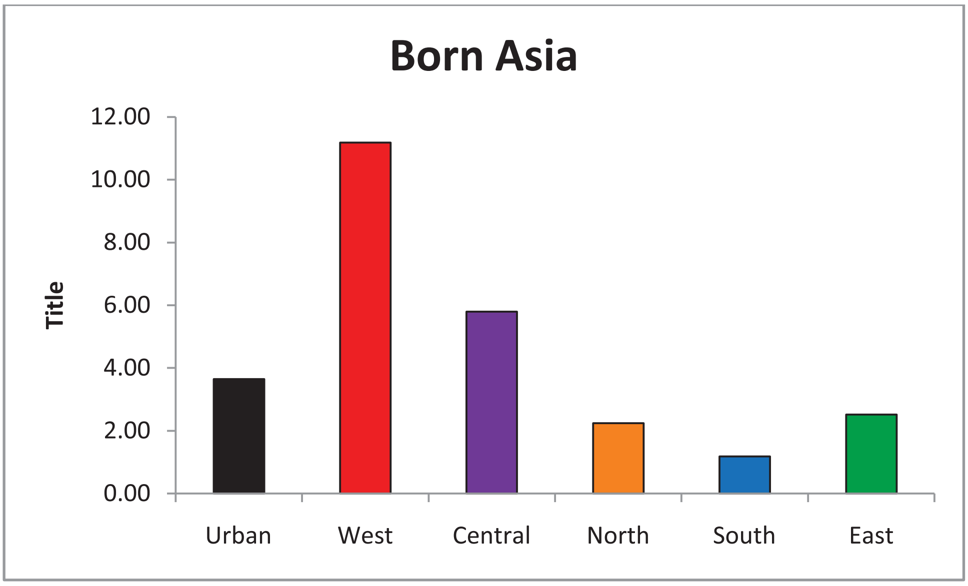


Source: ABS census 2001 and CYWHS data 2000-2002

The pattern of the percentage Asian born in the five areas (Figure 7.17) is almost identical to that for speaking another language at home (see Figure 7.14). This raises the possibility that many of those who speak another language at home are Asian born; which is a plausible explanation, as this is a relatively recent migrant population who could be expected to still use the language of origin. In terms of obesity prevalence, these figures suggest that children living in communities with a high Asian population are at much greater risk of obesity *if the community is disadvantaged in other ways* (e.g. West and Central), however moderate numbers of Asian born in the more advantaged East are not reflected in the obesity prevalence.

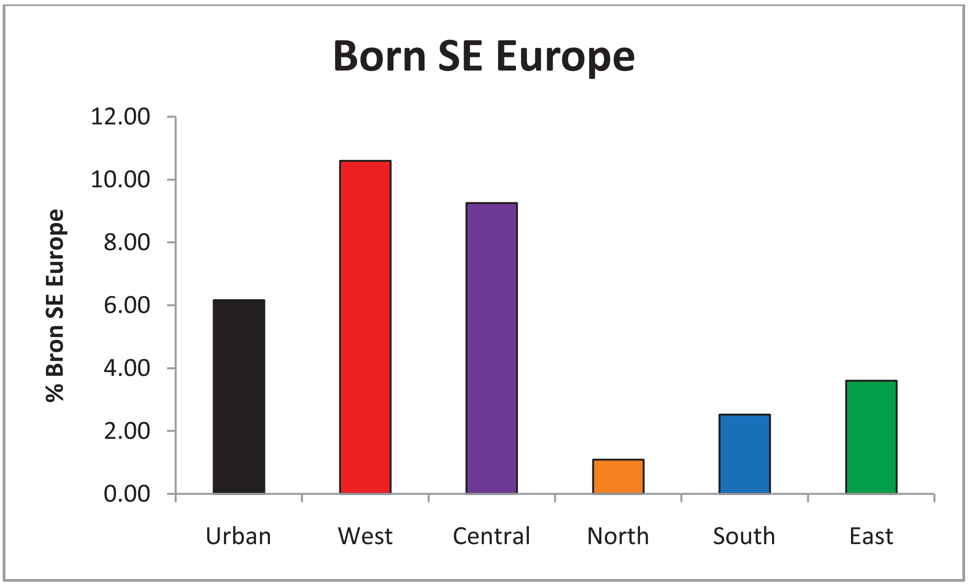
There is also a high percentage of South East European-born in both the Western and Central areas (Figure 7.18), which also have the highest prevalence of obesity. Taken together, these two results support the results of the analysis seen in Figure 6.6 and Figure 6.7, where children living in the higher quintiles for both South East European and South East Asian born persons are more likely to be obese.

Figure 7.17 Proportion of the population born in Asia,



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.18 Proportion of the population born in South-East Europe,

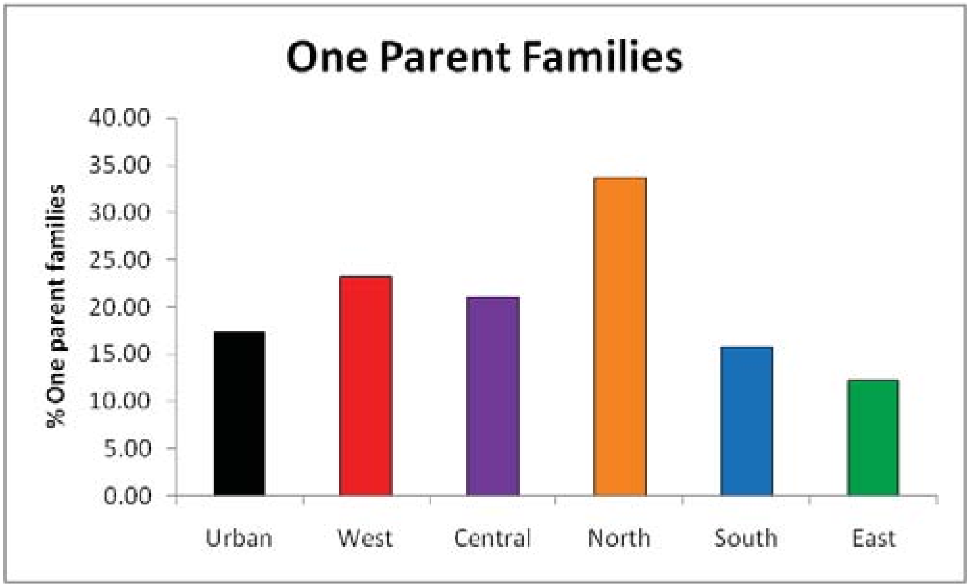


Source: ABS census 2001 and CYWHS data 2000-2002

7.3.1.4 Family Structure

The percentage of one parent families in the five areas (Figure 7.19) is positively related to obesity prevalence, except that the North has a very high percentage of one parent families but only moderate obesity. It seems that in general an environment with a high proportion of single parent families contains children more at risk for obesity – but that this can be moderated by other factors as appears to be happening in the North. Once again it is worth noting that the North does, however, have over 20% overweight prevalence, and the expression of the relationship between the census variables and weight status may once again be found in this statistic rather than obesity.

Figure 7.19 Proportion of families which have single parents,

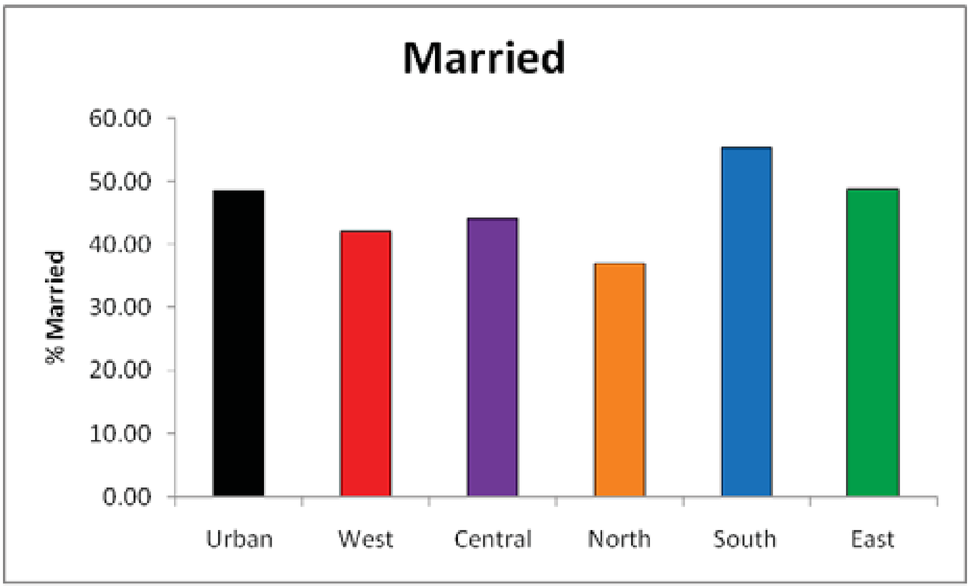


Source: ABS census 2001 and CYWHS data 2000-2002

The percentage of the population who are married (Figure 7.20) does not appear to have a strong association with the obesity prevalence in the five areas – but this may be a data issue in that all adults, not just those who may be parenting young children, are counted in the census statistics, including retirees and young professional couples.

There is some indication that the areas with a higher proportion of married people have a lower prevalence of obesity (Figure 7.20) but the pattern is not definitive.

