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THE IMPACT OF DIETARY HABITS AND PRACTICES DURING ADOLESCENCE ON THE RISK OF OBESITY: THE BIRTH TO TWENTY COHORT.

by

Alison Bridget Bernadette Feeley

Supervisors

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A THESIS

Submitted to the Faculty of Health Sciences, University of the Witwatersrand, in fulfilment of the requirements for the degree

of

Doctor of Philosophy

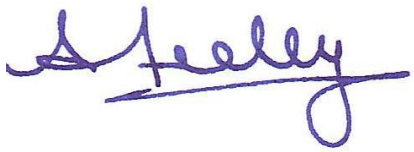
JOHANNESBURG, SOUTH AFRICA

2012

Declaration

I Alison Bridget Bernadette Feeley declare that this thesis is my original work. Where there has been contribution from other people, this has been duly acknowledged. This thesis is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination at this or any other university.

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Signature: Date: 15.05.2012

Thesis Material

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I. Feeley ABB, Pettifor JM, Norris SA. Fast-food consumption among 17-year-olds in the Birth to Twenty cohort. *South African Journal of Clinical Nutrition* 2009;22 (3):118-23.

Student's contribution to the paper

Design of the study, project management, training and supervising fieldworkers, data collection, data management including cleaning and analysis, writing of the manuscript.

II. Feeley ABB, Musenge E, Pettifor JM, Norris SA. Changes in dietary habits and eating practices in adolescents living in urban South Africa: the Birth to Twenty cohort. (Revised and resubmitted to Nutrition).

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Design of the study, project management, training and supervising fieldworkers, data collection, data management including cleaning and analysis, writing of the manuscript.

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Non-scientific Publications

The following newspaper articles, cartoons and radio reports resulted as a consequence of the publication of Paper 1:

1. Van Rooyen, C. "Soweto teens live on fast foods". *Health24,* 30 Sept 2008. <http://www.health24.com/news/DietFood_News_Feed/1-3420,48124.asp>

2. Sidimba, L. “Ikota a fatty timebomb". *City Press* 11 Oct 2008.

3. Naidoo S. "SA kids binge on killer food". *The Sunday Times*. 12 Oct 2008. <http://www.thetimes.co.za/PrintEdition/News/Article.aspx?id=861108>

4. Interview: "The Redi Tlhabi Show." Radio 702. 13 Oct 2008.

5. Interview: "Morning Live" The South African Broadcasting Corporation. 14 Oct 2008.

6. Madam and Eve. *The Star*. 20 Oct 2008.

7. Madam and Eve. *The Star*. 21 Oct 2008.

8. Madam and Eve. *The Star*. 22 Oct 2008.

Abstract

Background: South Africa is not exempt from the obesity epidemic and latest figures show that a third of adult men and two-thirds of adult women are either overweight or obese. Concomitant are changes in dietary habits and practices which have been implicated in the risk of obesity. Concern is that obesity and related non-communicable diseases (NCDs) manifest at younger ages. Adolescence, as well as being a stage during the life course when eating attitudes and behaviours are formed, is a particular time when the aetiology of NCDs becomes evident. Little is known about the dietary patterns during adolescence in South Africa, and if policymakers are to attempt to reduce the burgeoning statistics relating to obesity then it is important to understand adolescent dietary habits and eating practices.

Aims: To describe adolescent dietary habits and practices among South African adolescents and how they might influence obesity risk.

Methods: This study used a mixed methods study design, using both historical and prospective data and included four study components in both an urban (components 1-3) and a rural setting (component 4). Firstly, a cross-sectional assessment of fast-food intake of urban 17-year-olds from the Birth to Twenty Cohort (Bt20); secondly, a longitudinal descriptive analysis of dietary habits and practices of the Bt20 participants over a five-year period, between ages 13 – 17 years followed; thirdly a longitudinal assessment of the relationship between dietary habits, change in socio-economic status (SES) and obesity in the Bt20 adolescents was conducted; and finally, an exploratory survey assessing the availability of fast foods in a rural area.

Results: The cross-sectional analysis showed that mean fast food intake was 8.1 (4.6) items and 7.2 (4.7) items/week for males and females respectively. Furthermore, the kota (or quarter) was the most popular fast food item and on average it provided 5 370 kJ, 51 g fat (of which 13 g

Saturate fatty acids (SFA)). The longitudinal analysis showed that poor dietary habits and practices were embedded by the age of 13 years and were characterised by: high fast food consumption with at least five items/week consumed from the age of 13 years. Breakfast (weekday and weekend) consumption declined for both genders and females ate breakfast less regularly than males. Snacking while watching television increased with age: with females consuming more (4.0 (4.8) - 7.3 (5.9)) snacks per week than males (3.3 (4.5) - 6.0 (5.8). Two-thirds of participants ate their main meal with their family but among girls there was a trend towards eating this meal less regularly with increasing age. Confectionery consumption remained the same, around nine items/week for males and 10 items/week for females. Lunch box usage declined with age, conversely the number of tuck shop purchases increased with age. The prevalence of combined overweight and obesity was (8.1%) and (27%) in 17-year-old males and females respectively. In males only, soft drink consumption was associated with obesity denoted by BMI z-score and fat mass ($p<0.05$). In the final multivariate model, soft drink consumption remained positively and significantly associated with both outcomes and 'acquiring' a fridge over the 12-year period remained negatively associated with both BMI z-score and fat mass ($p<0.001$). Among females, no associations were found. Thus further data on other lifestyle variables are needed to understand better the exposures related to obesity risk in females. In the rural setting fast food was found to be available albeit a limited variety; two-thirds of the collected samples were either vetkoek (fried dough balls) or fried chips (yielding between 943 kJ – 5 552 kJ and 11 g – 64 g fat). Compared to the kotas available in Soweto, the samples obtained in the rural setting contained more energy and fat (6 300 kJ, 60 g fat vs. 5 369 kJ, 51.5 g fat).

Conclusions: This research highlights that poor dietary habits and practices prevail in adolescence which may be implicated in negative health outcomes in later life. Of concern is the finding that poor dietary habits were embedded by the age of 13 years which suggests that

interventions need to target families and children prior to adolescence in order to reduce the pervasiveness of these habits in the older child. The prevalence of combined overweight and obesity is higher than the national statistics for both boys and girls at the age of 17-years. This research confirms that some dietary behaviours are associated with obesity risk namely soft drink consumption – but in males only. However soft drink consumption may be a marker for other lifestyle behaviours associated with obesity. Other dietary habits were not shown to be associated with obesity in neither males nor females, which highlights the difficulty in the measurement of exposures relating to diet. This study also showed in males at least, that socio-economic factors are important when considering obesity risk. The availability of fast foods in a relatively impoverished rural area is concerning as it may indicate that this community is undergoing nutritional changes such as those seen in urban environments.

With urbanisation and economic transition, households experience a change in SES and these changes drive behaviour which can either enable or disable health outcomes. In this study SES improvement, e.g. fridge ownership seems to enable certain behaviours which can be obesogenic. However we cannot halt development in this context but we must devise ways to improve lifestyle choices which will promote health rather than impede it.

Key words: dietary habits, eating practices, adolescents, urban, rural, fast food, obesity, South Africa, middle-income countries.

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Definition of Terms and Abbreviations

BMI	Body mass index
BRISK	Coronary Heart Disease Risk Factor Study
Bt20	Birth to Twenty Cohort Study
DALYS	Disability-adjusted life years
DAM	Dietary assessment methods
DER	Daily energy requirement
DoH	Department of Health
FAO	Food and Agriculture Organisation
FBS	Food balance sheets
FFQ	Food frequency questionnaire
GNP	Gross national product
HICs	High-income countries
IMR	Infant mortality rate
IOTF	International Obesity Task Force
Kota	A South African fast food, composed of ¼ loaf of white bread filled with a range of ingredients (fried chips, cheese, processed meats, a fried egg and sauces)
LBW	Low birth weight

LE	Life expectancy
LICs	Low-income countries
LMICs	Low-middle-income countries
MICs	Middle-income countries
NCDs	Non-communicable diseases
NFCS	National food composition Survey
NDNS	National diet and nutrition survey
Quarter	see ‘Kota’
RDA	Recommended daily allowance
RNI	Reference nutrient intake
SES	Socio-economic status
THUSA	The Transition, Health and Urbanisation in South Africa (THUSA) Study
UK	United Kingdom
US	United States
Vetkoek	Dough shaped into a ball and deep fried
WHO	World Health Organisation

Preface

Inspiration for this PhD came from two sources: Speaking at the Nutrition Congress in Pretoria (2008), Barrie Margetts stressed the importance of assessing dietary pattern data and that current research is leaning toward this method of epidemiology. Research was beginning to show strong associations between dietary patterns and non-communicable diseases (NCDs). Of particular interest was the assessment of longitudinal data. Subsequently, I heard Barry Popkin's keynote address at the ICN Bangkok (2009), emphasising social changes in eating habits such as snacking and soft drink consumption, which have undergone rapid transformation over the past 30 years in the US. Snacks are energy-dense and micronutrient poor, are consumed at the expense of complete meals, and are implicated in obesity risk. Popkin's emphasis on social change around food behaviours highlighted a research gap: there is an extensive body of work which endeavours to relate diet to obesity risk, but there is limited data on behaviours around food choices – particularly in South Africa – which are central to the success of behavioural change interventions. This thinking was a challenging departure from my training in human nutrition and public health nutrition.

I was fortunate to have access to a rich longitudinal dataset which assessed dietary habits and eating practices of the Birth to Twenty participants over a five-year period, with questions that related to behaviours and habits around food choices including snacking behaviours. Thus the methodological approach in three of the studies contained in this thesis is novel, but I believe it to be just as valid as the more traditional approaches in assessing dietary exposures relating to obesity risk, since they add another dimension to the complexities of understanding human behaviour around food consumption.

This PhD thesis is presented ‘with publications’ and contains a series of three manuscripts and a Scientific Letter. All articles have either been published in or are currently under review by peer-reviewed journals. The format is divided into three parts:

- Part 1:
    - Chapters 1 and 2 contain the literature review and the contextual relevance of the work undertaken, and give details of the two study settings.
- Part 2:
    - Chapters 3-6 contain the four studies undertaken for this project: a) a cross-sectional study assessing fast-food intake among urban adolescents from the Birth to Twenty Cohort (Bt20); b) a longitudinal descriptive analysis of the dietary habits and practices of the Bt20 participants over a five-year period; c) an assessment of the relationship between longitudinal dietary habits, change in socio-economic status (SES) and obesity in the Bt20 adolescents d) an exploratory survey assessing the availability of fast foods in a rural setting.
- Part 3:
    - Chapter 7 consolidates and discusses the results of the four study components and includes a conclusion and recommendations for further work.

Part 1: Background and Literature

Chapter 1 Literature Review

1.1 Introduction

"The obesity epidemic is spreading to low-income and middle-income countries (LMICs) as a result of new dietary habits and sedentary ways of life, fuelling chronic diseases and premature mortality" Robert Beaglehole (2010) (3).

In September 2011 the United Nations (UN) will hold its first High-level Meeting of the General Assembly on chronic non-communicable diseases (NCDs) and in preparation for this meeting *The Lancet* launched a series of articles "Chronic Diseases: Chronic Diseases and Development", with the aim of providing leadership on the prevention and control of NCDs (4). Robert Beaglehole (architect of the series) stressed the importance of focusing public health efforts on children and adolescents, and specifically on obesity prevention. Furthermore, it has been demonstrated that if nothing is done to reduce chronic disease risk, serious human life and economic losses should be anticipated; for example, among 23 LMICs assessed in 2005, chronic diseases were responsible for half of the total disease burden (5). The authors showed that within those 23 selected countries we can expect an estimated 250 million deaths and $84 billion of lost national output between 2006 and 2015.

Once thought to be a disease of affluence, obesity is now the driver of NCDs in both developed and developing countries (1, 6), affecting socio-economic groups differentially depending on a country's development. Current worldwide estimates show that among adults the prevalence of overweight is 1.5 billion, of which 475 million are obese (7).

However, the threats of obesity and NCDs are not confined to adults; they are increasingly observed in children and adolescents in developing countries (1). Currently 43 million children (35 million in developing countries) under the age of five are estimated to be overweight or obese and a further 92 million are at risk of becoming overweight (8). Furthermore, around 40 million school-age children are classified obese, making this generation the first predicted to have a shorter lifespan than their parents (7).

Adolescence, as well as being a stage during the life course when eating attitudes and behaviours are formed, is also a time when the aetiology of NCDs manifest (9, 10). Of concern, however, is that little is known about the dietary patterns implicated in obesity risk among adolescent groups, particularly in South Africa. Thus, if policymakers are to attempt to disrupt the burgeoning statistics relating to obesity then it is important to understand adolescent dietary habits and eating practices, since such habits have been shown to track into adulthood and are precursors to NCD risk.

The following chapter is divided into 10 sections: firstly, an outline of the context in which this study was undertaken; in an emerging economy among an adolescent population. Within this section, two conceptual frameworks in which this body of work overlaps are described. Information on the components of dietary eating behaviours is presented, including an appraisal of the traditional methods of assessing dietary intake. Data on adolescent nutrition is presented with a specific emphasis on South Africans. Section 1.6 examines obesity, its prevalence and determinants, both worldwide among adults and adolescents and in South Africa. A further aspect of this chapter (1.7) considers methods of assessing obesity in non-adult populations. This leads into an appraisal of the literature around the relationship between dietary habits and

practices and obesity risk, with most of the emphasis being on younger populations. The methodological approaches to dietary assessment are then discussed, with alternative approaches addressing behaviours around food choice. This leads to a summary section where the research gaps are highlighted; those which give rise to the relevance and justification of this project. Finally, the research aims and objectives of each study component are presented.

1.2 The context of the problem under study

1.2.1 *Conceptual framework*

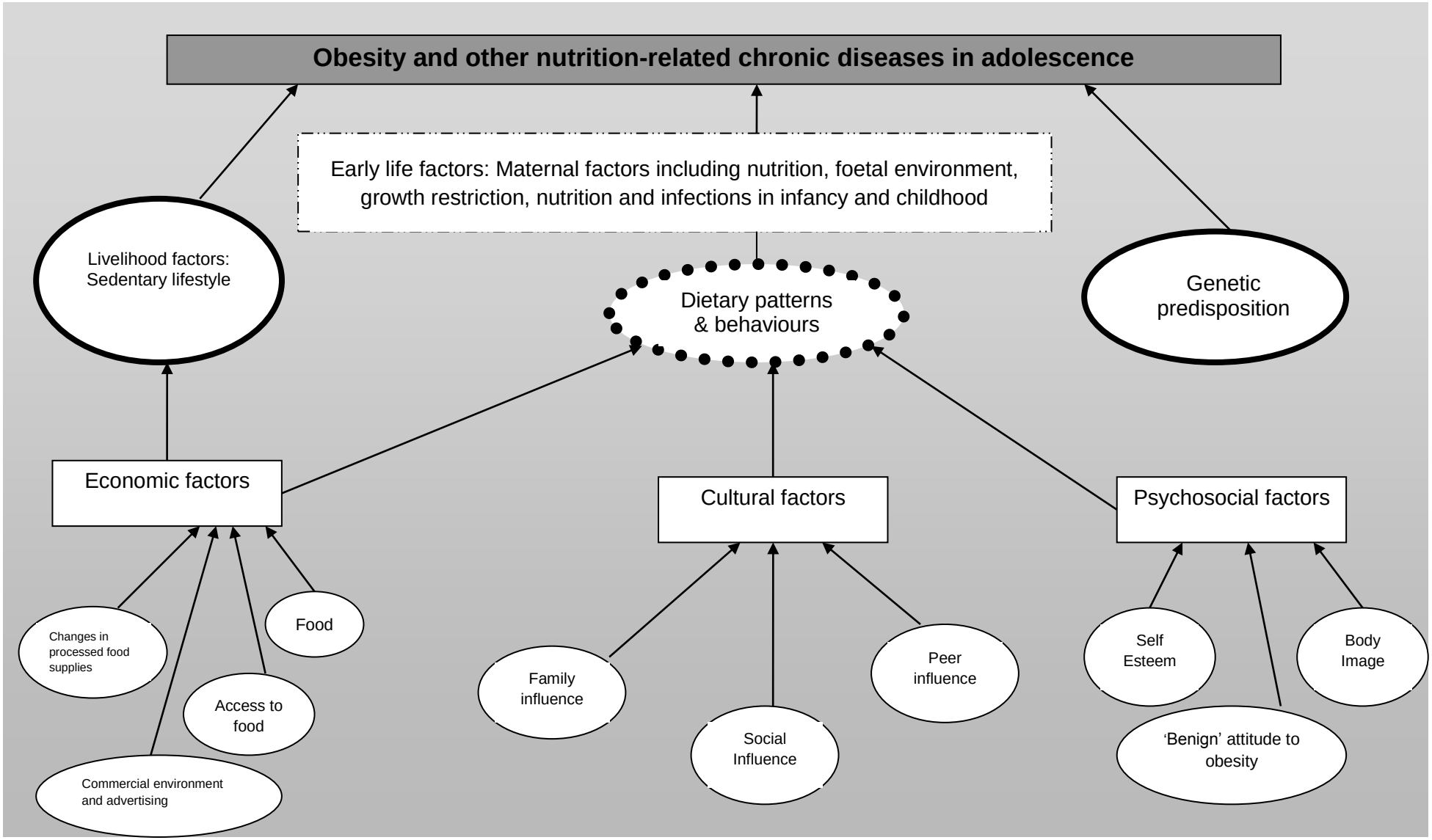
The first conceptual framework used in this thesis (Figure **Error! Reference source not found.**1.2.1) illustrates the influencing factors on the development of obesity risk among adolescents. Two key works have influenced this framework: Delisle and Strychar (2) from whom the framework diagram comes, and Popkin's nutrition transition model (1) in which the framework is set (i.e. the setting or the environment in which these factors influence obesity development). Small modifications have been made to adapt it further to the South African context.

The framework depicts that distal factors such as early life factors including maternal influences of nutritional intake, foetal nutrition and intrauterine growth restriction (IUGR), infant and childhood nutrition and infections, all relate indirectly to obesity risk in adolescence. Proximal factors include livelihood factors (e.g. sedentary behaviours), dietary patterns and behaviour and genetic predisposition, which all have a more immediate influence on obesity risk. Livelihood factors are influenced by economic factors which in turn are affected by changes in processed food supplies, the commercial environment and advertising, access to food and the food that is eaten. One's family, peer group and other social variables influence cultural factors.

Psychosocial factors are thus influenced by self esteem, body image and attitudes to obesity. In the South African context this is known as the ‘benign attitude to obesity’ discussed in section 1.6.2. Livelihood factors, dietary patterns and inadequacies are affected by economics, culture and psychosocial factors and they each also influence dietary patterns and nutritional inadequacies.

Although the framework recognises the influence of psychosocial, cultural and economic factors; all of which have an influence on dietary patterns and behaviours; a hierarchy is not denoted since the magnitude these influences have on dietary patterns and behaviours around food choice among adolescents is still unknown. In Figure 1.2.1 the grey background represents the context (on a macro level) in which these factors influence obesity risk, which is rapid transition, described in the following section. The topic of interest for this study, namely dietary patterns, is highlighted in a dashed circular line.

Figure 1.2.1 Conceptual framework 1



Sources: Popkin (1); Delisle and Strychar (2).

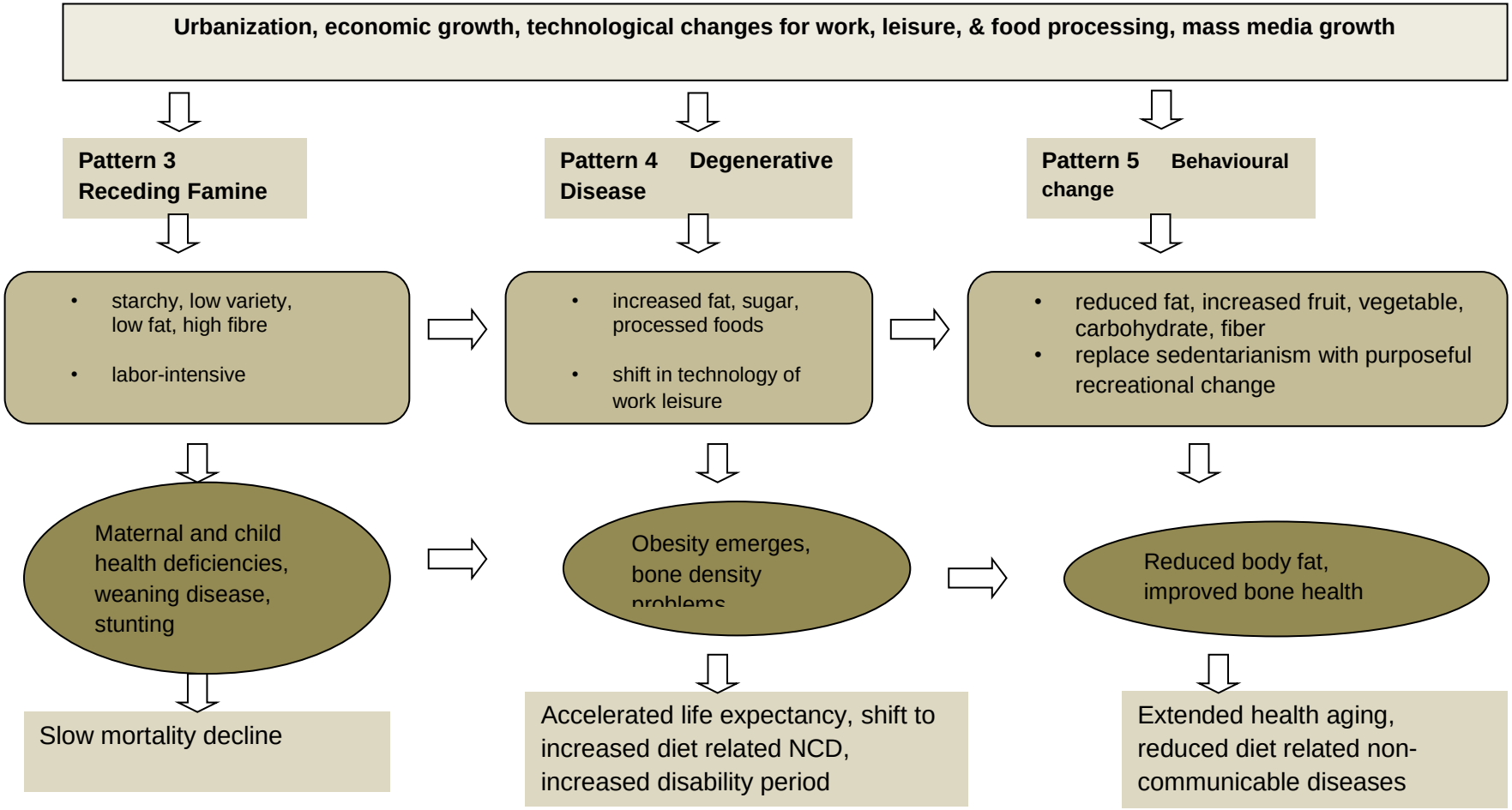
1.3 Nutrition Transition – definition

The nutrition transition is closely related to the demographic and epidemiological transitions. The demographic transition denotes the change in patterns from high fertility and high mortality to patterns of low fertility and low mortality. The epidemiological transition is the shift from a high prevalence of infectious disease associated with malnutrition, periodic famine and poor sanitation, to the high prevalence of chronic disease associated with urbanisation and industrial lifestyles (11-13). The nutrition transition therefore relates to the large shifts in dietary patterns; with a change from traditional foods (mostly plant-based, low in fat and high in fibre) to a substantial increase in the consumption of fat, sugar and refined foods (11).

Outcome measures used to assess these dietary shifts include stature, body composition changes and morbidity (6). Popkin described the nutrition transition in terms of five different sequential stages but without restriction to particular periods of time since it has been suggested that all societies undergo these changes, but at different periods in history.

The five stages of the nutrition transition include (1) collecting food, (2) famine, (3) receding famine, (4) nutrition-related non-communicable diseases (NCDs) and (5) behavioural change to reduce degenerative diseases and prolong health (12, 14). Figure **Error! Reference source not found.**1.3.1 describes the last three stages of nutrition transition which many countries are currently experiencing.

Figure 1.3.1 Stages of the nutrition transition. Only the last three stages are shown for ease of reading.



Source: Popkin & Gordon-Larsen (2004)

1.3.1 *Factors important in influencing the nutrition transition*

Key features of the current transition in developing countries are: rapid urbanisation with more of the poor migrating from rural areas and living in urban centres; economic change with increased incomes and higher inequality; and the globalisation of mass media such as increased television advertising, which has been shown to occur much sooner during economic growth than was faced by HICs in the past (15). Migration contributes to the broadening gaps between rich and poor; those who live in poverty do not benefit from the higher urban living standards. The scale of urbanisation exceeds governmental capacity to provide infrastructure and services, thereby exacerbating poverty (16).

The nutrition transition is influenced by a complex interaction of many factors (17). Income, price changes, individual preferences, beliefs, cultural traditions, geographic location, environment, and social and economic factors all interact in a complex manner to shape dietary consumption patterns (17).

Among the factors important in influencing the speed of the nutrition transition is urbanisation. Urbanisation is associated with dietary and activity changes. A reduction in physical activity is often reported (18) and is probably due to increased access to motorised transport and the increase in sedentary activities such as television-watching or the use of other modern technologies in the home, including use of washing machines and vacuum cleaners. Changing dietary eating patterns, and adopting tobacco and alcohol use are also related to urbanisation (19). Food availability in the urban environment is typically not subject to seasonality due to improved food systems infrastructure; there is also increased access to convenience food and eating away from home is more common (20).

The presence of commercial fast food chains (e.g. McDonalds and Steers) in developing countries has increased dramatically in recent years (21). This changing environment influences the dietary intake of the urban population. Increased consumption of food out of the home is associated with reduced home food preparation (22) and this may negatively influence long-term individual cooking skills, particularly among women who traditionally have this role. Urban areas offer a greater variety of foods which replace traditional rural foods which are usually higher in fat, sugar and salt and lower in micronutrients and fibre. Unique to developing countries, including South Africa, is the wide diversity of informal food vendors, (street vendors and tuck shops [also known as 'spazas']) that sell traditional foods (pap and meat) fast food items including vetkoek (fried dough balls), fried chicken (including traditional cuts such as feet and heads), deep-fried fish, fried chips and fried meats, including processed sausages. These outlets compete with the more formal enterprises and offer more choice and quick access to food away from home. Furthermore, informal vendors have lower overheads which often equates to their foods being competitively priced and more affordable to the consumer.