Figure 7.20 Proportion of the population married,

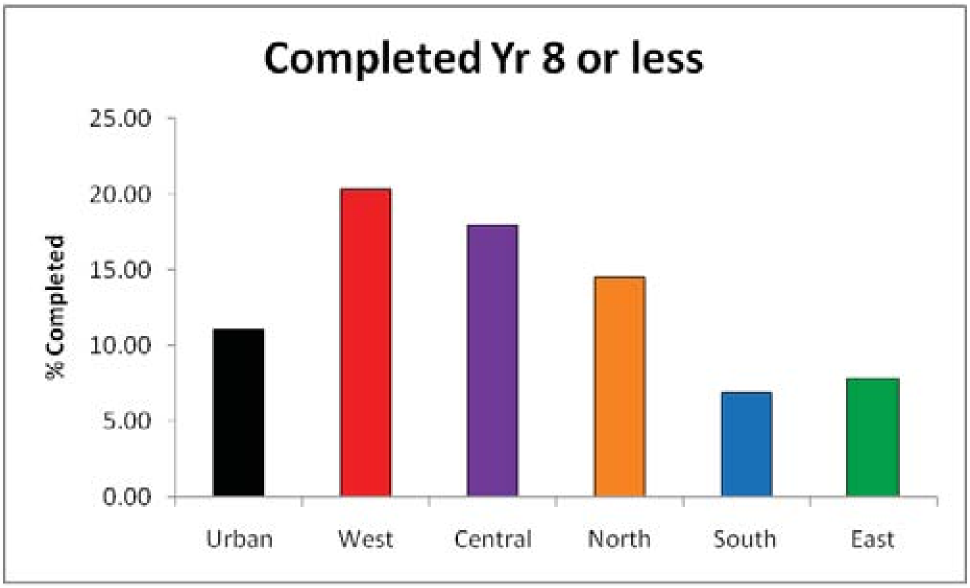


Source: ABS census 2001 and CYWHS data 2000-2002

7.3.1.5 Education and Qualifications

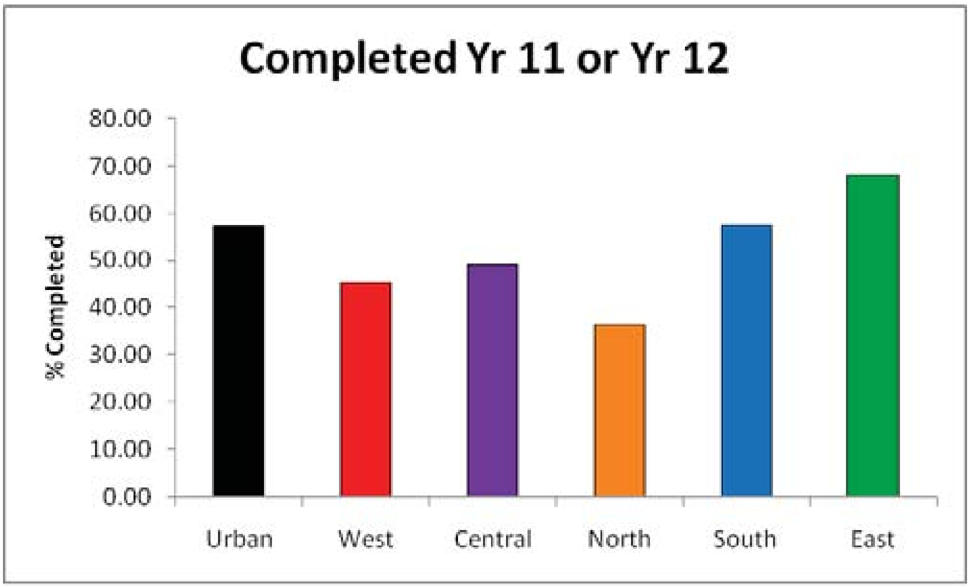
As in the area level analysis (Section 6.3.1.3), the percentage of people with a very low education level (Figure 7.21) in each area is positively reflected in the obesity prevalence, and this appears to have the strongest association out of all the education/qualification variables. The Southern area shows an unexpectedly low percentage of people with a bachelor's degree (Figure 7.23) – even lower than the West – considering the low obesity prevalence in this area and the individual-level relationship between obesity and bachelor's qualifications identified in Chapter 6 (see Figure 6.14). It is possible that some of this variance in the South is compensated for by the percentage of people with trade and other qualifications (see Figure 7.24), however this statistic is still well below that of the Eastern area. It is also below the average for the urban area and is very similar to the high-obesity West. These results suggest that high school education may be more important than other qualifications in terms of building a social environment that reduces the risk of obesity in young children, and/or that other factors in the South are ameliorating the influence of a population with relatively low levels of post-school qualifications.

Figure 7.21 Proportion of the population who completed Year 8 or less,



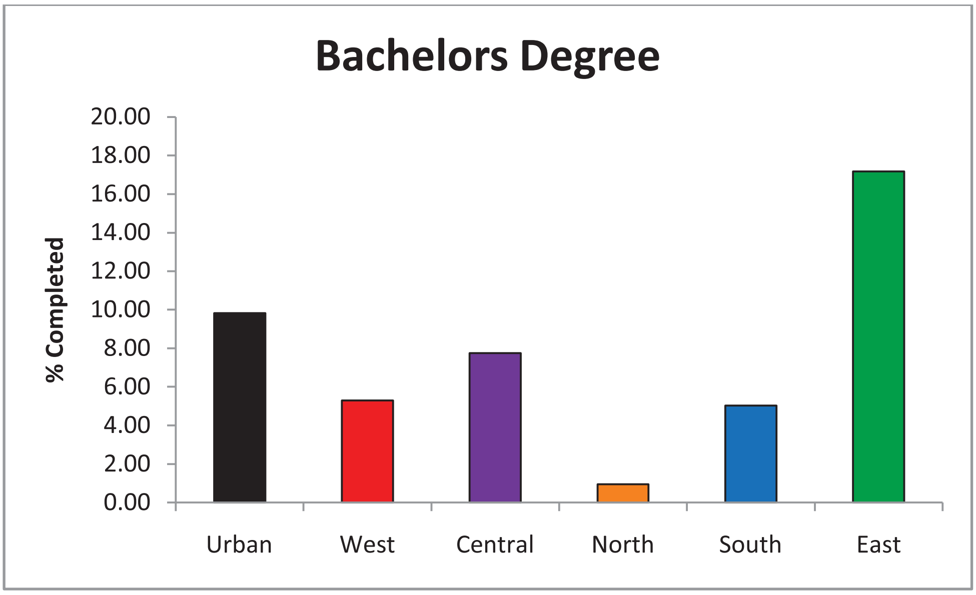
Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.22 Proportion of the population who completed year 11 or year 12,



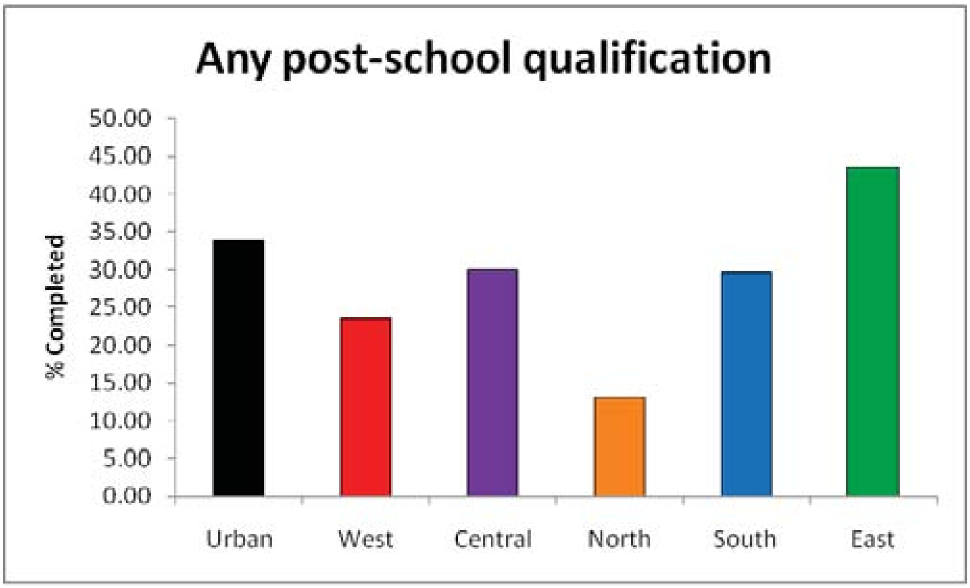
Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.23 Proportion of the population completed a Bachelor degree,



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.24 Proportion of the population with any post-school qualification,

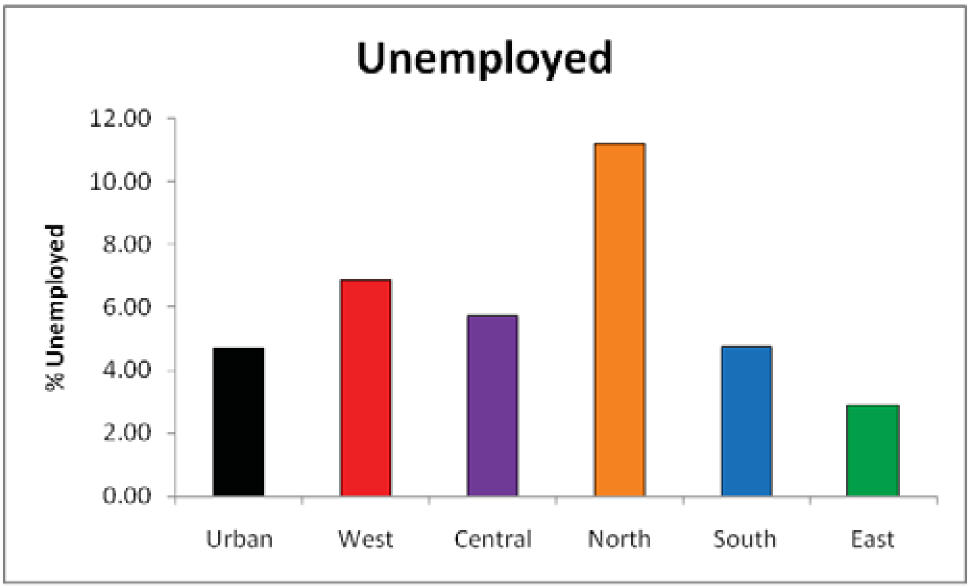


Source: ABS census 2001 and CYWHS data 2000-2002

7.3.1.6 Employment

Unemployment is another factor which is particularly high in the North (Figure 7.25); otherwise there is a clear parallel between the percentage unemployed and the obesity prevalence in the four remaining areas. The percentage of persons not in the labour force (NILF) is similarly highest in the North (Figure 7.26), otherwise the observation that those areas above the urban average have a higher prevalence of obesity and those areas below, a lower prevalence, is the key observation from this variable. There was no further information gained by examining female employment categories in the five areas as opposed to all persons (data not shown).

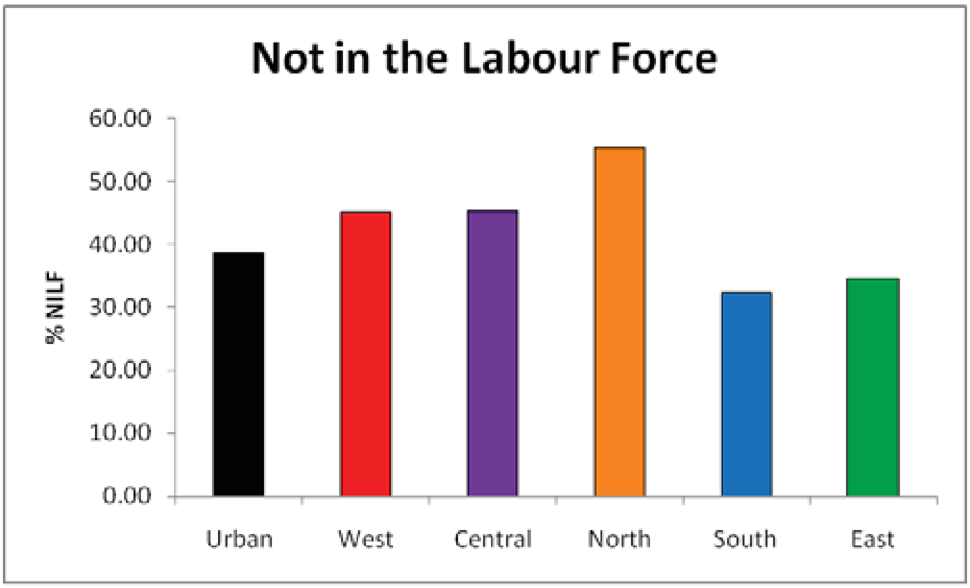
Figure 7.25 Proportion of the population unemployed,