1.3.2 *Trends in the nutrition transition in developing countries*

Popkin (15) proposed that although different countries are at different stages of transition, there is evidence to suggest that LMICs such as South Africa are undergoing transition at a much more rapid rate, i.e. over a decade or two, compared with higher-income countries, which underwent the transition over many decades, or even centuries.

Evidence suggests that countries such as China, Egypt, India and the Philippines are greatly advanced in the nutrition transition; there is evidence of declining cereal and plant consumption

with concurrent increases in animal products and oil consumption (1). Popkin has also shown these dietary changes are positively associated with increases in income (1).

In Latin America, (Chile and Brazil) the associations between poverty and body composition have highlighted evidence of the nutrition transition (23). Initially, poorer sub-groups had normal body weight whereas higher income groups experienced a greater prevalence of overweight. However, since the 1990s the converse has been seen; poorer individuals experience a high prevalence of overweight, with more sedentary behaviours, and the rich have reverted to their lower body weights (24).

1.3.3 *South Africa in context*

South Africa has a hugely diverse population with nine ethnic groups living in dissimilar environments, from highly industrialised cities with an urban Western culture to remote rural regions where large proportions of the population follow a traditional African lifestyle. Thus, as South Africa is currently undergoing major transformation, it is important to highlight some demographic, economic, health and developmental trends that distally or proximally affect health and nutrition.

South Africa's segregationist and discriminatory practices of apartheid ended officially in April 1994 with the first democratic national elections and the development of a new political dispensation (16). Currently South Africa is undergoing profound social, economic and epidemiological transitions. It is a country of high poverty and high unemployment (25.3% nationally in the second quarter of 2010, but in Mpumalanga for example, employment rates are

as low as 14%) (25). However, the gross domestic product (GDP) per capita is US$13 300, which is misleading as it ranks South Africa as one of the fifty wealthiest countries in the world (26).

Urbanisation in South Africa has accelerated at a phenomenal rate since the end of apartheid. Between 1990 and 2005 urbanisation among black South Africans increased from 10% to 56%. For other ethnic groups the increases have been much less dramatic (19).

Of the population of 44.8 million, 79% are black/African, 9.6% white, 8.9% mixed ancestry and 2.5% Asian/Indian (27). Average life expectancy (LE) has dropped from 61.6 years in 1992 to 51.5 in 2008 (26), and this has largely been attributed to South Africa's HIV/AIDs epidemic (16). The infant mortality rate (IMR) was 51.9 deaths per 1000 births in 2000 (26); this dropped to 47.9 by 2008.

South Africa experiences a unique set of health circumstances in that a quadruple burden of disease exists: In addition to experiencing the simultaneous occurrence of communicable diseases, including malnutrition (accounting for 22% disability adjusted life years [DALYs] in 2000), and NCDs (accounting for 33% of DALYs), South Africa also has the added burden of a high prevalence of HIV/AIDs (accounting for 30% DALYs), and violence-related trauma (accounting for 14% of DALYs in 2000) (28).

Chapter 2 outlines the two study sites in more detail; Soweto (urban) and Agincourt (rural).

1.3.4 *Evidence of the nutrition transition in South Africa*

Since South Africa has no national dietary intake survey data prior to 1999 (16), food balance sheets (FBS) serve as a proxy to show trends in per capita consumption (29). It must be stressed that FBS present an assessment of food supply (including production, imports, stock changes and exports) and utilisation (including industrial non-food use, animal feed use, seed use and waste), by item or commodity (17). Therefore, per capita supplies of macronutrients are derived from all food commodities and they do not denote actual consumption or access to food, thus this data does not account for how distribution of food is undertaken, neither within regions, SES groups, gender, age, nor does it include other demographic variables.

Nonetheless, assessment of FBS between 1962 and 2007 shows an increase in per capita food and energy availability in South Africa with an increase of approximately 1 658 kJ/d (396kcal/d) (29); from 1 0891 kJ/d (2 603 kcal/d) in 1962, to 12 548 kJ/d (2 999 kcal/d) in 2007 (see Figure 1.3.2). Fat (availability) increased by 20.6 g over this period, from 61.2 g to 81.8 g, carbohydrate increased from 445 g to 484 g and available protein increased from 68.4 g to 81 g. As a proportion of total energy intake the macronutrient composition was 21.2% fat, 68.3% carbohydrate and 10.5% protein in 1962, and 24.5% fat, 64.6% carbohydrate and 10.8% protein in 2007 (29). This data shows an increase in available food to the population, but it is concerning to see the decrease in the proportion of total energy from carbohydrate and the increase of fat, which is indicative of a shift to the Western dietary pattern and its concomitant health implications.

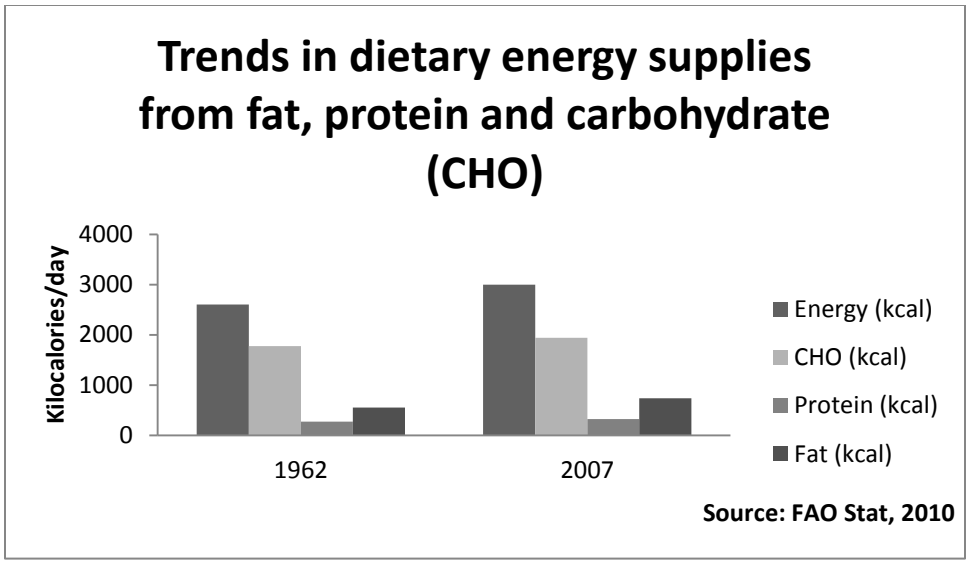


Figure 1.3.2 Trends in dietary energy supplies from fat, protein and carbohydrate in South Africa, FAO, 2010.

Other evidence, reviewed by Bourne (30) that the nutrition transition is in progress in South Africa comes from a number of cross-sectional studies among black ethnic groups in both rural and urban environments over a 52-year time span, from 1940–1992. Even though the methodologies employed varied between studies and some were incomplete (in many cases no standard deviations were reported and sampling methods and procedures were not fully reported), the data is important in that it elucidates certain dietary patterns. The data showed that although diets met prudent dietary guidelines (>50% carbohydrate, <30% total fat, ~15% protein), there was a progressive increase in fat with a concurrent decrease in carbohydrate content over this period. Fat intakes increased from 16.4% to 26.2% and carbohydrate intakes decreased from 69.3% to 61.7% as a proportion of total energy (30, 31). Furthermore, in a study among black adults living in Cape Town, Bourne (32) found that although protein consumption was the same (~15%), the amount of protein from animal sources increased, with a concurrent reduction in protein from plant sources. Additionally, Bourne assessed macronutrient intake differences among those residing in the urban environment for different durations. Over time

she found a concomitant decrease in % energy from carbohydrate and an increase in % energy from fat, from 61.4% to 52.8% and 23.8% to 31.8% respectively. One can conclude that these macronutrient intakes reflect a change from a more traditional diet (>60% energy from carbohydrate, <25% energy from fat) to that of a Western intake.

1.4 Influences on food choice and eating behaviour - conceptual framework

This thesis examines the dietary habits and practices of adolescents therefore it is important to contextualise those factors influencing these habits and practices. Dietary intake and food choice behaviour among adolescents results from a complexity of socio-economic and psycho-social factors. Story et al. (33) adopted an extensive conceptual framework with the aim of understanding factors that influence adolescent eating behaviours and food choices; the model was based on social cognitive theory (SCT) with an ecological perspective. SCT explains behaviour in terms of a triadic, reciprocal model in which an individual's behaviour, personal factors, and the surrounding environment interact and influence one another (34). Important concepts of SCT relevant to diet behaviour include modelling (learning through observing), reinforcement (response to a behaviour which either increases or decreases its chance of recurring), self-efficacy (self-confidence to undertake behavioural change) and self-control (35). The ecological model presents the relationship between individuals and the environment; behaviour is seen as affecting, or being affected by concentric spheres or levels of influences (microsystems, mesosystems, exosystems and macrosystems) on the individual (36), (see Figure 1.4.1). The central theme of SCT and the ecological model is 'reciprocal determinism' (37) meaning that the environment shapes, maintains and constrains behaviour. However, individuals are also able to change their environment since they are not passive entities.

This combined model has identified many factors that interact either proximally or distally to influence an adolescent's food choice (38-42). At the individual level (microsystems) these include:

- psychosocial factors:
    - food preferences
    - taste
    - hunger and nutrition
    - meanings of food
    - self-efficacy
    - knowledge

- biological factors:
    - hunger
    - gender

- lifestyle factors:
    - time and convenience
    - cost of food
    - meal patterns
    - dieting

At the social environmental level (mesosystems) these include:

- the family:
    - family meals
    - food availability in the home
    - socio-economic position/demographics
- peer influences:
    - food sharing/socialising

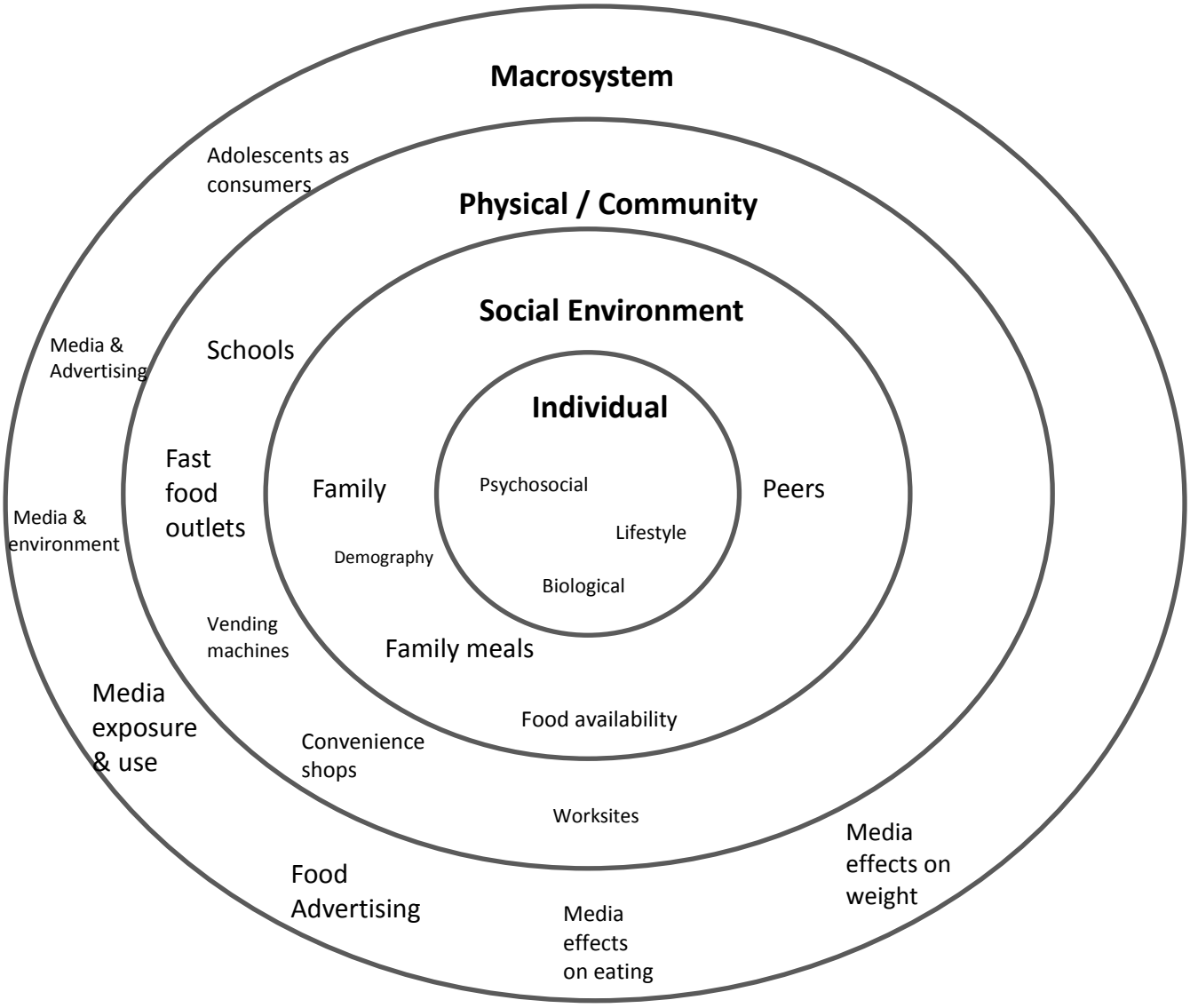
At the physical environment or community level (exosystems) factors include:

- schools (tuck shop purchases)
- fast food restaurants
- informal or street vendors
- convenience shops
- vending machines
- worksites of parents (these influence parents' available time to prepare and be present at home for meals)

Finally, at the macrosystem level one considers societal influences on adolescents becoming consumers such as:

- media and advertising
- the media and environment

- food advertising
- the media effects on eating
- media effects on weight concerns



Adapted from Story et al. (33)

Figure 1.4.1 Conceptual framework: factors that influence adolescent eating behaviours and food choices.

While some of these factors such as food preferences are constant and influence food choice throughout the life course, others are developmental factors and are only associated with being an adolescent (33). For example, individual identity is expressed and adolescents increasingly

take control over their eating practices; what they eat, where they eat and with whom they eat (40); important developmental factors that influence eating patterns of adolescents (43).

Contrary to the belief that dietary behaviour is a function of one's choice, an ecological perspective enquires as to what extent the environment may promote or prevent an individual's health promoting behaviour (44, 45). In this thesis, the dietary habits and eating practices of urban adolescents are explored within the social environment and the physical/community environments; specifically food behaviours within the home, school and community.

1.5 Dietary Intake of Adolescents

The following section outlines the nutritional intake studies undertaken in adolescents and children, with a specific emphasis on those living in South Africa.

1.5.1 *Adolescent nutrition*

Research based on dietary assessment methods has led to the belief that the adolescent diet is nutritionally inadequate. In terms of energy this is not the case since ecological studies have shown that linear height has continued to increase over recent decades (46). In addition, the incidence of obesity in this group is increasing (see section 1.6), which suggests that energy surplus (or a deficit in energy expenditure) is a likely problem. Research among different adolescent groups has shown that diet quality declines from childhood to adolescence (47, 48); for example, moving from primary to secondary school has been shown to be related to reduced breakfast consumption and increased soft drink consumption (47). Other research has shown that micronutrient intakes can be low and are coupled with high amounts of fat, salt and sugar

(40). Briefly, in the UK the latest *National Diet and Nutrition Survey* (NDNS) (49) found that average intakes of zinc, potassium, magnesium and calcium in older boys and girls were below the reference nutrient intakes (RNI), and in girls, mean iron intake was also below the RNI. Vitamin A and riboflavin intakes were also raised as a concern. In terms of energy composition the UK NDNS showed that adolescents met percentage of dietary energy from fat (<35%) but this was due to the high proportion of energy from non-milk extrinsic sugars (about 16% of energy compared to the recommended 11%). Total carbohydrate was <50% of energy. Intake of saturated fatty acids exceeded the recommendation of 11% by 4.2% and dietary fibre was below the adult recommendations of 18 g/d. Other developed-country research has shown similar patterns (40, 50).

1.5.2 *The diets of South African children and adolescents*

There is a dearth of nutritional data among adolescent populations in South Africa (see Table 1.5.1) for the published nutritional surveys carried out on children and adolescents between 1990 and 2001), with most survey data being published several years after it was collected.

To date only one nationally representative dietary intake survey among younger people has been conducted. In 1999 the first National Food Composition Survey (NFCS) was carried out on 1 – 9 year olds (n=2 894) (51). Twenty four-hour recalls were used to assess dietary intake and validation was assessed with three repeated 24-hour recalls on a random sub-sample. Furthermore, mothers helped to complete FFQs with information on dietary patterns of their children in the past six months. The results of the survey showed that that most children ate three meals each day, with (44%) or without (31%) in-between snacks or meals. However, 14% of children ate only two meals a day. The most commonly consumed foods included maize

meal, sugar, tea, whole milk, brown bread and hard margarine. The number of fruit and vegetable portions was not presented, but in another cross-sectional survey carried out on 3 – 6 year old African children it was found that their diets were deficient in vegetables and fruit, with an average intake of 1.3 portions per day (52) as opposed to the recommended amount of a minimum of five daily portions or 400 g (53). The NFCS found that 14% of urban and 18% of rural 7 – 8 year olds achieved less than 50% of the recommended daily allowance (RDA) for energy and that 25% and 40% of urban and rural children were getting two thirds of the RDA for energy respectively. On the other hand, 49% and 30% of children in urban and rural areas respectively achieved more than 100% of the RDA for energy. Total fat contributed to 26.5% (SD 7.7) and 21% (SD 7.9) total energy for urban and rural dwellers respectively. Interestingly, when assessed by region, those living in Gauteng (a largely urban province, encompassing Johannesburg-Soweto) had the highest proportion of fat, 27% (SD 7) of total energy. The lowest region was the Free State with 20% (SD 8) of energy derived from fat. Sugar contributed 15% of total energy and protein intake was 12.5% of energy. Significantly urban/rural differences were found for total carbohydrate; with contributions of 58% (SD 8) and 64% (SD 9) for urban and rural areas respectively. On the whole, South African children had intakes of micronutrients that were below two-thirds of the RDA, namely: calcium, iron, zinc, selenium, vitamins A, D[1], C and E, riboflavin, niacin, vitamin B6 and folic acid.

In another large cross-sectional study assessing the determinants of obesity risk in 10 – 15 year olds in the North West Province (covering both rural and urban environments, see Table 1.5.1), Kruger and colleagues reported briefly on their dietary intake (54). The eating patterns of the respondents indicated a high consumption of cereal- or starch-based staple foods (maize meal, bread, rice) ‘empty-calorie snack foods’ (fried maize snacks) and cold drinks, and a low

[1] However, children’s sun exposure is high due to the climatic conditions in South Africa.

consumption of nutrient-dense foods (milk, meat, fruit, vegetables). Dietary intake data revealed that in boys, mean energy intake was 1 915 kcal (SD 722 kcal), which is lower than the recommended daily energy requirement (DER) of 2 666 kcal for 11 – 14 year old boys (55). Girls' mean energy intake was 1 767 kcal (SD 660 kcal); also lower than the DER of 2 299 kcal for 11 – 14 year old girls. Energy derived from fat ranged between 26% – 27% of total energy, which complied with prudent dietary guidelines of 30% or less. The study indicated low fibre, vitamin A and folate (as a result of limited fruit and vegetable consumption), although actual intakes were not reported. The researchers reported on low motivation and low compliance of respondents during the 24-hour recall interviews, which may be a reason for the possible under-reporting shown. However, they did not say how they tried to improve compliance, if at all. Nonetheless, this latter study does indicate poor dietary practices of these adolescents' low dietary diversity, but with the contribution of energy from fat being less than most Western populations of ~30%.

Two articles reported on the same population's dietary intake (56) and food habits which explained the dietary intake data (57); a cross-sectional study undertaken in Lebowa, a rural area. It is unlikely that this data applies to the population at present (since the data is 20 years old) but for interest their findings are highlighted here: Two groups were assessed, 6 – 10 year olds (n=100) and 11 – 14 year olds (n=189). The mean energy intakes of the older group were similar to the younger children; 1 520 – 1 582 kcal: ~70% of energy from carbohydrate, 18% – 19% energy from fat and 6% – 9% from non-milk extrinsic sugars. Mean protein (54 – 58 g) intakes were notably higher than the RDA (28 – 46 g). Micronutrient intakes were low for vitamin A, B6, B12, C, riboflavin, iron, calcium and zinc. In terms of food diversity tea, maize meal, brown bread, and tomato gravy were eaten by a large proportion of respondents. Subjects did not consume even one portion of dairy products per day, indicative of low calcium intakes. Mean

fruit and vegetables amounted to between 128 g – 186 g/d, suggesting low fibre and low micronutrients.

Table 1.5.1 Published nutritional surveys carried out on children and adolescents in South Africa between 1990 and 2001.

Source	Date of Study	Study and DAM	Ethnic group	Area	Age in years	Issues
Labadarios et al., 2005 (51)	1999	NFCS (24-hr recall x 3 & FFQ)	All	Nationally representative of South Africa	1-9: n=2894	
Steyn et al. 1993 (57)	1991	Lebowa (24-hour recall)	black	Northern Province, rural	6-14: n=289	Old data reporting on food diversity in a poor rural community
Badenhorst et al. 1993 (56)	1991	Lebowa (24-hour recall x1)	black	Northern Province, rural	6-14: n=296	Reporting on energy intake of the above rural community
Bourne et al. 1994 (52)	1990	BRISK (24-hour recall x1)	black	Western Cape, urban	15-64: n=983	Did not present data by age therefore could not determine adolescent dietary intake.
Kruger et al. 2006 (54)	2000-2001	THUSA BANA (24-hour recall x 1)	All	North West Province, rural/urban	10-15: n=1 257	
Zingoni et al. (58)	2007	Bt20 (FFQ)	black, white	Soweto	15 N=150	Small non-representative sample.

A small sub-study of dietary intake was undertaken among the Birth to Twenty cohort (Bt20)[2] (n=150) (58). Table 1.5.2 shows the energy and proportion of total energy each macronutrient contributed, stratified by gender and ethnic group. Overall, the macronutrient intake of the urban adolescent sample was 33.3% fat, 51.8% carbohydrate, 10.7% protein and 14% added sugar as proportions of total energy intake. Mean fibre was 28 g. Statistical differences were found between white boys and black boys for total protein ($p<0.001$), and between white girls and black girls for total energy ($p<0.01$), total protein ($p<0.01$) and total carbohydrate ($p<0.05$).

Table 1.5.2 Energy and proportion of total energy each macronutrient contributed stratified by gender and ethnic group from the Bt20 cohort Zingoni et al; (59).

Variable	Whole sample (n=150) Mean (SD)	White girls (n=15) Mean (SD)	White boys (n=9) Mean (SD)	Black girls (n=65) Mean (SD)	Black boys (n=61) Mean (SD)
Energy (E) (kcal)	2 900 (1069)	2 227 (643)	3 148 (1070)	2 845 (1105)	3 087 (1061)
Total Protein (%E)	10.7 (1.9)	12.3 (2.4)	12.3 (20)	10.4 (1.9)	10.4 (1.6)
Total fat (%E)	33.3 (5.3)	34.9 (5.1)	30.0 (5.7)	33.6 (5.3)	33.0 (5.2)
Total CHO[a] (%E)	51.9 (5.6)	48.3 (5.6)	52.9 (7.0)	52.0 (5.5)	52.4 (5.3)
Added sugar (%E)	14.0 (5.6)	12.3 (8.2)	14.4 (7.0)	15.2 (5.6)	13.0 (4.5)
Dietary fibre (g)	28.3 (12.6)	25.8 (14.5)	36.1 15.0)	25.8(12.2)	30.5(11.6)

[a]carbohydrates

[2] The Birth to Twenty Cohort is a birth longitudinal study on which this thesis is based, detailed in Chapter 2.

1.6 Obesity

1.6.1 *The consequences of obesity*

"Excess bodyweight is the sixth most important risk factor contributing to overall burden of disease worldwide" (59). Obesity is associated with a number of chronic diseases including osteoporosis, cardiovascular disease, hypertension, ischaemic stroke, type 2 diabetes, all cancers except brain and lung cancer, dyslipidaemia, sleep apnoea, gallstones, gynaecological problems and psychological problems such as depression (NHLBI, 2001). However, the risk of hypertension, diabetes and dyslipidaemia increases from a BMI of 21.0 kg/m^2 (59) and mortality rates increase with BMI greatly increasing above 30kg/m^2 (60).

For example, 53% of all deaths in the *Women's Health Study* (n= 115 195) could be attributed to a BMI of >29kg/m^2 (61). Joubert et al. (62), estimated that in 2000, compared with other risk factors investigated in the South African Comparative Risk Assessment (CRA) study, overweight ranked fifth in terms of both death and disability adjusted life years (DALYs). Furthermore, this figure was double for women than for men and; one in 10 female deaths in 2000 could be attributed to excess body mass.

According to the WHO in 2004, (63) more than 30% of deaths in high- (HIC) and middle-income countries were attributed to NCDs including: coronary heart disease, stroke and other cerebrovascular diseases, some cancers, type 2 diabetes and hypertensive heart disease (63). However in low-income countries (LIC) 15% of all deaths could be attributed to coronary heart disease and stroke and other cerebrovascular diseases.

Currently, type 2 diabetes is ranked as the 8th leading cause of death in HICs and is ranked the 10th leading cause of death in MICs (63). It is estimated that by 2025 there will be 300 million cases of this disease worldwide (64) In South Africa, type 2 diabetes accounted for 2% of all deaths in 2002 (65) and as in the rest of the world, this number is predicted to increase.