Source: ABS census 2001 and CYWHS data 2000-2000

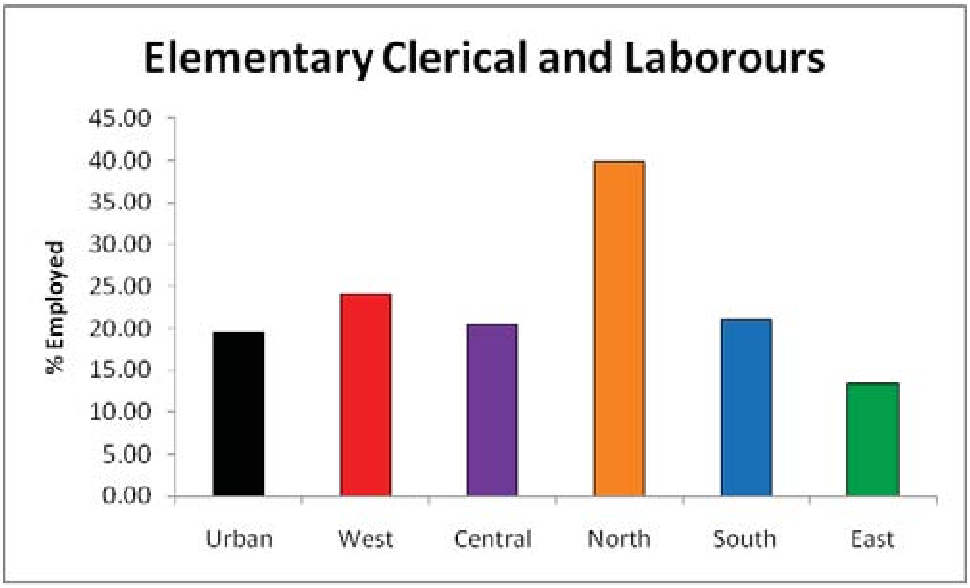
Occupation rank (Figure 7.27 and Figure 7.28) again points to the north as a very disadvantaged area with a high percentage of people employed in low status occupations and a correspondingly low percentage of people in high status jobs. The south is also something of an anomaly in that the percentage of people in low status occupations is actually quite high – especially considering the low obesity prevalence. For both the high status and low status occupations, the south is actually slightly more disadvantaged than the west – a disadvantage which is not reflected in the obesity prevalence.

Figure 7.26 Proportion of the population not in the labour force,



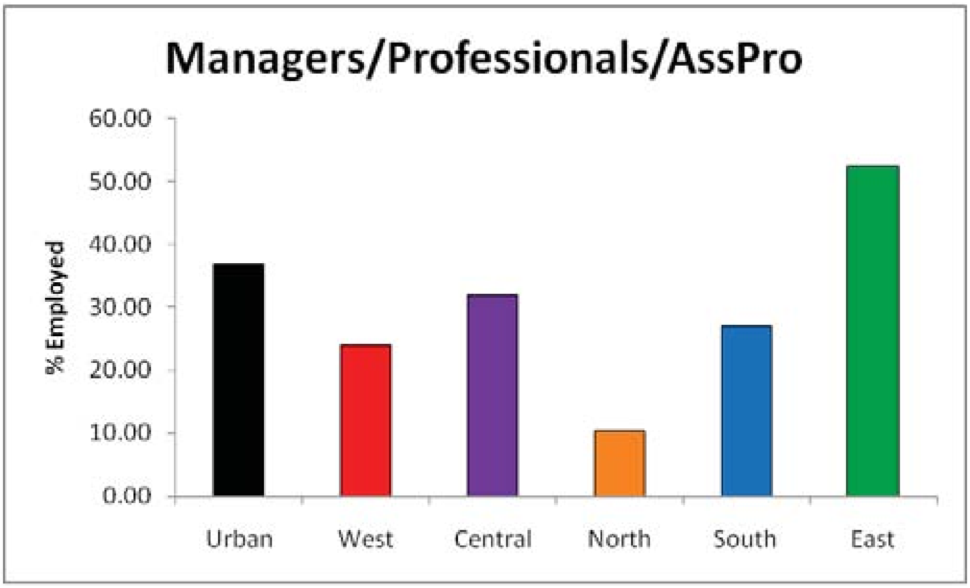
Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.27 Proportion of the population in low status employment,



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.28 Proportion of the population in high status employment,

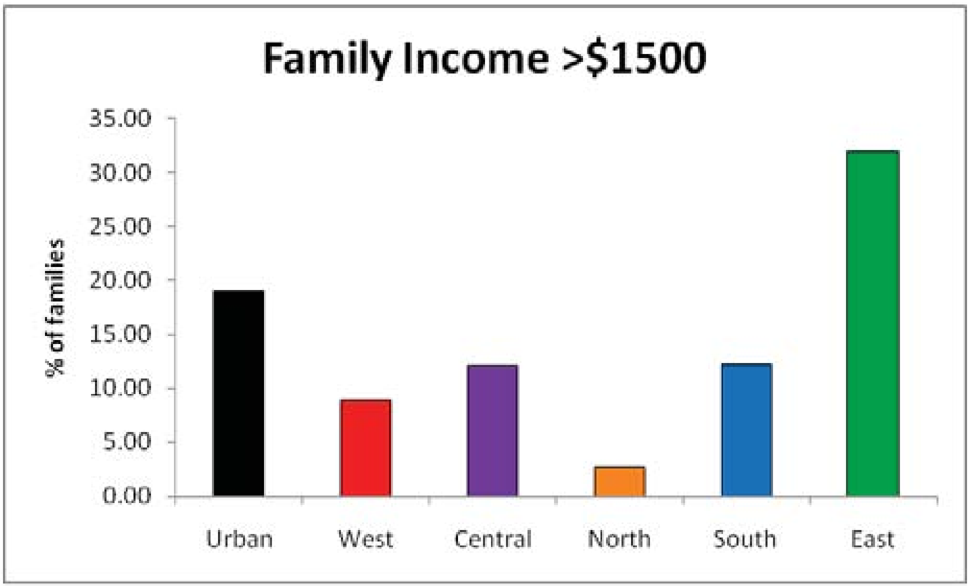


Source: ABS census 2001 and CYWHS data 2000-2002

7.3.1.7 Income

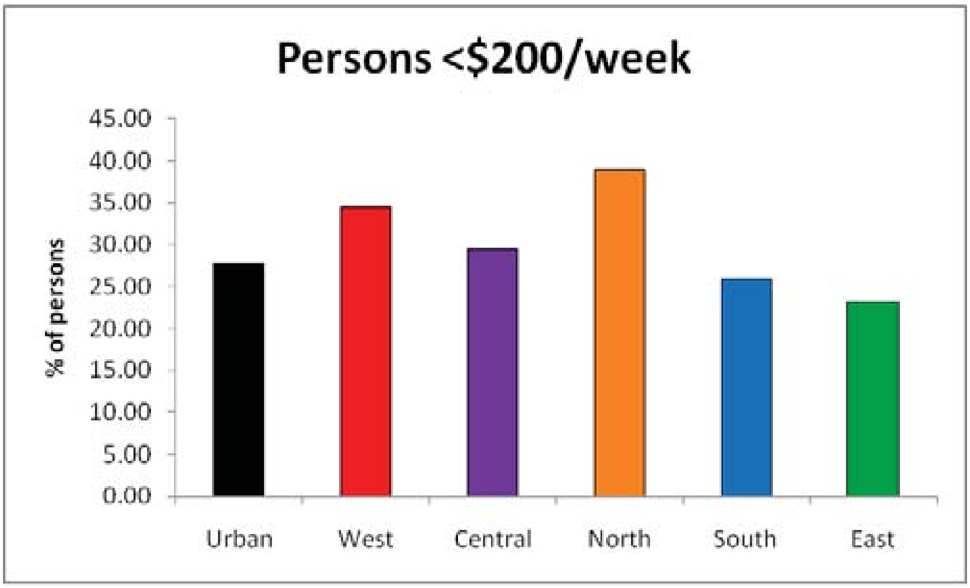
The North again exhibits the highest level of disadvantage in all of the income categories (Figure 7.29, Figure 7.30, Figure 7.31). However, if this area is removed from consideration there is a relatively straightforward relationship between obesity prevalence in the other four areas and the income statistics. There is one exception in the high family income category (Figure 7.29) where the South has a relatively low percentage of high income families which is actually similar to the West – a pattern which is, once again, not reflected in the obesity prevalence.

Figure 7.29 Proportion of families with income >$1500 per month,



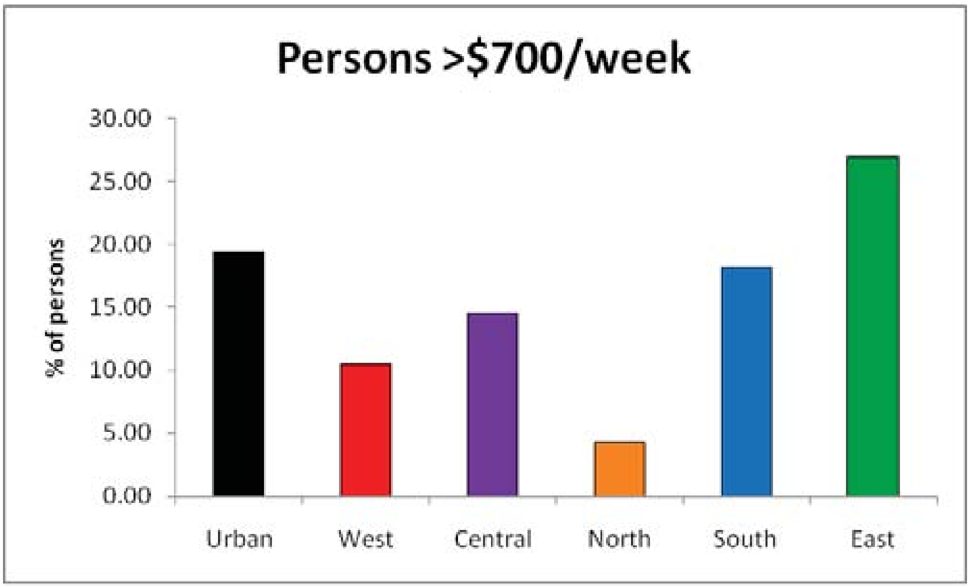
Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.30 Proportion of persons with income <$200 per week



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.31 Proportion of persons with income >$700 per week,



Source: ABS census 2001 and CYWHS data 2000-2002

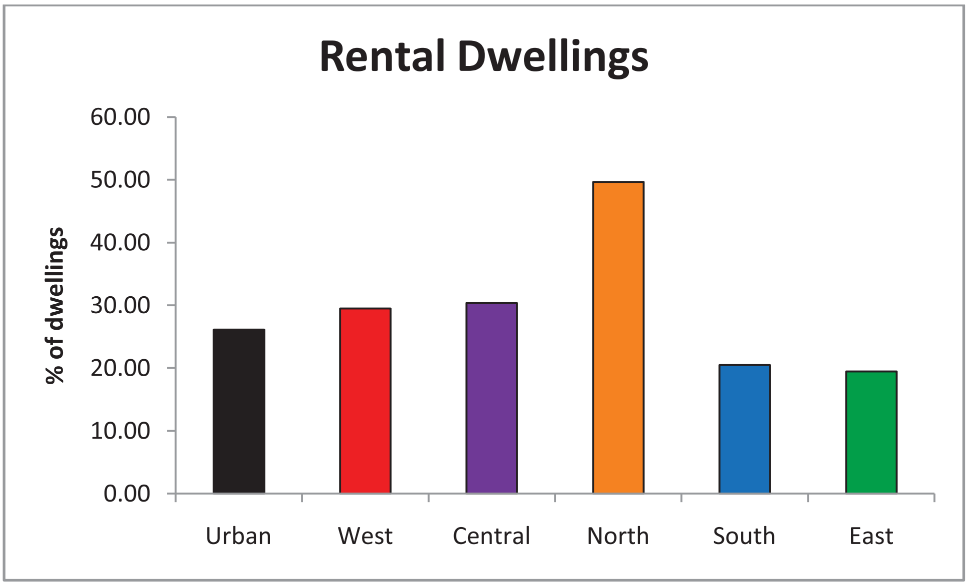
7.3.1.8 Housing and Tenure

The percentage of rental dwellings in each area (Figure 7.32) appears to be related to the obesity prevalence in that areas above the urban average have a higher obesity prevalence than those below. The North again stands out with a very high percentage of rental dwellings, and the other two 'high obesity' areas have a very similar percentage to each other, as do the two 'low obesity' areas. This pattern is almost identical to that seen for the NILF variable in the employment category (Figure 7.26) and suggests that similar complexities may underlie both sets of figures.