In 2004, in South Africa, the WHO estimates of the burden of disease suggested that NCDs caused 28% of the total burden of disease measured by DALYs (66). Cardiovascular disease, type 2 diabetes, respiratory diseases and cancers combined, contributed 12% of the overall burden of disease. The burden from NCDs in South Africa is two or three times higher than in developed countries and similar to that in some sub-Saharan African countries that fall into the highest burden quintile (66). These NCDs are on the rise in rural areas and affect a disproportionate number of poorer urban dwellers (66).

1.6.2 *Determinants of obesity*

While it is widely recognised that positive energy balance (either as a result of a surplus in energy intake or a deficit in energy expenditure, or both) results in weight gain over time, its causes are complicated and numerous and include both genetic and environmental factors (67). However an emerging hypothesis which extends the energy balance hypothesis (or thermodynamic theory) is the concept of metabolic perturbation. In 2008 Lustig challenged the direction of causality in the energy balance model, arguing that excessive insulin is the primary metabolic derangement leading to excess adiposity, either by impaired insulin signalling or through leptin perturbation (68). These metabolic causes of weight gain have been investigated from different perspectives from the metabolic flexibility and the regulation of fuel supply, to the

fructose and metabolic flexibility hypothesis (for a full discussion see Taubes, Lustig, Basciano et al. and Wells and Siervo respectively (69-72).

It is speculated however that the increase in the prevalence of obesity 'among genetically stable populations' points to environmental and possibly perinatal factors (73). Among the environmental determinants/influences, gender, ethnicity and socio-economic status (SES) have received much consideration both in developing and industrialised countries. Females have been shown to experience a higher prevalence of obesity and socio-cultural factors such as high rates of overweight in girls; midlife and postpartum weight gain may influence these gender differences (67).

Ethnic differences in the prevalence of overweight and obesity have been shown in different population groups around the world. In the US the 2003–2004 *NHANES* published that the prevalence of obesity in blacks was 45%, 37% in Mexicans and 30% among whites (67). In South Africa, women are more obese than men and in terms of ethnic groups, obesity is highest among black women, followed by white men (16). Ethnicity has been used as a proxy for unmeasured confounding variables related to social, cultural and economic differences among groups (67), and this is apparent in South Africa since groups marginalised in the past have the highest poverty (past and present) and disease burdens today.

Individuals in lower socio-economic groups have less access to healthier foods, for example Liese et al.(45) showed that those living in rural US had less choice in terms of healthier foods (usually less energy-dense and more micronutrient rich) and also that if these were available

(e.g. low fat milk) they were more expensive than standard equivalents (e.g. whole milk). Furthermore, the urban poor usually live in less leptogenic[3] environments than those who are better off. In a review of the aetiology of obesity among children, Procter (74) cited deprivation as often being associated with obesity: Procter has shown that there is a higher density of fast food outlets in poorer suburbs in the US; there are few safe play-areas for children and a lack of opportunities for children to undertake activities other than watching TV.

Physical activity and exercise patterns have shifted over the previous decade. Although causal evidence is lacking, various longitudinal and ecological studies have purported the link between reduced energy expenditure and obesity risk; physical activity has also become recognised as an important health behaviour, associated with reduced all-cause morbidity and mortality (16). Popkin has cited that the decline in physical activity is due to improved access to transportation and increased sedentary leisure activities such as watching television and using computers, resulting from home electricity access and the development of labour-saving devices such as washing machines (6, 11). Although there are few South African physical activity studies, there is evidence to show a decline in activity levels, especially in urban populations and in those groups migrating from rural to more developed areas. The *National Youth Risk Behaviour Survey* (75) which sampled 10 000 of 13 – 19 year olds, found that more than one third of the teenagers did not participate in sufficient moderate-to-vigorous activity on a weekly basis, and in all racial groups bar that of Indians, females reported more sedentary behaviour than males. Furthermore, one quarter reported watching more than three hours of TV per day. Adults do not fare much better; in a representative cross-sectional sample of 2 014 South Africans in 2003, (16), less than one third met the WHO's recommendation of 30 minutes of physical activity on

[3] Promoting leanness (leptos=thin)

most days of the week. Furthermore, 46% reported inactivity – the figures being higher for females than for males.

Obesity patterns develop in a particular way over time and this is replicated differently in low-- and high-income countries (60). For example, in LICs, those in higher SES groups and those in urban areas often have a higher prevalence of obesity first and this becomes apparent in middle-aged women before any other demographic group. However, in more developed countries obesity is associated with those in lower SES groups, particularly females and those in rural communities (17, 60).

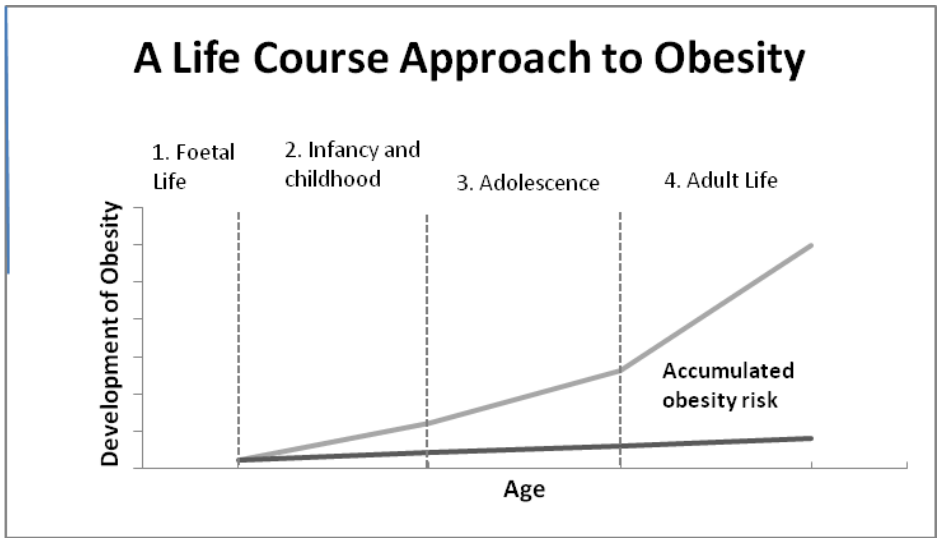
Cultural factors including family influence such as maternal BMI and household socio-economic status, social influence and peer groups, all have an influence on obesity risk (2, 24). Attitude to overweight and obesity in the African population is such that overweight is considered a sign of health, well-being and affluence, and that overweight children reflect a positive state of health (76). The South African Demographic Health Survey (SADHS) (77) found that in women, lower educational attainment was associated with higher BMI and it also related to misperceptions of actual body weight. Other international studies corroborate that lower educational status is associated with obesity (11).

Stunting (low height-for-age) remains a public health problem in South Africa and in some studies it has been found to be associated with obesity (18) but others not (78). The prevalence of stunting almost equals that of overweight among 1 – 9 year olds nationally (79). Furthermore, of interest is the relationship between malnourished children residing in the same household as their overweight maternal caregiver; for example in Limpopo province, 31% of underweight children were found to have an overweight caregiver (80). It has been suggested that there are

common underlying causes of overweight and underweight when occurring in close proximity (81).

1.6.3 *Life course approach to obesity risk*

In recent years a 'life course approach' has been adopted to address the burden of NCDs. This life course approach views the actions and behaviours of individuals in context with the continuum of their lives from birth to death, and transition through each life stage and transition point. These key stages and the accumulation of risk along the way can increase susceptibility to risk of obesity and its concomitant diseases, particularly cardiovascular disease and diabetes (24, 82, 83).



Adapted from Aboderin et al. (82)

Figure 1.6.1 A Life Course approach to obesity risk.
(The bottom line on the graph represents genetic susceptibility to obesity and the top line represents the environmental exposures to obesity risk).

Figure 1.6.1 shows that the risk of obesity, and thus the ensuing NCDs, accumulates with age and is influenced by factors acting at all stages of the life-cycle. The main factors of different stages of life include the following:

- Foetal life: foetal growth, maternal nutritional status, socio-economic position at birth, birth weight (birth length/head circumference).
- Infancy and Childhood: Growth rate, breastfeeding (or formula feeding) and complementary feeding practices, infectious diseases, unhealthy diet, lack of physical activity, obesity, socio-economic position.
- Adolescence: unhealthy dietary practices, lack of physical activity (sedentary behaviours including TV viewing), tobacco and alcohol use.
- Adult life: established adult risk behaviours (diet/physical activity, tobacco use, alcohol use), biological risks, socio-economic status, and environmental conditions. The proportion of overweight/obese increases significantly. A stage when expression of chronic disease manifests.

In this research, adolescence is the stage in the life course which is under assessment, with a specific emphasis on dietary habits and practices during this period. Research has shown however that adolescence is one of three critical early-life periods when obesity risk is heightened. Overweight, with its origins in adolescence, will persist into adulthood in about half of those affected (84). The other two periods which have in recent years been explored in great detail are the early-life period (infancy) and the period of adiposity rebound (5 – 7 years of age).

Prenatal and perinatal nutrition influence obesity risk in later life and an indicator of prenatal exposures is birth weight. There is evidence to show a strong positive association between birth weight and overweight and obesity risk in later life (85). However other studies have shown that there is a J-shaped or U-shaped relationship between birth weight and adult BMI, with a higher prevalence of adult obesity taking place at both low and high birth weights (86). A higher birth weight has been associated with increased risk of hypertension, type 2 diabetes and ischaemic heart disease (87) and cancer (88). Conversely, low birth weight (LBW) is associated with cardiovascular disease (89), raised blood pressure (90) and type 2 diabetes (91). Furthermore, it has been found that those with the highest prevalence of type 2 diabetes were obese adults, but were also born LBW (91).

Adiposity rebound, the period when BMI increases (at around 5 – 7 years of age), following its reduction in the earlier years, is a critical window when obesity risk increases. The timing of adiposity rebound influences the onset of the adolescent growth-spurt and thus, also BMI risk in later years (92).

1.6.4 *The prevalence of obesity in adults worldwide*

Historically, excess body mass has been regarded as a problem of 'the West' associated with affluence however, obesity and its related health outcomes now threaten to devastate both developed countries and developing countries. For example, Mendez and colleagues (93) examined adult female patterns of underweight and overweight in 36 developing countries, and concluded that overweight exceeded underweight in more than half of those countries studied. The International Obesity Task Force estimates that worldwide, 1.5 billion adults are overweight, including 475 million who are obese (7).

The prevalence of obesity among adults is increasing throughout the world's population and Figure 1.6.2 (A and B) shows the increasing obesity trends for selected countries (both developed and undeveloped examples) among males and females aged 15+ respectively, from 2002 – 2010 (94). In the US the prevalence of obesity increased from 12% – 20% between 1978 to 1990 (95), in the UK between 1980 to 1995 the increase was from 7% to 16% (95). In China between 1996 and 2004 the increase in overweight was rapid, from 4% to 15% in men and 10% to 20% in women (60). Pacific populations have the highest prevalence of obesity, for example in Nauru, 82% of adults are obese (94).

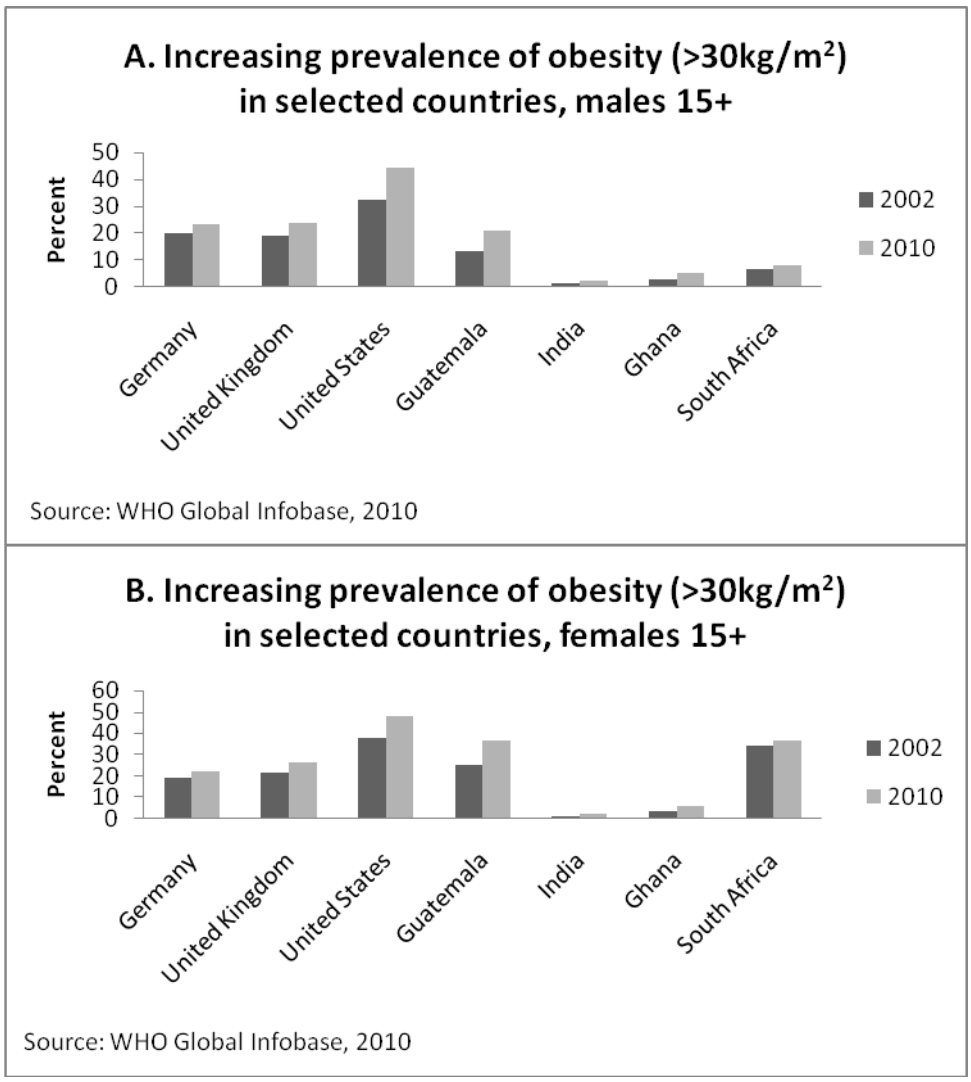


Figure 1.6.2 Increasing prevalence of obesity in selected countries among male adults (A), and female adults (B).