The statistics for the percentage of homes being purchased (Figure 7.33) in each area are quite intriguing, and although there does not appear to be any relationship with the obesity prevalence overall, the high incidence of home purchase in the South is a conspicuous statistic which may go some way towards explaining the other anomalies which have been noted in the South. Motivation and goals can have an influence on behaviour, such that working towards a goal such as home ownership may lead to improved self confidence and feelings of self worth and ultimately positive feelings about oneself and the future (Rohe, Van Zandt et al. 2001). This statistic potentially implies a community of young families working hard to achieve equity in their homes and lives, and implies a sense of purpose and a positive environment. If these inferences could be substantiated, it might provide a key indicator of the relationship between both community and individual attitudes and their relationship to health outcomes such as weight status.

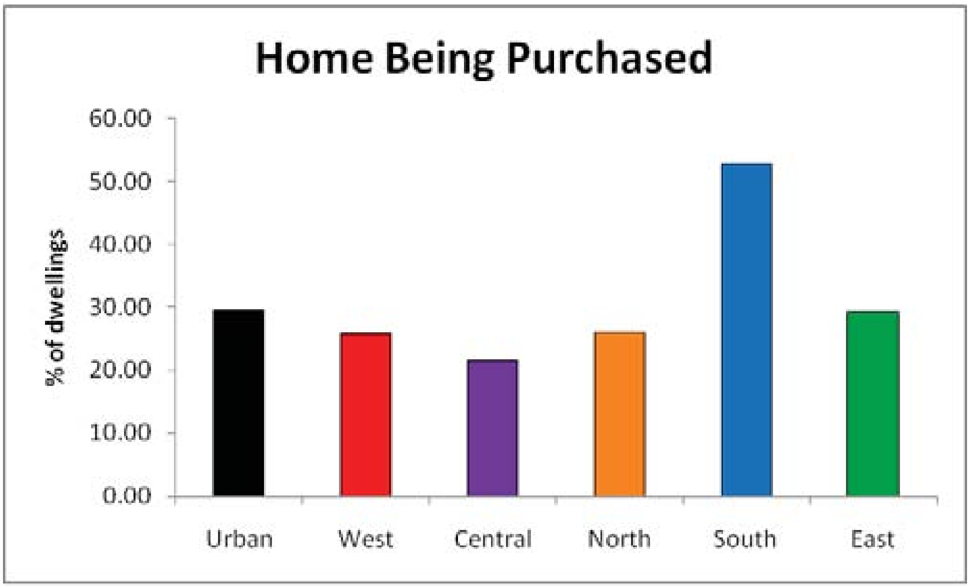
The home purchase rates in the other four areas are actually very similar, but it is likely that there are very different reasons underlying these statistics which relate differently to the obesity prevalence in each area. For example, the East most likely contains many dwellings which are already fully owned so the home purchase percentage is quite low, whereas the other areas have a high percentage of rental dwellings (i.e. households without the resources to purchase) so their home purchase percentage is similarly low but there are very different socio-economic drivers behind these similar statistics.

Figure 7.32 Proportion of homes being rented,



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.33 Proportion of Homes being purchased,

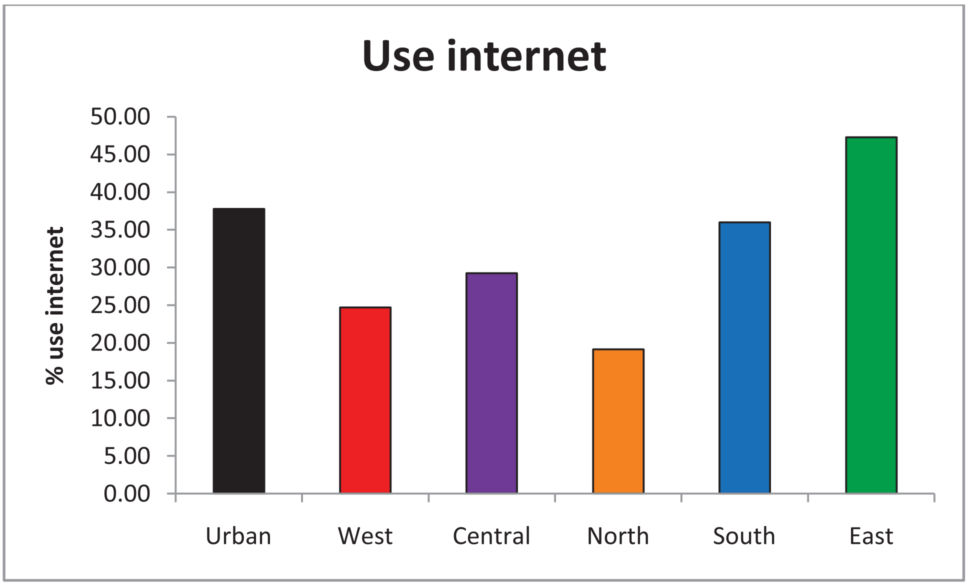


Source: ABS census 2001 and CYWHS data 2000-2002

7.3.1.9 Other

As in the individual level analysis, obesity prevalence increases in the areas as internet use decreases (Figure 7.34), although the north is again conspicuous by its level of disadvantage in this variable. The south is also slightly below the urban average for internet use, but still has a low prevalence of obesity.

Figure 7.34 Proportion of the population who use the internet,



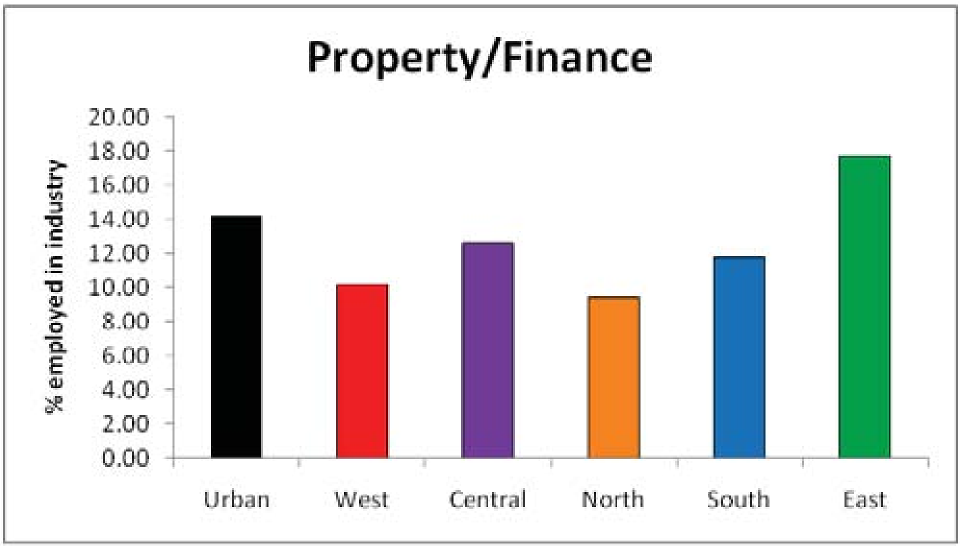
Source: ABS census 2001 and CYWHS data 2000-2002

Investigation of the industry of employment (Figure 7.35, Figure 7.36, Figure 7.37) did not reveal any recognisable patterns in relation to obesity prevalence, other than confirming the east and the north as respectively the most advantaged and disadvantaged areas in these categories.

Figure 7.35 Proportion of the population employed in low status industries

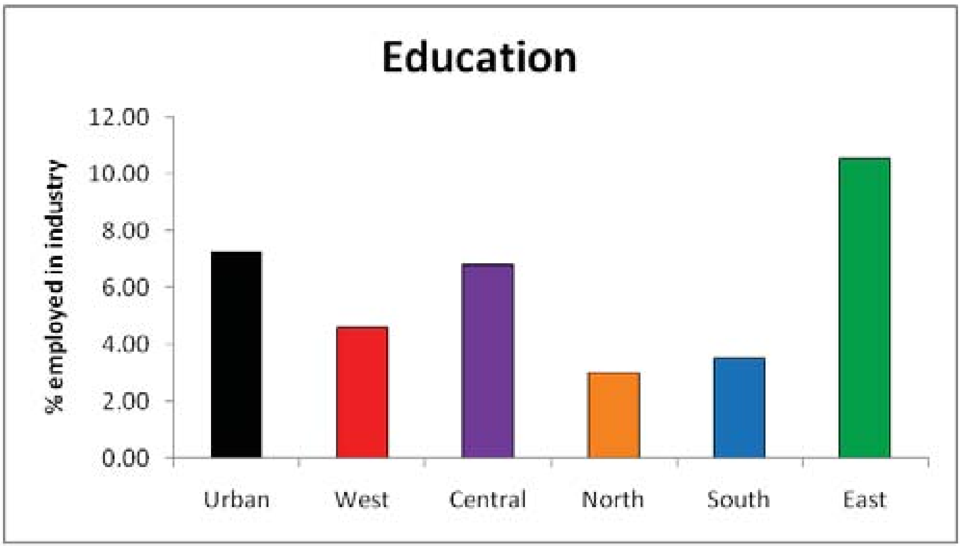
Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.36 Proportion of the population employed in high status industries,



Source: ABS census 2001 and CYWHS data 2000-2002

Figure 7.37 Proportion of the population employed in the education industry (indeterminate status),