The WHO map (Figure 1.6.3) shows the worldwide distribution of obesity in women; it can be seen that in countries marked in black (including USA, countries in South America and South Africa, the prevalence of obesity is 36% or more).

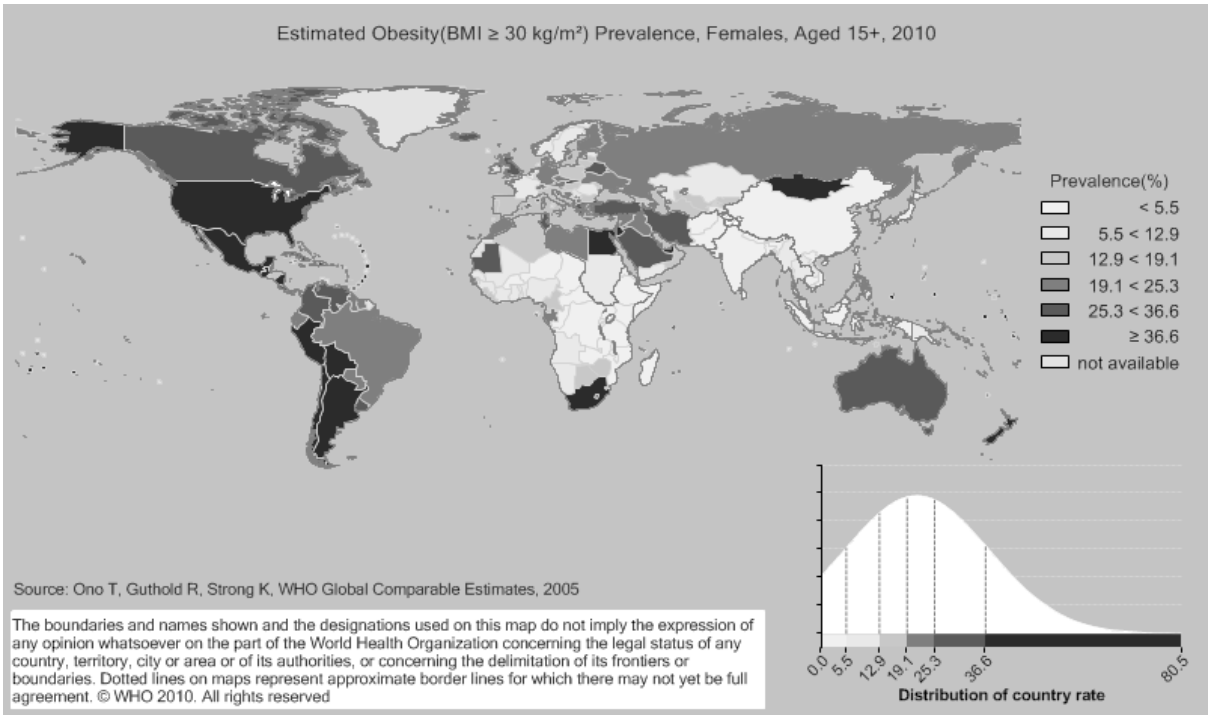


Figure 1.6.3 WHO estimates of the worldwide prevalence of obesity in women (2010).

1.6.5 *Obesity in South African adults*

Of all sub-Saharan Africa, South Africans have the highest average BMI. Females and males aged between 15 – 69 years of age have a mean BMI of 27.3 kg/m^2 and 23.4 kg/m^2 respectively (19). Hence, results from the first SADHS undertaken in 1998, found that 29% of men and 56% of women were classified as overweight or obese (77). It was also estimated that 10% of females aged between 15 – 24 years of age were obese (77). Furthermore, in the same study in which more than 7 000 women aged 15 – 95 years were assessed, it was found that those with the highest BMI were black women (58.5%), followed by those of mixed-race ancestry (52%),

white women (49.2%) and Indian women (48.9%). The SADHS also showed that mean BMI increased with age among both genders. Among males the rise in BMI was from 20.7 kg/m^2 to 24.4 kg/m^2 and in females from 23.4 kg/m^2 to 29.6 kg/m^2 between the ages of 15 to 64 respectively. Furthermore, BMI declined after the age of 64 among both genders.

In accordance with international data it was also found that women living in urban environments had a significantly higher BMI than their rural counterparts. Additionally, the SADHS highlighted that women with lower educational attainment had the highest BMI and that they also work in more manual related jobs than their thinner counterparts. These patterns were different for men in that the prevalence of overweight and obesity was lowest in men of mixed ancestry (31%), followed by Indian men (32.7%) and African men (35%), and highest in white men (54%). In 2003, a follow-up SADHS was conducted and it showed that in men, 9% were obese and 21% overweight, for women 23% were obese and 29% overweight (96), a slight increase for men and a slight decrease for women since the 1998 SADHS. Furthermore, the SADHS (77) showed that in women, lower educational attainment was associated with higher BMI and it also related to misperceived body weight perceptions. Other international studies corroborate that lower educational status is associated with obesity (11) in developing countries.

1.6.6 *Obesity in children and adolescents*

The prevalence of childhood obesity has rapidly increased over the past decade in both developed and developing countries; currently over 200 million school-age children are overweight, making this generation the first predicted to have a shorter lifespan than their parents (7). Currently, 43 million children (35 million in developing countries) under the age of five are estimated to be overweight or obese and a further 92 million are overweight, defined as

weight-for-height >+2 SDs using NCHS/WHO reference median (8). Of the developing regions, North Africa had the highest prevalence (8%) followed by southern Africa (6.5%), with South Africa contributing the highest prevalence of 6.7%.

Using the International Obesity Task Force (IOTF) BMI-for-age cut-offs, Wang and Lobstein (97) assessed anthropometric data of school-age children (ages 0 – 18 years) in 60 different countries across less-developed to more-developed nations (Table 1.6.1). Their findings showed that in all countries, except for Russia, there was an increasing annual prevalence in overweight and obesity, between 0.2% in rural China to 2.3% in East Germany. They found that obesity had increased the most dramatically in economically developed countries and in urban environments. However, increases were also found in LMICs, albeit at relatively slower rates. Parts of Southeast Asia and sub-Saharan Africa had the lowest prevalence. South and Central America, northern Africa and the Middle East countries lie between. Of note is the fact that the prevalence of overweight children and adolescents in many developing countries (Brazil, Chile, Mexico and Egypt) had reached levels similar to industrialised nations by 2010.

As with adult obesity patterns, in younger people the development of obesity is influenced by the country's GDP, and an individual's SES, gender and ethnicity (98).

The Bogalusa Heart Study found that BMI tracked from childhood to adulthood, with 53% of overweight children becoming overweight adults compared with only 15% of those whose BMIs were <50th centile (84). Other research in developed countries has also shown that tracking is especially likely if obesity is present in later childhood or adolescence with the odds ratio rising

linearly with age (99). The concern with rising overweight and obesity levels is that it not only predisposes individuals to metabolic disease in adulthood, but also places overweight children at risk of higher blood pressure, increased insulin resistance and higher cholesterol compared to their normal weight peers (100).

Table 1.6.1 Prevalence of overweight and obesity in school-age children based on latest available data and the IOTF criteria, and estimated for 2010 based on population-weighted annualised increases in prevalence (89).

	Most recent surveys		**Projected 2010**	
WHO Region (dates of most recent surveys)	Overweight (including obesity) %	Obesity %	Overweight (including obesity) %	Obesity %
Africa (1987 – 2003)	1.6	0.2	[a]	[a]
Americas (1988 – 2002)	27.7	9.6	46.4	15.2
Eastern Med (1992 – 2001)	23.5	5.9	41.7	11.5
Europe (1992 – 2003)	25.5	5.4	41.7	10.0
South East Asia (1997 – 2002)	10.6	1.5	38.2	5.3
West Pacific (1993 – 2000)	12.0	2.3	27.2	7.0

[a]Insufficient data to make estimates of projected prevalence rates.

1.6.7 *Obesity in South African children and adolescents*

As with nutrition data in South Africa, there are also a limited number of national anthropometric surveys assessing the prevalence of overweight and obesity among adolescents. Therefore, as

shown in Table 1.6.2, the studies obtained include younger children and also smaller regional surveys (including both rural and urban environments) carried out between 1994 and 2004.

Table 1.6.2 Studies assessing the prevalence of overweight and obesity among children and adolescents in South Africa.

Source	Date of Study	Study Name	Ethnic group	Area	Age in years sample size	Summary of findings*
Jinabhai et al. (2005)	1994-1998	Review of 4 cross-sectional studies	Not stratified by ethnicity	KwaZulu-Natal Rural/urban	2-5 4-11 2-5 8-11 n=18823	Overweight and obesity prevalence between 7% and 34.1% Overweight more prevalent in girls than boys
Monyeki et al. [4](1999)	1996	Ellisras Longitudinal Investigation in Rural Community Children Project	black	Limpopo Province Rural	3-10: n=1336	0-2.5% in males and 0-4.3% in females had BMI above NHANES III 85th percentile
Steyn et al. (2005)	1999	NFCS	All	Nationally representative of South Africa Rural/urban	1-9: n=2894	Overweight and obesity prevalence 17.1% Urban dwellers highest prevalence Lower SES associated with decreased risk
Kruger et al. (2006)	2000-2001	THUSA Bana	All	North West Province, Rural/urban	10-15: n=1257	Overweight and obesity prevalence 7.8%. More prevalent in girls than boys. White children: highest prevalence (14.2%), followed by black (7.1%), Indian (6.4%), Mixed Ancestry (2.9%)
Armstrong et al. (2006)	2001 - 2004	Health of the Nation Study	black, white, Mixed Ancestry	Random sample of primary schools within each province and SE category Rural/urban	6-13: n=10195	Prevalence of overweight and obesity 14%, 3.2% for boys and 17.9%, 4.9% for girls

[4] Monyeki et al. (1999) used 85th percentiles of the NHANES III to estimate overweight, the remaining studies used IOTF (93) cut-off points to estimate overweight and obesity.

The 1999 NFCS found that the prevalence of combined overweight and obesity (>25 kg/m^2) in children aged between 1 – 9 years old at the national level was 17.1% (95% CI = 15.00 – 19.23) (79). However, regional differences were found in that the highest prevalence of overweight and obesity was found in 'formal urban' areas (21.1%, 95% CI = 16.01 – 21.19), followed by 'tribal areas' (15.8% 95% CI = 13.52 – 16.80), 'informal urban' areas (13.4%, 95% CI = 10.02 – 16.80) and lastly, among farm dwellers (10.8%, 95% CI = 6.03 – 15.50).

The NFCS was designed to oversample an additional 25% of respondents from low socio-economic backgrounds. An interesting and important finding related to under-nutrition was that the national prevalence of stunting was similar to overweight 19.3% (95% CI = 17.5 – 21.2). Furthermore, many of the determinants of both overweight and stunting were the same, but in opposing directions. For example, mothers (or primary caregivers) who had lower educational attainment presented a significantly lower risk for overweight but a significantly higher risk of stunting among their children. In contrast, having a flush toilet in the home (an indicator of SES) conferred a higher risk of overweight and a lower risk of stunting.

In their *Health of the Nation* survey Armstrong et al. (101), used random sampling of primary schools in five of the nine provinces of South Africa to assess overweight and obesity using IOTF cut-offs (102), among children aged between 6 – 13 years (n=10 195). Participants were from diverse socio-economic backgrounds; the Provincial Department of Education provided pentile or decile ratings for each school according to SES and schools were ranked according to these criteria before a random selection process was undertaken. This cluster-stratification provided a sample of schools representative of the wide range of socio-economic backgrounds in South Africa. The authors determined that the prevalence of obesity and overweight in males

was 2.4% and 10.9% respectively and in females was 4.8% and 17.5% respectively, for all ethnic groups combined. These findings are similar to the NFCS results. An interesting finding was that combined overweight and obesity in black girls in this sample, increased from 12% to 22% between the ages of 6 and 13 years. Divergent patterns were found among white girls in that combined overweight and obesity decreased with age, from 25% to 15%. It has been suggested that cultural differences in the perceptions of ideal body weight or body size may account for these different body composition patterns. For example, in African cultures a larger body size represents wealth and happiness (103). Moreover, being larger is a sign of not having HIV/AIDS, which is an important factor considering the current epidemic in Africa. Conversely, some research has shown that white females embrace the Western body size norm which rejects fatness (104).