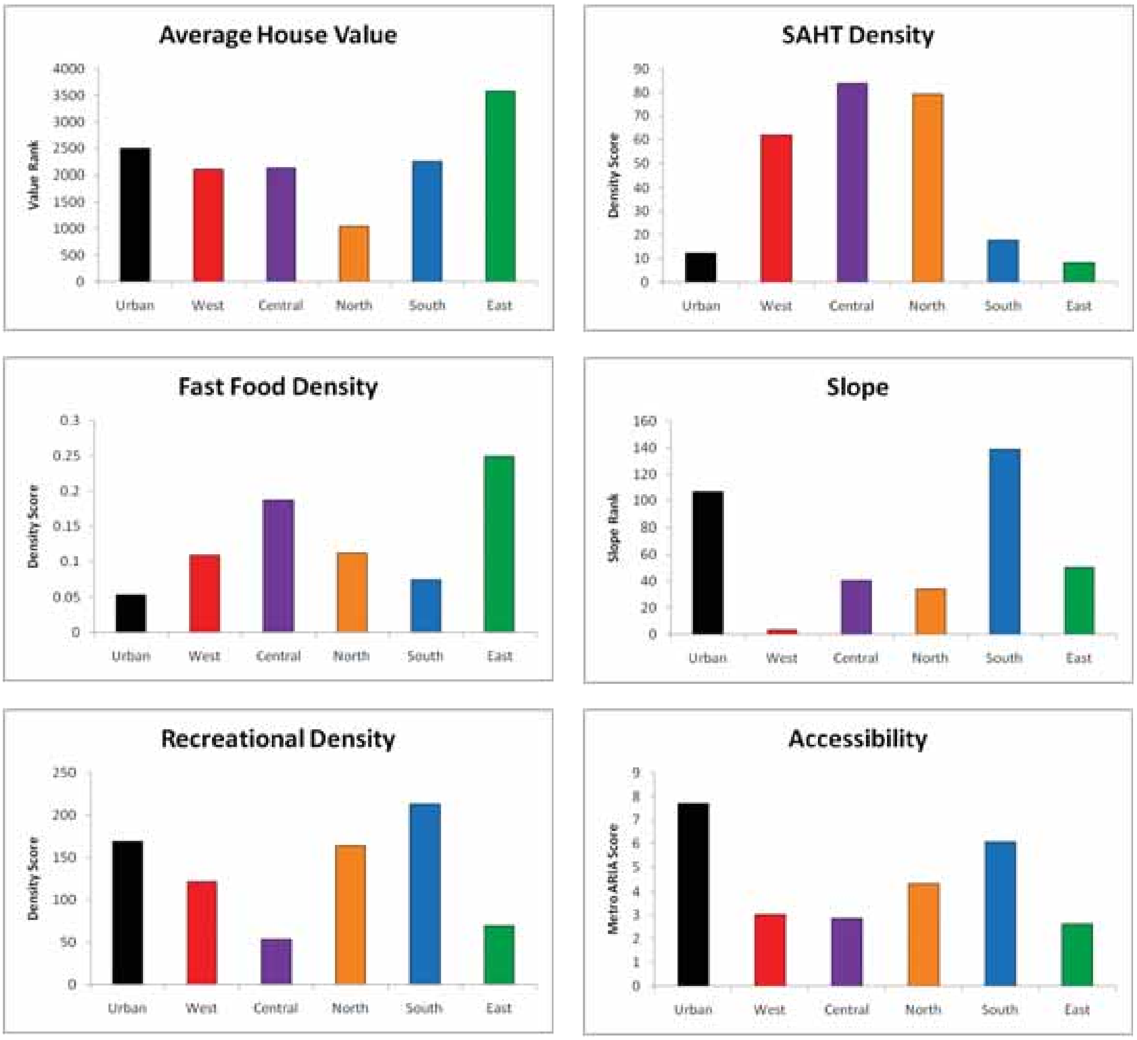
Source: ABS census 2001 and CYWHS data 2000-2002

7.4 Assigned Variables

The values derived from supplementary data sets and assigned to individual children, (as discussed in Section 5.2), can also be aggregated to the small area level to illustrate the similarities and differences between these communities. These comparisons are presented in Figure 7.38. The environmental aspects of the five communities as measured here do not greatly help to explain the obesity prevalence in these areas. In fact some of the results are counter-intuitive, with the low-obesity eastern area having easily the highest density of fast food restaurants[10]. However, the high density of public housing properties in the areas with the highest obesity prevalence is notable, as is the high slope and recreational density in the south. Once again the north tends to exhibit high levels of disadvantage in most (but not all) categories.

[10] This concentration is likely due to the eastern area including, by chance, a main road with fast food locations. It is a unique feature of this location compared to the other four areas.

Figure 7.38 Assigned variables (from Chapter 5)



Source: ABS census 2001 and CYWHS data 2000-2002

7.5 Discussion

The data presented in this section generally support the premise that area level disadvantage is related to a higher prevalence of obesity in this population of four year old children. However, it is clear that the relationship is not necessarily straightforward. Two things in particular stand out from this analysis. The first is the moderate obesity prevalence (6.2%) in the North despite this area having a high level of disadvantage in almost every category investigated. The second area of particular interest is the South, with a low prevalence of obesity despite many measures of disadvantage being similar to the high-obesity Western area.

The Northern area – centred on the suburb of Davoren Park – has the lowest SEIFA IRSD score, the highest percentage of single parent families, the lowest percentage of people with senior high school education and other qualifications, the highest unemployment rate, the highest percentage of people in low status occupations and the lowest percentage of high income earners. While it would be erroneous to state that the children in the CYWHS data set who live in this area experience all these forms of disadvantage at an individual level – i.e. in their own households – it is reasonable to assume that many children are directly affected by at least some of these aspects of disadvantage. It is also likely that the community as a whole is adversely affected by the high levels of individual and household disadvantage. Community resources and attitudes are likely to reflect the lack of opportunities and experiences inherent in this disadvantaged profile.

However, the prevalence of obesity in this area is not the highest – as would be expected if there was a straightforward relationship between obesity and disadvantage. While no concrete explanations for this are apparent from this data, the question must be asked: "Is it possible for a community to be *too* disadvantaged to support the energy imbalance which leads to obesity?"

This is a plausible explanation, as parallels can be seen in work on obesity in developing countries where the most disadvantaged section of the population (usually the rural poor) have lower rates of overweight than the more prosperous, often middle class, city dwellers (Wang, Youfa and Lobstein 2006). It is also interesting to note that as reported in Section 5.2.1.2 of this thesis, the children who live in closest proximity to

– i.e. potentially resident in – public housing properties were less likely to be obese than those who live a little further away; and a similar theory could be used to explain this disparity.

Conversely, the Southern area exhibits a lower prevalence of obesity – at 2.6%, most similar to the East – than might be expected, especially considering the SEIFA IRSD score for this area is actually below the urban average, indicating greater disadvantage. For a number of the variables, this area is also more similar to the high obesity West, (9.3% obesity prevalence), than it is to the East. However one variable in particular stands out and that is the very high proportion of dwellings being purchased. Together with the percentage of married people, this trend potentially offsets the disadvantage implied by the relatively high percentage of people employed in low status professions and less 'attractive' industries with the accordingly low percentage of high income families and persons with a university education. The predominance of intact families and persons engaged in purposeful employment indicates a level of self-efficacy which may compensate for other attributes of perceived disadvantage.

It is interesting that Baum *et al.* (2007) have found a similar anomaly while investigating social capital and health in urban Adelaide postcodes which are spatially and socio-economically similar in distribution to the small areas described in this chapter. Their study found that the southern postcode study area, despite having a lower socio-economic profile than the inner-northern postcode, either rated similar to or better than it for many of the measures investigated. They suggest that this area could be considered as a "relatively successful lower socio-economic environment" (p116); a concept which may well be relevant to the nearby area investigated in this current study.

7.6 Quantifying the area differences

In order to complement the descriptive work on the differences between these five communities, various methods for statistical assessment have been attempted. The aim was to determine statistically if the different area level census variables explored in the preceding section showed a differing contribution to the obesity prevalence in the five different small areas. This analysis has been complicated by the application of area level variables to individuals.

Clearly, obese children are unevenly distributed between the five areas. An index of dissimilarity calculation – commonly used in population studies to provide summary comparisons for a wide range of population statistics (Rowland 2003 p95) - confirms that approximately one third of the children would need to change their area of residence for the obesity prevalence to be equalised between the areas (
Table 7-2).

Table 7-2 Index of dissimilarity calculations for the distribution of obese children in five selected areas of Adelaide

Area	All Children	Obese Children	x	y	x-y	INDEX
West	315	36	0.455696	0.213957	0.241739	
Central	161	15	0.189873	0.111963	0.07791	
North	259	16	0.202532	0.18635	0.016182	
South	274	7	0.088608	0.204755	0.116147	
East	374	5	0.063291	0.282975	0.219684	
Total	1383	79	1	1	0.671663	**0.335831**

Source: CYWHS data 2000-2002

While the index of dissimilarity provides a useful summary of the extent of the uneven distribution of obese children within the five areas, this method cannot be used to determine the relationship of the area-level census statistics to that distribution. Linear regression methods are also unsuitable due to the structure of the data. Generalised Estimating Equations, which allow for the analysis of clustered or correlated data, was also attempted by analysing the individual children within each area according to the values for the actual CD within which they reside. However, the results were not robust and this is probably due to the low numbers of obese children in some of the CDs, especially in the East and South.

Binary logistic regression – once again using the census data values (in percentages) for each child's CD rather than their whole area – while not a perfect solution for the complexities of this particular data set, seems to offer the best interpretation of the census differences and their relationship to the presence of obesity among the children in the five areas. These results should still be interpreted with caution, but they do provide some indication as to the particular factors which seem to have an influence in the five areas.

Eleven census statistics were chosen based on the perceived relationships with obesity prevalence as discussed in Section 7.3, and these were individually input into a binary logistic regression model where obesity (yes or no) was the dependent variable and the area with the lowest obesity prevalence (East) was used as an indicator against which the prevalence of obesity in the other areas could be compared. The results are presented in Tables 7-3 to 7-14, where Table 7-3 indicates the odds of a child being obese in the other four areas compared to the East and the remaining tables show how this relationship changes when the individual census statistics are input to the model as covariates. While the confidence intervals are very large, this is likely due to the small numbers of children in some CDs and should not negate the strength of the overall results indicated by the Significance and Odds Ratios.