In contrast, Monyeki and colleagues (105) found the prevalence of overweight and obesity in young rural children from Limpopo Province to be low; 0 – 2.5% and 0 – 4.3% in boys and girls aged between 4 – 7 years respectively, children aged 3, 8 and 9 did not show signs of overweight or obesity. However, BMI was assessed according to the *National Health and Nutrition Examination Survey* (NHANES III) 85th centile cut-off points (106). Caution is required when making comparisons between studies, particularly when different cut-off points are used. This study however, also assessed fatness (the sum of triceps and sub-scapular skinfold measurements) and those with measurements of >85th percentile were categorised as over-fat. It is interesting to note that among boys about 15% displayed over-fatness at ages 3 and 4, while a lower prevalence was found at older ages. In girls 8% of 3 year olds displayed over-fatness and at 6 years of age this figure dropped to 0.6%. This study was undertaken in a rural area close to the Botswana border.

Jinabhai et al. (107), undertook secondary analyses of two national surveys (Table 1.6.2, Steyn et al. and Armstrong et al.) plus two regional surveys of KwaZulu-Natal, which has the highest rural population (60%). Regarding the two national surveys, the researchers extracted data pertaining to KwaZulu-Natal only. Their findings showed a high prevalence of overweight and obesity across all ages (2 – 11 years old) but it did decrease with age (see Table 1.6.2). Furthermore, the prevalence was greater among girls than boys across all age categories. The advantage of this previous study was that the authors assessed overweight and obesity using the gender and age-adjusted IOTF cut-offs, to allow for comparisons among the four surveys. However, the surveys were carried out at different times (1990–1994) and the selection criteria were different as were the age groups selected, which all may have a bearing on the results. Data on ethnicity and SES was not presented and although the surveys included rural and urban respondents, no distinctions were made when reporting the statistics (except for one survey which only included rural respondents). Historically, ethnicity and SES are strongly related and are potential confounders for growth patterns which were not addressed. However, in spite of the heterogeneity of the surveys and some limitations, the authors consistently showed a high prevalence of overweight and obesity, with girls being more affected than boys. This is consistent with adult data.

In a regional cross-sectional study in the North West Province which covered both rural and urban areas, Kruger and colleagues (54) investigated the determinants of overweight and obesity among 10 – 15 year olds. The prevalence of combined overweight and obesity was 8% in those living in urban environments. Urban children consumed slightly more energy and fat and had the highest BMI, triceps skinfold and sub-scapular skinfold measures, followed by children in rural and informal areas. Compared with children from rural and informal areas, urban children had a moderately high mean body fat percentage.

1.7 Assessment of obesity in children and adolescents

1.7.1 *Fat mass*

Body fat is the ideal measure of obesity risk but is not always practical when used to assess in epidemiological studies (102, 108) since it requires either specialist skills to undertake measurements (such as skinfold thickness) or additional equipment which is costly and immobile (e.g. air displacement plethysmograph (Bod Pod) or a dual-energy x-ray absorptiometry machine (DXA)). Furthermore, currently there is little epidemiological data on body fat content with one normative body reference curves published by McCarthy et al. (109), however this is based on a UK child and adolescent population. Other research has shown that DXA estimates of body fat correlate well with measures of insulin resistance, glucose intolerance and blood lipids (67) but interestingly, Steinberger et al. (110), found that DXA measures and adverse cardiovascular risk factors in adults and children were no higher than those presented by BMI or skinfold measures.

This research project had available a DXA machine, which was used to assess fat mass as a comparative measure against body mass index (see 4.5.2). This method is a 2-compartment body composition technique that differentiates between bone mineral and soft tissue, allowing fat mass (FM) and lean mass (LM) to be calculated. These measurements are not affected by growth and development which makes it ideal to assess body composition in children and adolescents. This technique has high precision (~1% in adults) but there are concerns regarding the accuracy of measurements (111). Although its advantage over more crude methods of assessment is that it is able to measure soft tissue, its main limitation is that body density is assumed to be constant and it has been shown that body density varies according to ethnicity and bone density (112). However, such methods can help elucidate the relationship between

body composition and chronic disease risk since precise measurements on soft tissue can be made.

1.7.2 *Central fat distribution*

Central fat distribution has been found to be significant in the aetiology of disease related to obesity; intra-abdominal fat, particularly visceral fat, is associated with increased risk of insulin resistance, hypertension, dyslipidaemia and atherosclerosis (113). Hence, central obesity is defined by a cut-off point of the waist:hip ratio of 1.0 and 0.85 in men and women respectively (65). In the SADHS, central obesity was found in 42% of women with black urban women experiencing the highest prevalence. In men, central obesity affected 9.2% of the sample with older men and white men most affected (77). However, it is debatable as to whether central adiposity measurements are appropriate for children and adolescents (114).

1.7.3 *Body mass index (BMI)*

In adults the clinically accepted measure of obesity is body mass index (BMI). BMI, a weight-for-height index reflects total body fat and is calculated by weight (kg) / height (m^2). Although it does not differentiate between adipose tissue and lean tissue, given the same BMI, the relative compositions of FM versus lean tissue are dependent on age, gender and ethnicity (67).

Height and weight can be measured with some accuracy in different laboratories and field settings (101). The cut-off for overweight is 25 kg/m^2 and for obesity 30 kg/m^2, and both cut-offs are closely correlated with adverse health outcomes in adults (115). However, in some populations it has been suggested that the cut-offs should be lowered since there is emerging

evidence to suggest that the increased risks associated with obesity occur at a lower BMI in different population groups. In Asia-Pacific populations the recommended BMI cut-offs for overweight and obesity were 23 kg/m^2 and 25 kg/m^2 respectively (116) and these figures may be different in Chinese populations, 24 kg/m^2 and 28 kg/m^2 respectively (115).

In children and adolescents, there has been lack of consistency in the use of the terms 'overweight' and 'obese'. Although the most widely used recommendations (see 1.7.4 onwards) take into account the two levels of excess weight, the use of different definitions has led to confusion on interpretation of research results, monitoring trends or comparing prevalence data, both nationally and internationally (24).

1.7.4 *The 2000 CDC/NCHS growth charts*

The most commonly used growth reference charts are those based on the US Centers for Disease Control and Prevention (CDC), originally developed in 1977 as a tool to monitor growth in children. In 2000 these charts were modified to include BMI to assess overweight and obesity (117). 'At risk of overweight' is classified by a BMI of >/= 85th percentile and 'overweight' is defined as >BMI 95th percentile. Yet a criticism of this method is that the cut-off points were arbitrary and the population on which these criteria were based was US-specific, which would make the reference cut-offs less applicable to non-US populations. Furthermore, since the growth charts are composed of data from five US surveys, they do not represent the US population at any one time point (118).

1.7.5 *International Obesity Task Force cut-offs*

In 1999 the IOTF agreed that BMI was a reasonable measure of adiposity in children and introduced the terms 'overweight' and 'obese', to have consistency with adult definitions. But unlike in adults, BMI varies substantially with age and gender during childhood; with the median as low as 13 kg/m^2 and as high as 17 kg/m^2 at age 1, it decreases to 15.5 kg/m^2 at 6 years of age and increases to about 21 kg/m^2 at age 20 (102, 115). Accordingly, in 2000 the IOTF (102) presented a new reference for BMI cut-offs in children and adolescents, which were age- and gender-specific (see Table 1.7.1). These references were based on internationally pooled data from six nationally representative cross-sectional growth surveys (from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States), each sample with >20 000 participants aged between 6-18 years old (N=192 727). Centile curves were drawn so that at age 18 they passed through the cut-off points of 25 kg/m^2 and 30 kg/m^2 (to correspond with adult overweight and obesity respectively). Consequently these curves were averaged to give age- and gender-specific cut-off points from 2 to 18 years.

The IOTF age-and gender-specific BMI cut-off points are less arbitrary than the CDC cut-offs in that they correlate with adult BMI cut-offs which are appealing to clinicians and researchers. Some suggest that cut-offs in children and adolescents should be based on morbidity risk since they are likely to be different to adults (117). Other considerations which have been highlighted are that IOTF cut-offs may under- or over-estimate overweight in comparison to national definitions, that they do not give cut-offs for underweight or severe obesity and they do not include children under the age of two years (118).

Table 1.7.1 International cut-off points for body mass index for overweight and obesity by gender and age groups 13, 15, and 17 years, defined to pass through body mass index 25kg/m^2 and 30kg/m^2 at age 18, obtained by averaging data from six cross-sectional surveys.

	Body mass index 25kg/m^2		Body mass index 30kg/m^2	
Age (years)	Male	Female	Male	Female
13	21.91	22.58	26.84	27.76
13.5	22.27	22.98	27.25	28.20
15	23.29	23.94	28.30	29.11
15.5	23.60	24.17	28.60	29.29
17	24.46	24.70	29.41	29.69
17.5	24.73	24.85	29.70	29.84

1.7.6 *World Health Organisation growth references*

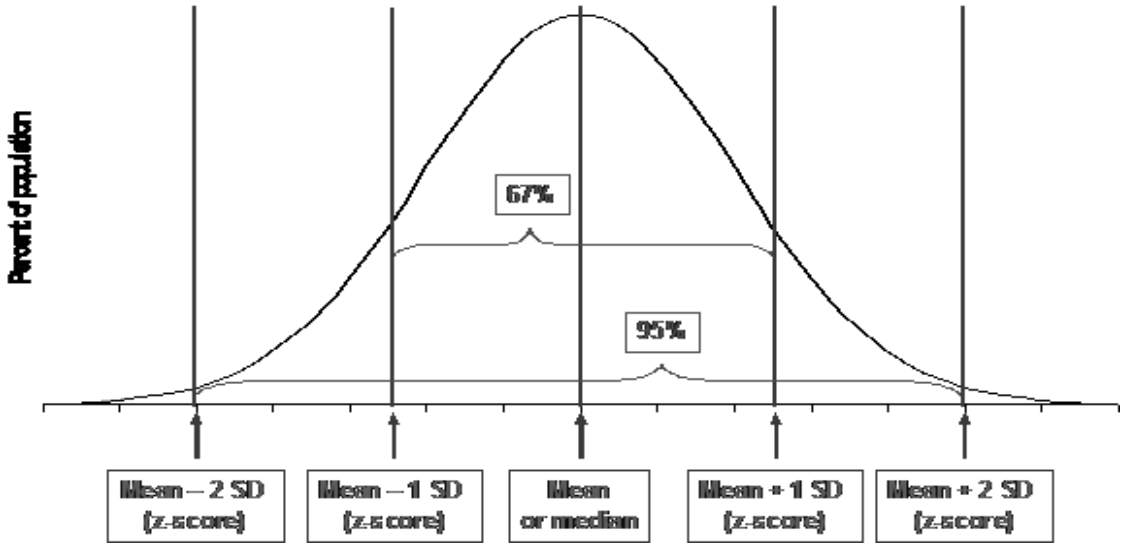
In 2007 the WHO produced growth reference data for 5 –19 year olds (119). This reference complements the WHO child growth standards for 0 – 60 months, published in 2006 (120, 121). The WHO growth reference for 5 – 19 year olds was based on merged data from the 1977 National Centre for Health Statistics (NCHS)/WHO growth reference (1 – 24 years) and the WHO Child Growth Standards (0 – 5 years). Statistical modelling techniques were used to construct the growth curves. After the model was fitted, the curves were truncated to cover the required age range of 5 – 19 years, for height-for-age and BMI-for-age. The cut-offs for overweight and obesity are as follows: overweight, >+1SD (equivalent to BMI 25 kg/m^2 at 19 years) and obesity, >+2SD (equivalent to BMI 30 kg/m^2 at 19 years).

NCHS/WHO references were developed on the basis of data collected from the US only, which means that this dataset does not represent optimal growth patterns for all age groups and from all regions of the world (122). An additional concern is that the distribution of BMI in the

population in question was positively skewed with a high prevalence of overweight.

1.7.7 *BMI z-scores*

Where the international references are not applicable, especially in LMICs populations which experience delayed sexual maturation, an alternative approach to classify overweight and obesity is the use of BMI z-scores (or standard deviation scores). A z-score or standard deviation is the measure of the dispersion of data; it is a measure of an individual's value with respect to the distribution of the reference population (123). For example, a z-score indicates how many standard deviations an observation is above or below the mean, and is derived by subtracting the population mean from an individual raw score and then dividing the difference by the population standard deviation, see Figure 1.7.1.



Source: LSHTM (124)

Figure 1.7.1 Example of a z-score distribution.

BMI z-scores allow individual measurements to be compared to the relative standings of the population under investigation. Overweight (equivalent to BMI 25 kg/m^2) is >+1SD and obesity (equivalent to BMI 30 kg/m^2), >+2SD. As a standardised measure, z-scores have the advantage of being comparable across ages and gender and indicators (122).

1.7.8 *Limitations of BMI*

A criticism of all BMI cut-offs for overweight and obesity in children and adolescents is that none are based on morbidity risk as with the adult cut-offs. However, currently there is insufficient data to allow for such a classification (122).