Table 7-3 Binary logistic regression – all areas compared to East

	Sig.	OR	95% C.I. Lower	95% C.I. Upper
East	0.000			
West	0.000	9.523	3.689	24.58
Central	0.000	7.582	2.707	21.24
North	0.002	4.859	1.757	13.437
South	0.264	1.935	0.608	6.162

Source: CYWHS data 2000-2002

Table 7-4 Binary logistic regression – influence of SEIFA IRSD score

	Sig.	OR	95% C.I. Lower	95% C.I. Upper
East	**0.000**			
West	0.000	10.189	3.078	33.723
Central	0.000	7.937	2.531	24.895
North	0.039	5.453	1.092	27.236
South	0.261	1.992	0.600	6.621
SEIFA IRSD	0.856	1.000	0.997	1.003

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-5 Binary logistic regression – influence of high personal income

	Sig.	OR	95% C.I. Lower	95% C.I. Upper
East	**0.000**			
West	0.009	6.378	1.592	25.553
Central	0.011	5.501	1.487	20.350
North	0.222	2.852	0.530	15.346
South	0.516	1.537	0.421	5.612
Income >$700/week	0.443	0.979	0.926	1.034

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-6 Binary logistic regression – influence of post-school qualifications

			95% C.I.	
	Sig.	OR	Lower	Upper
East	**0.000**			
West	0.019	5.348	1.320	21.665
Central	0.011	5.063	1.446	17.729
North	0.434	2.070	0.335	12.802
South	0.688	1.317	0.344	5.050
Any Qualification	0.275	0.973	0.928	1.022

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-7 Binary logistic regression – influence of very low education levels

			95% C.I.	
	Sig.	OR	Lower	Upper
East	**0.002**			
West	0.000	10.591	3.252	34.496
Central	0.001	8.307	2.516	27.429
North	0.003	5.166	1.727	15.447
South	0.268	1.924	0.604	6.132
Completed Year 8 or less	0.768	0.992	0.940	1.047

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-8 Binary logistic regression – influence of internet use

			95% C.I.	
	Sig.	OR	Lower	Upper
East	**0.000**			
West	0.001	13.473	2.995	60.605
Central	0.001	10.107	2.454	41.633
North	0.027	7.519	1.258	44.955
South	0.209	2.318	0.624	8.612
Use Internet	0.558	1.015	0.966	1.066

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-9 Binary logistic regression – influence of unemployment rate

			95% C.I.	
	Sig.	OR	Lower	Upper
East	**0.000**			
West	0.000	9.221	3.158	26.922
Central	0.000	7.418	2.507	21.947
North	0.045	4.535	1.036	19.856
South	0.284	1.907	0.585	6.209
Unemployed	0.899	1.008	0.889	1.143

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-10 Binary logistic regression – influence of single parent families

			95% C.I.	
	Sig.	OR	Lower	Upper
East	**0.000**			
West	0.000	9.190	3.267	25.850
Central	0.000	7.369	2.497	21.744
North	0.220	4.535	1.240	16.581
South	0.276	1.912	0.595	6.140
One Parent Families	0.866	1.003	0.968	1.039

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-11 Binary logistic regression – influence of languages other than English

			95% C.I.	
	Sig.	OR	Lower	Upper
East	**0.000**			
West	0.000	9.287	3.005	28.702
Central	0.000	7.478	2.529	22.111
North	0.002	4.875	1.757	13.526
South	0.263	1.940	0.608	6.187
Speak Other Language	0.936	1.001	0.976	1.027

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-12 Binary logistic regression – influence of public housing tenancy

	Sig.	OR	95% C.I. Lower	95% C.I. Upper
East	**0.000**			
West	0.000	9.052	3.407	24.049
Central	0.000	7.305	2.570	20.762
North	0.014	4.301	1.344	13.765
South	0.288	1.882	0.586	6.039
Renting from SAHT	0.668	1.004	0.986	1.022

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-13 Binary logistic regression – influence of indigenous population

	Sig.	OR	95% C.I. Lower	95% C.I. Upper
East	**0.000**			
West	0.000	9.774	3.501	27.286
Central	0.000	7.731	2.650	22.557
North	0.010	5.090	1.481	17.487
South	0.265	1.933	0.607	6.158
Indigenous	0.897	0.989	0.831	1.176

Source: ABS census 2001 and CYWHS data 2000-2002

Table 7-14 Binary logistic regression – influence of purchasing a home

	Sig.	OR	95% C.I. Lower	95% C.I. Upper
East	**0.000**			
West	0.000	9.230	3.505	24.303
Central	0.000	7.168	2.413	21.291
North	0.004	4.673	1.641	13.310
South	0.254	2.119	0.583	7.703
Purchasing a home	0.756	0.996	0.968	1.024

Source: ABS census 2001 and CYWHS data 2000-2002

The first thing to note is the quantification of the risk of childhood obesity in the other four areas compared to the East. From the odds ratios (OR) in Table 7-3 it can be seen that the odds of a child being obese in the West is over nine times higher than for a child living in the East, ranging through to nearly two times higher for a child living in the South. These differences are highly significant for all areas except the South, where the actual obesity prevalence is not dissimilar to that of the East. When the other factors are introduced to the model, the change in OR indicates what sort of an effect (if any) each area-level census statistic has upon the odds of a child being obese in each area as compared to the East.

The first covariate to be reported is the SEIFA IRSD score (Table 7-4) and this result indicates that as area disadvantage increases, the odds of obesity rise by a magnitude of 0.7 in the West and North and 0.3 in the Central areas. It does not appear to have any effect in the South, but results for this area are not significant in any case. This confirms the general trend which has been observed throughout this and other studies of a positive relationship between disadvantage and obesity. However it is apparent from the earlier work in this chapter that the overall relationship between obesity and disadvantage is not necessarily reflected when using specific measures of disadvantage within the five study areas, therefore a selected set of census variables, chosen in line with those reported in Section 7.3, have also been input into the binary logistic regression model, and the results are discussed here.

Although only significant in the West and Central areas, an increase in the percentage of people in the higher category of personal income appears to decrease the odds of obesity in all areas (Table 7-5). This effect is strongest in the West, followed by the North and Central areas. Another ‘positive’ socio-economic indicator used for comparison is the percentage of persons with any post-school qualification (Table 7-6). The results from the inclusion of this variable are very similar to that of personal income in terms of both significance and OR reduction, although it appears to have a stronger effect (greater reduction in OR) than high personal income. Once again, the West exhibits the strongest effect followed by the North and Central areas. In comparison, areas with a very low level of education exhibit increased odds of obesity (Table 7-7) with the strongest effect this time being in the West and Central areas.

Another outcome of interest is the significant increase in the odds of obesity when internet use is entered into the model (Table 7-8). This has a particularly large effect in the West and Central areas, but is clearly evident in the North as well. It is unclear why this would be so, especially as internet use could be seen as an indicator of advantage which might act to lower the risk of obesity. It is most likely a data issue rather than a true indication of odds increase, perhaps reflecting homogeneity of this statistic among area CDs, for example.

Of the remaining variables, it is interesting to note that most of the perceived low SES indicators such as unemployment rates, (Table 7-9) percentage of one parent families (Table 7-10), speaking another language (Table 7-11) and the percentage of families in public housing (Table 7-12) actually appear to contribute to an overall *decrease* in the odds of child obesity in the four areas compared to the East; however these differences are not large. Once again, homogeneity among the area CDs may be influencing these result. Conversely - and more in line with what might be expected from a statistic which is perceived as a negative SES indicator - a higher percentage of people identified as indigenous in each area (Table 7-13) is reflected in a slight increase in the odds of obesity, except in the South where the odds are actually slightly decreased.

Also showing an effect in the direction which might be expected is the percentage of homes being purchased (Table 7-14) - which could be thought of as a positive SES indicator – as an increase in this statistic also slightly decreases the OR in all areas except the South. Once again this result for the South is not statistically significant and may be an anomaly partly due to the very high number of homes being purchased in this area compared to the others.

Taken together, these last two results could be seen as evidence that the neighbourhood level socio-economic environment in the South has an opposite effect– in some respects – on obesity risk than the broad correlations between SES and obesity prevalence observed in earlier chapters might lead us to expect. This suggestion is, however, difficult to substantiate, especially given the lack of significance between the odds of obesity in the South compared to the East (Table 7-3), which carries through to the ensuing models.

Although the results are not statistically robust and can be ambiguous at times, it is clear that that the variables analysed here are not necessarily having an equal effect in all areas. It appears that the West, with the highest prevalence of obesity, may also be more sensitive to fluctuations in community SES as that area consistently shows the highest magnitude of OR effects when different variables are introduced into the model. Although the Central area has the next highest prevalence of obesity, it does not always have the second highest changes in the Odds Ratios, as the North appears to be more sensitive to some variables. Although all variables except indigenous status and home purchase (discussed above) show a consistent effect in terms of the direction of their effect on the odds of a child being obese in a given area, no single variable can be identified as having an identical relationship with obesity in all five areas. In summary, an increase in disadvantage generally translates to increased odds of obesity but this effect is more pronounced in the Western and Northern areas.

This type of analysis again illustrates the complexity of the relationship between socio-economic variables – particularly when measured at the area level – and obesity in young children. It raises the possibility that particular community characteristics operate differently to contribute to or protect against obesity *depending on their interaction with other characteristics of each community*.

7.6.1 Discussion

The use of kernel density techniques to achieve an unbiased visualisation of the distribution of obese children has clearly shown areas of higher and lower obesity prevalence among this population and has allowed the detection and delineation of small areas of particular interest. Within these areas there are inconsistent relationships between overweight and obesity prevalence, such that a high prevalence of overweight does not necessarily indicate a high prevalence of obesity, and vice versa.

While overarching relationships between aspects of disadvantage and obesity in four year old children can be demonstrated in urban Adelaide, this chapter has shown that these associations do not necessarily hold true at the small area level. This is an important finding with implications for policy development as it suggests that one single policy – be it for prevention or intervention – may not be appropriate and will likely be ineffective in some of the communities where it is most needed.

Furthermore, it appears that socio-economic variables may have different associations with obesity prevalence in different communities, and may indeed be subject to modification by other factors. The association between ethnicity and obesity, for example, appears to be modified by advantage; while there is some suggestion that communities with the highest levels of disadvantage may actually be too disadvantaged to support a high prevalence of obesity.

CHAPTER 8

Implications and Summation

8.1 Introduction

This examination of the weight status of South Australian preschool children between 1995 and 2003 has shown that the overweight and obesity prevalence in this age group has not only increased over time, but that it varies according to location. The spatial disparity is underlain by individual biological and familial factors, but is at least partly a reflection of area-level socio-demographic variation. There is some evidence that gender may confer a differing sensitivity to aspects of the social environment and that the presence of disadvantage, as opposed to the absence of advantage, is more indicative of obesity risk.

This study has been carried out in an academic environment where the debate about and research into the many facets of obesity development in people of all ages has continued unabated over the last decade or more, and seems unlikely to cease any time soon. While there are still many contradictions and differing opinions, a body of knowledge is emerging which aims to fully describe the risk factors for obesity in both individuals and populations. Much of this research has been focused on older children and adult populations, and it is not well understood if and how the findings have relevance for young children. This thesis contributes to the increasing knowledge base by utilising the unique CYWHS data set to examine characteristics of both individual children and the communities in which they live in relation to their weight status. Importantly, the current work stresses the significance of *place*, and suggests that factors which are related to the development of energy imbalance in one place may be moderated by other factors in different places.

This final chapter summarises the findings from the thesis with reference to the original aims and objectives. From this discussion, a number of issues emerge which are key to consider in light of future policy formulation and when conducting further research into the issue of overweight and obesity, particularly in young children. In a climate where governments and policy makers demand empirical evidence to support decision making, this type of population-based research provides clear evidence of the correlates, patterns and implications underlying the development of obesity in this cohort.

8.2 Objectives and Achievements

The first objective of this research was to investigate overweight and obesity in this previously neglected age group comprising young children just prior to school entry. The large administrative data set collected and maintained by the CYWHS has proven to be a valuable resource for exploring the occurrence, variation and distribution of weight status in this population. While the data quality has limited the epidemiological robustness of the conclusions which have been drawn, it is still a highly representative data set which is well suited for exploratory analysis and hypothesis generation and has allowed the detailed exploration of area-specific influences for the first time in South Australia. Use of this data set has enabled the study of this phenomenon in a discrete age group at a scope which is not possible using more limited sample populations or research cohorts.

These data were initially used to identify the spatial and temporal variation in overweight and obesity prevalence in this population, as proposed in the second objective. Overweight and obesity among four year old children in South Australia has increased from approximately 11% in 1994 to around 20% in 2002, with the prevalence consistently higher amongst girls. This is comparable with nationally reported statistics (Australian Institute of Health and Welfare 2004a).

The state-wide statistics presented here mask a great deal of variation between different types of communities within the state, with both the actual prevalence numbers and the rates of change showing marked differences between metropolitan Adelaide and the rest of the state; and further within and between the six major regional centres and the other location categories. The prevalence of overweight (including obesity) is higher in non-metropolitan children and has been consistently so since 1998. This disparity appears to be largely driven by the high prevalence in the major regional centres – particularly Port Lincoln, Port Pirie and Port Augusta.

The third objective was to identify areas of high and low obesity prevalence within metropolitan Adelaide. This was accomplished firstly by visualising the distribution of overweight and obesity among the urban children by both CD and suburb. The western and northern suburbs generally exhibit a higher prevalence of overweight than the southern and eastern areas. Kernel density estimation was then applied and has proved to be a valid and versatile technique for assessing the distribution – unconstrained by administrative boundaries and statistical requisites - of obese children within the urban Adelaide area. Using these maps, concentrations of particularly high or low obesity prevalence were identified – three high-prevalence ‘hot spots’ in the north-western area of the city, and two low-prevalence ‘cold spots’ in the south-eastern region.

The fourth objective involved the identification of social and environmental characteristics of residential areas which may contribute to the observed differences in obesity prevalence. The drivers behind these differences can be attributed to both individual and environmental influences, and most probably a combination of both. An analysis of the data which were available for individual children indicates that birth weight has a very strong influence on weight status at age four, with children of higher birth weight more likely to be overweight or obese. There is also a suggestion that low birth weight is not as protective of overweight as might be expected given the strong correlation between high birth weight and later overweight. At the same time, a very strong negative relationship is evident between reported breastfeeding at 3 months of age and obesity, but not overweight, at age four.

Using language as a proxy for ethnicity, children from different ethnic backgrounds are found to be more likely to be overweight than English-speaking children, particularly those from Western European backgrounds and boys from Asian language backgrounds. Children identified as indigenous were also more likely to be overweight than their non-indigenous counterparts, although the results are not consistent between genders.

In this context, other data on housing and physical environments which could be attributed to individuals was also analysed for the urban children. Poor quality of housing and close proximity to public housing were found to have a strong relationship with obesity, but the influence of other factors such as proximity to fast food restaurants and walkability (among others) was generally nil or indeterminate.

Also among the urban children, many area-level socio-economic variables were found to have a relationship with obesity. Obesity prevalence increases as the socio-economic status – measured by the SEIFA index of relative disadvantage – of the children's area of residence decreases; and obesity prevalence is also correlated with many of the unique census data items. Children living in areas where a greater proportion of people were born overseas or speak another language are more likely to be obese, as are children in areas with a high percentage of indigenous people. Further statistics derived from the census for such variables as family structure, income, education, employment patterns, occupational status, housing and even internet use also show distinctive relationships with obesity in four year old children such that higher levels of disadvantage usually translate to a higher prevalence of obesity.

Using these findings, the significance and prevalence of obesity in South Australian preschool children can be clearly demonstrated to those responsible for policy decisions. It will therefore be possible to recommend policy initiatives which address the identification of communities where children are at higher risk of overweight due to a combination of socio-economic and environmental influences at the neighbourhood level (see Section 8.5).

The final objective was to contribute to the understanding of the underlying drivers of obesity. This study has demonstrated quite clearly that there are area-level influences which impact upon the weight status of young children above and beyond the usual individual measures which are already implicated in the development of obesity, and as such they may explain some of the variation in correlations which have been observed in other studies. These underlying environmental factors should be taken into consideration by researchers, practitioners and policy makers to develop a fuller understanding of the complex interaction of factors which are driving the high obesity prevalence rates in young children.

Taken together, the exploration of these objectives has achieved the over arching goal of answering the major research question: ‘Is there significant spatial variation in the prevalence of overweight and obesity in South Australian four year old children and, if so, what are the underlying causes of this disparity?'. Significant spatial variation has been demonstrated in various contexts from whole of state, to between cities, to within the urban area while a number of factors have been identified which may contribute to this disparity in terms of both the wider socio-demographic context of different communities and aspects of the physical environment which may impact upon children and families at their place of residence.

These results and, more importantly, a synthesis of these findings have built up a unique picture of the factors which underlie the development of overweight and obesity in this age group. The different variables which have been explored are primarily those which are nested within the outer ring of the ecological model conceived by Davison and Birch (2001) and relate specifically to the community and societal characteristics which feed through to the family dynamics and then the individual child characteristics, all of which are believed to interact to determine the weight status of a given child. The availability of this evidence from a large, population based study provides opportunities for policy development which take into account not only individual and familial factors but area-level variables, particularly as indicators of communities where young children are particularly at risk of obesity. This enables a focus on both prevention and intervention in populations where it is most needed.

8.3 Study Limitations

While this research has identified a number of aspects which are of importance to the further study of obesity in young children and the possible interactions between environment and weight status, it has also been subject to limitations of both data and method. While these do not undermine the strengths of the study, they must be acknowledged and their impact evaluated.

An administrative data set of this type, which is been collected as part of the routine operation of a large organisation, has not been obtained or transcribed with the same rigour as is standard and expected in a formal investigative study. As such, the accuracy and completeness of the data records – especially when possible transcription inaccuracies are taken into consideration – cannot be guaranteed. While every effort has been made to verify the representativeness of these data and to omit records which are obviously incomplete or inaccurate, it is highly unlikely that all errors have been accounted for and this must be regarded as an important consideration which underlies the veracity of the study results. It has also been shown that indigenous children and children from non-English speaking backgrounds are underrepresented in this data set, and this limits the conclusions which can be drawn from individual correlations between ethnicity and obesity.

Likewise, the specific data items collected by CYWHS are not targeted for research purposes and do not include information about the individual children which would have greatly improved the utility of this data set for this type of study. The lack of a measure of individual socio-economic status in particular has proven to be a significant limitation.

The inconsistency in the reporting of such variables as breast feeding and indigenous status in the CYWHS data set and the lack of robustness of these data items has also limited their contribution to the overall analysis. This is particularly unfortunate as these variables show particularly strong correlations with weight status and could potentially be considered as confounding factors in a broader ecological analysis.

In many ways the limitations inherent in the data set have contributed to the limitations in method. This is particularly evident when considering the application of multi-level modelling techniques to explore the relative contribution of individual and area level influences on the development of overweight in children, as the lack of individual-level data is a crucial factor limiting the use of this method. This has largely driven the subsequent statistical analysis, which is generally restricted to bivariate tests of association and limits the study to an exploratory role rather than one in which definitive outcomes can be expected.

This study has also been limited by the need to make choices regarding which aspects of the data to explore. The sheer size and spatial extent of the CYWHS data set along with the wide range of census and environmental data available and the potential to integrate these data easily and accurately in the GIS environment has provided a wealth of possible avenues of exploration. The choice to present an overview of overweight prevalence by location, followed by a more focused analysis of the relationship between area level census and environmental variables and obesity in urban Adelaide, is an appropriate approach for the initial exploration of this new data set. However it must be recognised that the study could easily have focused upon any number of different areas - for example, the disparity in overweight status between the regional centres or the contribution of ethnicity to the development of obesity – and that the exploration of these types of issues could potentially make a valuable contribution towards the achievement of the study aims.

While these limitations are important to consider in the context of this thesis, they also underpin opportunities for further study. Improved data collection would enable more robust statistical analysis of this and similar data sets while there is obviously much more research which could be initiated using the existing data. It is also apparent that research focusing on the links between ethnicity (both as a cause and as a confounder) and obesity at both the individual and area level would prove a significant addition to the current study.

8.4 Synthesis of Findings

A key finding is that overweight and obesity appear to be manifesting as two separate conditions in this population. After analysis of the individual variables, it seems that high birth weight is a key factor in the development of overweight at age four, and may have such an influence that other factors have a minimal impact on the more moderate levels of overweight. However when obesity alone is considered, other factors such as breastfeeding (in particular) exhibit a much stronger relationship with this more pronounced degree of overweight. It seems as if birth weight may exert a ‘baseline’ influence on weight status, and it is only when this is influenced by unfavourable external factors that the more marked energy imbalance which manifests as obesity is prone to develop.

While the expected relationships between disadvantage and obesity prevalence have been identified in this analysis, there is some indication of a stronger relationship between neighbourhood SES indicators and obesity prevalence among boys than among girls. The drivers behind this disparity cannot be determined from this study, but it could be hypothesised that the interaction between disadvantage and biology is somehow modified by gender. Future research would benefit from considering males and females separately and further confirming, exploring and quantifying these differences.

Further, it appears that the highest levels of disadvantage usually have a stronger statistical relationship with obesity prevalence than the lowest levels of advantage. The implications of this are that the presence of disadvantage is not comparable to the absence of advantage; therefore actual measures of disadvantage, (e.g. a very low level of education) may be a more accurate indicator of children at risk of obesity than measures of advantage (e.g. a very high level of education).

This study has demonstrated that these types of census statistics for small areas can potentially be used to identify areas where young children are most at risk of obesity. However there is also a suggestion that the most disadvantaged neighbourhoods do not necessarily have the very highest levels of obesity, leading to speculation that some communities may be too disadvantaged to support the development of obesity among the young children living there.

This theory is developed from a number of separate findings including that the most disadvantaged regional city (Whyalla) does not have the highest prevalence of obesity, that the gradient in obesity prevalence between children living in the poorest quality housing or in very close proximity to public housing stock and children in the next category tends to be negative or less marked than might be expected (see Section 5.2.1), and the identification of a similar pattern in the analysis of some of the other area-level census variables including some aspects of ethnicity and income, among others (Section 6.3.1). This premise is supported by the work in Chapter 7, which shows that although the small study area in the north of Adelaide is clearly the most disadvantaged in almost every indicator measured, it does not have the highest prevalence of obesity.

It is possible that in a relatively affluent society there are sufficient resources available to most families to purchase discretionary foodstuffs which, in the case of populations with low education and poor health literacy might tend towards the consumption of high energy density convenience foods (North and Emmett 2000; Campbell, Karen, Crawford et al. 2002b) and sweet drinks (Baur and Burrell 2004; Welsh, Cogswell et al. 2005; Malik, Schulze et al. 2006) which have been associated with the development of obesity. However it is likely that some families simply do not have the resources for this type of consumption and may even suffer from food insufficiency – and it is this most disadvantaged proportion of the population which may therefore have a lower prevalence of obesity in contrast to the usually reported relationship between these two variables.

This finding is important in that it illustrates the true complexity of this problem in this age group – something that should be borne in mind by anyone involved in prevention and intervention efforts. A population approach to obesity may not be effective unless it can be tailored for different community dynamics. Another aspect of this complexity is the very high prevalence of overweight in the Northern area of Adelaide. It could be postulated that even a slight rise in the socio-economic status of this area would actually enable greater participation in the obesogenic environment, potentially tipping a large number of children into the obese category. This mechanism could also possibly explain some of the very high prevalence of overweight in Port Lincoln compared to the other regional centres, especially in light of the decrease in unemployment and corresponding increase in household income for that city between the two census periods. For this reason, weight status monitoring with intervention as required should be considered in communities which are undergoing socio-economic change.

8.5 Policy Implications

This study has shown that overweight and obesity among four year old children in South Australia is a multifaceted phenomenon with complexities of spatial distribution, biological influences and physical and social environmental correlates. As such, developing appropriate and effective policy to encourage and maintain a healthy weight status among these young children – and by extension their older counterparts – must take into account these complexities.

That there is a high and increasing level of overweight and obesity in this population has been quantified and confirmed by this study, so the need for effective policy is clear, especially in light of the fact that current intervention and prevention efforts tend to be aimed at school-aged children, many of whom are already overweight by the time they enter the school system (Hesketh, Waters et al. 2005). Of particular concern is the potential for overweight children to become increasingly overweight as they become older, thereby perpetuating the problem into the adult population (Whitaker, Wright et al. 1997; Sugimori, Yoshida et al. 1999; Guo, Huang et al. 2000). Related to this is the notion that heritable changes occur during the lifespan (Fraga, Ballestar et al. 2005; Junien, Gallou-Kabani et al. 2005), in which case it is even more important to prevent obesity – and potential epigenetic changes which could also be expressed in the next generation - from developing in young children.

Effective policy for both prevention and intervention of overweight (including obesity) in this age group needs to acknowledge both individual and community influences. While recent research has found that intervention targeted specifically at the parents of overweight children is most likely to be effective (Golan 2006), it can be argued that even programmes like this can be more effectively targeted at a neighbourhood level by assessing community characteristics, rather than relying on individual referral or recruitment.

Given the strong relationship between both birth weight and breastfeeding and eventual weight status at age four it seems essential to direct resources towards potential parents – i.e. to provide education and health intervention programs to young adults prior to conception. After the birth of a child, the resources and support to make healthy choices around nutrition, activity and emotional environment for the whole family and community would conceivably help to lower the incidence of obesity in young children, particularly in the most vulnerable communities.

It is clear from this research that the weight status of young children is at least partly related to the broader social context within which they live. The exact mechanism of this relationship is unknown, although other authors have suggested that different expectations of life might shape attitudes towards health behaviours (Chamberlin, Sherman et al. 2002; Wilkinson 2006; Kunitz 2007). The current analysis provides some indication of particular community characteristics which may either contribute to, or be protective of, the development of obesity. Communities which have high levels of disadvantage are particularly vulnerable, although care must be taken to match any increase in SES in the most disadvantaged communities with appropriate intervention to ameliorate the consequences of potentially increased participation in the obesogenic environment by families with young children.

This study has identified links between indigenous status and obesity in young children, both at an individual level and also when an area has a high proportion of indigenous people. While much of this may be explained by overall disadvantage, the many policies which are in place to ameliorate indigenous disparities in things like education and health would benefit from a specific consideration of obesity as an issue for indigenous people of all ages, and for the communities in which they live.

Similar findings at both the individual and area level in relation to ethnicity serve to identify children from non-English speaking backgrounds and children living in highly ethnic communities as being particularly vulnerable to the development of obesity. It is clear that health and nutrition needs should be a component of immigration support initiatives so that the risk of obesity development in both the immediate and subsequent generations can be addressed. At the same time, language and cultural barriers in health promotion must be acknowledged and resolved for existing ethnic communities to benefit from the obesity intervention and prevention initiatives which are evidently needed for the healthy development of their young children. This is a health literacy issue which is of particular relevance to this sub-population.

These recommendations are complementary to the notion of 'Health in All' policy, which has been proposed for South Australia and supported by the South Australian Government (Kickbusch, McCann et al. 2008). The premise that the health needs of the population should be considered in all policy areas – e.g. education, urban planning, transport, housing, youth, etc. – is fundamental to successfully limiting the development of obesity in people of all ages.

8.5.1 Implications for data collection

It is clear that administrative data sets such as the CYWHS data used in this study can be valuable resources for the assessment and monitoring of population health. Funding to support the improvements in data collection, data entry and data transfer which would improve the completeness and accuracy of these data would significantly enhance the analysis. In particular, emphasis on the collection and transfer of data relating to breast feeding and birth weight would be particularly valuable for epidemiologically robust research into the relationship between these important factors and weight status at age four, while the inclusion of individual measures such as family structure, parental education, parental employment and household income would open up a wealth of opportunities to effectively apply multi-level modelling criteria to this data set which would quantify the contribution of neighbourhood socio demographic and environmental variables to the weight status of individual children.

To this end, and in line with recommendations proposed by the Obesity Working Group (National Preventative Health Taskforce 2008), consideration should be given to the introduction of a mandatory preschool evaluation including height and weight measurements. This would enable timely monitoring of weight trends at this key age and provide evidence for further action. At the same time, appropriate resources should be allocated to ensure that the data collection procedures are robust. This would enable the resulting data to be used with confidence for monitoring the distribution of overweight and obesity in this age group as well as for further research. The addition of some measure of individual SES, or the ability to link these data with other administrative records, would also greatly enhance the utility of such a data set.

8.6 Future Directions

The issue of overweight and obesity in young children is likely to remain of concern for some decades to come, and the full implications of the increasing levels of overweight in this age group are probably yet to be felt as the first cohorts reach maturity where they are more likely to suffer the early onset of diabetes and cardio-vascular disease than previous generations. They are also likely to have higher birth weight babies, thus helping to perpetuate the cycle for the next generations. Facing this scenario, it is important that research continues into this issue, and that this research contributes to the establishment of long term public health prevention and intervention programs to support the work of health care professionals who will, and should, continue to deal with overweight and obesity on an individual basis.

This research has identified a number of avenues of interest for further exploration. Possibly one of the most crucial is the suggestion that having a BMI-for-age score classified as 'obese' is the true indicator of dysfunctional energy balance in this population. Whether this is due to the arbitrary nature of the current definitions available for child overweight and obesity, or whether the link between birth weight and later overweight is such that birth weight provides a baseline weight status upon which other factors can then act to affect weight at age four, is important to determine. If one or both of these mechanisms can be confirmed and quantified then this will cause a shift in the way in which these types of analyses are conducted in the future, as either the definitions will change or studies to determine causal environmental factors will need to concentrate more specifically on obesity.

Where possible, there is a need for spatial visualisation and analysis to become integrated in this type of research. Even when registry-type data are not available, the physical and social environmental context in which a child (or other subject) lives and develops has been shown by this research to be related in some way to the development of obesity, and to ignore this spatial context is to limit the validity of the analysis. If comprehensive data sets including at least some of the individual measures detailed above are made available, then future research could potentially develop a comprehensive understanding of how the apparent, complex multi-factorial aetiology of childhood overweight actually functions.

This type of analysis would also benefit from the inclusion of other data sets which would contribute to a more comprehensive description of the physical and social environment. In particular, data on social issues such as crime and gambling and built environmental attributes such as the presence of footpaths would provide a more complete picture of the prevailing environment.

Both the individual attributes and the census data which have been analysed in this study have highlighted the need for further investigation into the links between ethnicity and obesity. The development of obesity in children from Asian language backgrounds does not necessarily have the same relationship with birth weight as for English speaking children, and this raises many questions about biology, cultural norms and the effects of migration. Likewise, the higher prevalence of obesity among children who live in CDs with a high proportion of people who speak another language is not necessarily a direct relationship and it would be worthwhile to determine the actual drivers behind this apparent link – be they biological, behavioural, socio-economic or a combination of factors. Until these determinants have been studied more closely, it is still pertinent to note that communities with a high proportion of non-English speakers have a child population which is disproportionately at risk for obesity and that intervention and prevention programmes – specifically tailored to be culturally accessible – would likely have a positive impact in these neighbourhoods.

The residential geocoding of the CYWHS data set and its subsequent manipulation in the GIS environment has been a key component of this research. The type of location data needed to conduct this type of analysis is often routinely collected in administrative data sets, and as this study has demonstrated that privacy can be maintained then consideration should be given to the spatial analysis of other routinely collected data. Many more spatial analysis methods, including sophisticated spatial statistics techniques, are available to the researcher for use with appropriate data sets, and this type of investigation could conceivably add a great deal of value to existing data holdings and provide an innovative and enlightening examination of many other social and health phenomena.

8.7 Conclusion

In the context of a global focus on obesity and the increasing recognition of the ramifications of overweight in even very young children; this study has successfully used a consecutive, administrative, spatially referenced data set to examine the prevalence and distribution of overweight and obesity in South Australian preschool children. While statistical analysis of the CYWHS data set as presented has yielded some intriguing results, the addition of the spatial dimension and the incorporation of complementary data based upon location have enhanced the depth and utility of this study. The use of GIS techniques and technology to link data based on location and to visualise the distribution of overweight in this population has enabled a more extensive analysis of an otherwise restricted data set. The inclusion of even the limited number of census and other environmental variables explored here has highlighted the complexity of the interaction between individuals and their environments and suggested many further avenues for more traditional epidemiological research.

As governments are increasingly coming to recognise the importance of early childhood as a crucial period for the patterning of health and social development into adulthood, so this research has emphasised the contextual effects of area-level socio-economic indicators with regard to the weight status of four year old children. The exploratory and hypothesis-generating aspects of this study have highlighted a number of areas which should be considered, both for immediate policy consideration and/or future research.

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Appendices

Appendix 1: Summary Table of Census Variables

Summary of the variables examined in Chapter 6 and their relationship with obesity in the study population

	MALES	FEMALES	
	Relationship		***Direction***
SEIFA IRSD (disadvantage) decile	**	*	neg
Polarisation - decile difference	--	--	pos
% Indigenous	*	*	pos
% Born overseas	**	*	pos
% Speak other language	**	**	pos
% Born in SE Europe	*	**	pos
% Born in SE Asia	--	*	pos
% Married	*	*	neg
% Separared/Divorced	*	--	pos
% Couple families with children	--	--	neg
% One parent families	*	*	pos
% Completed year 8 or less	**	**	pos
% Completed year 11 or 12	**	*	neg
% with any post-school qualification	**	*	neg
% with Bachelors degree	**	*	neg
% with Post-Graduate degree	**	--	neg
% Unemployed	**	*	pos
% Employed	**	--	neg
% Not in the labour force	**	--	pos
% in Higher status occupations	**	--	neg
% in Lower status occupations	**	*	pos
% employed in Manufacturing/Wholesale/Trade	*	*	pos
% employed in Property/Finance	*	--	neg
% employed in Education	*	*	neg
% of Family Incomes <$300/week	--	--	pos
% of Family Incomes >$1500/week	**	--	neg
% of Individual incomes <$200/week	*	*	pos
% of Individual incomes >$700/week	**	**	neg
% Rental dwellings	*	*	pos
Presence of SAHT stock in CCD	**	*	na
% of Dwellings being purchased	**	*	neg
% Use internet at home	**	*	neg

** Statistical relationship between variable quintile and prevalence of obesity, P< 0.05*
*** Statistical relationship between variable quintile and prevalence of obesity, P< 0.005*
-- Relationship not statistically significant
pos = Positive relationship between variable quintile and obesity prevalence
neg = Negative relationship between variable quintile and obesity prevalence

Source: Compiled by the author