BMI is an indirect measure of fatness (108), it underestimates the effect of height on weight; taller children tend to have larger BMIs than shorter children and results in them being

incorrectly classified as overweight. As shown in the foregoing subsections, the international community uses different references based on different populations with little or no representation of populations from developing countries. Adolescents from LMICs mature later than their developed county counterparts and thus the reference populations used in the abovementioned growth references (125). This will most definitely lead to misclassification and spurious prevalence figures of overweight and obesity in these populations. For example, Wang and Wang (115) used national data from the US, China and Russia and found that if the US BMI 85th percentiles (NCHS/WHO reference adolescents) and the IOTF BMI references which were used to define overweight, showed that the prevalence was much lower in adolescents (10 – 18 years) than children (6 – 9 years) from Russia and China, but that the prevalence among children and adolescents was similar to that in the US.

Researchers have identified ethnic differences and secular trends in growth, body composition, body build and sexual maturity that complicate the interpretation of BMI cut-offs (122). For example Wells et al. (126), compared contemporary Cambridge adolescents to the British reference population and found that the contemporary group had higher fat mass and lower lean mass. This led to the suggestion that current BMI cut-offs may have underestimated the obesity prevalence figures.

Despite its limitations, BMI is the universally accepted measure of relative fatness; height and weight measurements are relatively easy to undertake and they require very little equipment and little skill to take the measurements. More direct techniques of measuring fat mass are more cumbersome and may be time-inefficient for the fieldworker (skinfold thickness) and expensive or inappropriate in a field-setting (DXA and densitometry).

1.8 The relationship between dietary habits and practices and obesity

A key to understanding the development of obesity lies in changing dietary patterns and physical activity patterns, although the latter topic is beyond the scope of this research and will not be discussed. However, not only is the dietary intake of adolescents a concern, but their dietary habits and practices are of importance (40).

Dietary habits and practices formed in childhood may be entrenched by adolescence and track into adulthood. Tracking, the correlation between early measurements and measurements in later life (127), seems to hold for dietary intake patterns as there is evidence that patterns developed in younger years are maintained into adulthood (128-132). Assessing dietary intake (with a DAM such as a FFQ) is difficult for subjects to conceptualise and also for health workers to communicate effectively[5]. In contrast, a more qualitative approach which focuses on specific behaviours around food intake, might be a more effective approach in clinical and research settings (133); respondents would find the concept of a habit around an eating practice easier to comprehend than trying to recall servings of a particular food. Furthermore, the general population would find it easier to understand recommendations based on buying patterns and servings of foods, as opposed to nutrient intakes (67). Thus research into dietary habits (and behaviours) can complement DAMs by emphasising areas of potential risk of poor eating behaviours.

Typical adolescent eating behaviours include snacking (usually energy-dense foods), skipping meals (particularly breakfast), irregular eating patterns, high consumption of fast food and sweetened beverages (eating away from home regularly), and low intake of fruit and vegetables

[5] An example of this would be the move towards educating the public in terms of food-based dietary guidelines as opposed to disseminating nutrition information in terms of nutrient intakes which are often difficult to interpret.

and dairy (24). Some adolescents develop strong food beliefs, adopt 'fad diets' and experiment with vegetarianism (46, 134). In many cultures alcohol intake commences at adolescence (often tobacco use and other drug taking may also begin) and binge drinking can become a problem (135).

Thus, research into specific dietary habits associated with obesity risk among adolescents has focused on breakfast habits, meal-skipping, consumption of food while watching TV, snacking, food intake at school, eating the main meal with the family, fast food and soft drink consumption (136-142). The following section outlines the main research outcomes in these areas however there is a noticeable lack of data from LICs and MICs, particularly in South Africa.

1.8.1 *Breakfast*

Many studies have examined the associations between breakfast and health-related issues such as micronutrient intakes (143), body weight (144) nutrient status (145) and serum lipids (146). In a study, of nearly 5 000 British 16 – 17 year olds, it was found that 78.7% of males and 63.1% of females ate some breakfast over a 4-day period, (143). In a US study of 10 year old children's breakfast consumption (n=467), the results indicated that overall, 16% did not have breakfast and that African American girls skipped breakfast the most (24%) (147). In their review of breakfast and nutrient associations, Ruxton and Kirk (136) found that the omission of breakfast is most common among young adults and those aged between 13 – 16 years, and that the omission of breakfast increases with age, with girls more likely to skip breakfast than boys. This trend of increasing breakfast omission with increasing age was also highlighted in the UK Sodexho *School Meals and Lifestyle* survey (148). It was found that 8% of children have

nothing to eat before school, and this rises to 12% for 15 – 16 year olds and 17% for 15 – 16 year old girls.

Studies in adults in developed countries have shown that routine breakfast consumption aids weight loss, or maintenance (133). After controlling for energy intake, energy expenditure and other confounders, Ma et al. (149) found that skipping breakfast (>75% of days measured by repeated 24-hour recalls) was associated with 4.5 times higher risk of obesity compared with those who reported to eat it regularly; 95% CI: 1.57 – 12.90. However, the study was cross-sectional and these findings cannot be considered causal, i.e. the data may be representative of current diet but not of past diet (which may actually mean that the diet led to the obesity). Furthermore, only <4% of the sample reported skipping breakfast. This is substantially lower than the US population as a whole, in which one quarter of adults usually skipped breakfast (*Third National Health and Nutrition Examination Survey* (NHANES III)), (150). Nonetheless, a strength of the study was that an average of 15 repeated 24-hour recalls was used for each participant, which would have reduced intra-person variation. Although the authors stated that this was a strength of the study, participants would have anticipated the questions and possibly become complacent with their responses.

The relationship between breakfast habits and BMI among children and adolescents is equivocal, again due to study design limitations. Cross-sectional studies in developed countries have shown that overweight children eat breakfast less regularly than normal-weight children (151). Children who skipped breakfast were reported to have a higher percentage of energy from fat and a lower intake of energy from protein and of micronutrients (152), consumed more snacks higher in fat, and had higher total cholesterol levels (153). However, it cannot be claimed

that the relationship between breakfast-skipping and overweight is causal because of the nature of the above studies. In one longitudinal study (n=14 000) that assessed breakfast-skipping and BMI both in cross-sectional and longitudinal analyses, different results were found. As with other studies, when assessed in cross-sectional analysis, skipping breakfast was associated with increased BMI, and breakfast-skippers' energy and fat intakes were higher than regular breakfast consumers. However, in longitudinal analyses, breakfast-skipping among overweight adolescents was associated with relative BMI declines over the 1-year follow-up period (in boys -0.66 +/-0.22, p=0.01; in girls -0.50 +/-014, p=0.01) but in the normal weight participants there was a non-significant increase in relative BMI over the same period (in boys +0.21 +/-0.13, p=0.11; in girls +0.08 +/-0.05, p=0.15) (154). A limitation of this study was that questionnaires were self-administered by mail, and included self-reported height and weight data so there is a possible issue with under-reporting, particularly in overweight subjects. However, in an attempt to counter this, the study design used 1-year BMI changes and compared overweight children to other overweight children (of differing breakfast intake frequencies). The sample size of this study was impressive, and the subjects were offspring of women who had participated in the *Nurses' Health Study*, however this group is not necessarily representative of the US population as lower socio-economic groups would be under-represented.

1.8.2 *Family main meal*

In adolescents, a higher frequency of participating in family meals has been shown to be associated with a reduced consumption of soft drinks and fried foods, and increased intake of fruits and vegetables (155) and micronutrients (156). The family meal influences adolescent diets in two ways: the family provides food, and it also influences attitudes to food, food preferences and (food) values, which last throughout the life course (33). It is therefore

suggested that the main family meal setting has the potential to positively influence the dietary intake of children and adolescents and may be a means of preventing obesity (141).

An American study of >90 000 adolescents aged between 11 and 17 years, found that 20% of participants rarely ate their main meal with their family (0 – 1 days/week) while 45% frequently ate this meal with their family (between 5 – 7 d/week). Furthermore, >50% of the younger adolescents (11 – 14 years of age) frequently ate the main meal with the family, compared to just over 30% of the older adolescents (15 – 17 years of age). The research also showed that overall, more males (47%) than females (42%) ate this meal frequently with their families (141). In another US study, the proportion of adolescents who never ate their main meal with their family increased with age: from 8.9% in ages 11 – 13 years to 15.4% in ages 16 – 17 years (140).

Research has been conducted to investigate the relationship between main family meal frequency and obesity risk however, results have been somewhat ambiguous. In a cross-sectional analysis, Tavares et al. (157) found that after adjusting for confounders (SES, age, maturation, baseline height, ethnicity, physical activity, physical inactivity and energy intake) the odds of being overweight were lower (0.85; 95% CI: 0.76, 0.96) among adolescents who reported eating the main family meal on most or every day of the week during the past year, compared with those who ate family main meal ‘never’ or ‘some days’. However, in their longitudinal analysis of the data (1-year follow-up), the odds ratios between previous year frequency of eating family meals and 1-year incidence of becoming overweight were 0.95 (95% CI: 0.78, 1.16) and 1.04 (95% CI: 0.85, 1.27) for those who ate their main meal on ‘most days’ and ‘every day’ respectively, compared with those who ate it less regularly. Fulkerson et al.

(140) undertook a similar study but with a 5-year follow-up. Similar to the previous study, their findings showed that in the cross-sectional analysis there was a significant inverse association between family meal frequency and overweight status among females only, although no association was found in the longitudinal analyses.

Tavares et al. (157) outlined potential reasons as to why there was no longitudinal association between frequency of main meal and overweight: the significant finding in the cross-sectional analysis may be a result of a mechanism that occurred in earlier childhood, in that the family influence on food choice occurs earlier in life. Reverse causality may explain the cross-sectional findings: those who were overweight may have been skipping the family meal in an attempt to control their weight, which would have resulted in biasing the longitudinal results towards that of no finding. The wider confidence intervals in the longitudinal analysis suggest that the sample size was too small to detect an association between the two variables. However, their sample included 16 882 participants, which is substantial. Finally, perhaps there truly is no association between family meal frequency and overweight; future research could incorporate data on diet quality and meal composition.

1.8.3 *Snacking behaviour*

It is hypothesised that snack foods may contribute to weight gain in several ways: snack foods contain 140-300 kcal per item and thus if several items are consumed per day, these would contribute a substantial amount of energy to total intake (158). Many snack foods contain a high proportion of fat which may be a mediating factor for weight gain, yet there is little consensus on the definition of a snack and certainly no consensus on what defines a ‘healthy’ snack.

Snacks have been defined in a variety of ways; according to the name identified by the respondent, the time of day, food type, or defined by their energy value (which can include sweetened beverages); however, some workers have classified snacks as eating occasions outside of meals (159-162). Different definitions contribute to the difficulty in assessing and comparing results between studies and their impact on body composition. However, there has been a concurrent rise in the prevalence of obesity and increased snacking. Studies have shown increased energy intake related to snack habits (159) and there is equivocal evidence that frequent snacking has been associated with childhood weight gain (163). Snacks and meals are obtained from many environments and there has been considerable attention paid to snacking while watching television and the relationship between hours of viewing and energy intake. Snacks are also taken at school at breaks, at home and while away from home.

Ecological US data assessing snack intake among young people (aged 2 – 18 years; n=31 337) between 1977 and 2006, has shown important increases in snacking behaviour across all age groups assessed; that children and adolescents now tend to consume three main meals plus three snacks per day, and snacking accounted for up to 27% of energy intake (163). Limitations of this study include study protocol differences between the different surveys; 24-hour recall methods differed between studies and number of days of intake studied may have influenced the outcome, although the researchers used two days from each study for uniformity. Furthermore, these findings do not show a relationship with obesity risk, merely an estimate in the increasing trend in consumption of snack foods.

In a prospective study among offspring from the *Nurses' Health Study* (158), the results showed that snack foods were not an independent determinant of weight gain among those aged 9 – 14

years. However, although snack foods data was collected, the number of snacking occasions was not measured, that is, foods eaten as snacks such as sandwiches or cereal, were not measured. Therefore, snacking occasions were probably underestimated and snacking patterns of the respondents may have been misclassified, which may be one explanation for the lack of positive association. Furthermore, the findings from this study cannot be generalised to economically disadvantaged populations.

1.8.4 *Snacking while watching television*

There is considerable research assessing the exposure to food television adverts that are contrary to a healthy diet (164, 165). Studies have elucidated that generally, food advertising leans towards fast food, energy-dense snacks and soft drinks and that there is less advertising for healthy food items (164, 166). In an ecological study of advertising of food to children and obesity risk in the US, Australia and eight European countries, Lobstein and Dibb (166) found that there was a significant association between the proportion of children who were overweight and the amount of advertisements per hour on children's television encouraging the consumption of energy-dense, micronutrient-poor foods ($p<0.01$). They concluded that the number of adverts on children's television appear to be related to the prevalence of excess body weight and that the content of the adverts appears to have a specific effect. Their recommendation was that there was a need for taking precautionary measures to reduce children's exposure to obesogenic marketing practices.

The time spent watching TV and its influence on dietary habits has also been assessed. Utter et al. (2005) showed that the more frequent exposure to (food) advertising influences the frequency of consumption of soft drinks, some sweets and snacks, and some fast foods among

children and adolescents. Furthermore, the odds of being overweight or obese increased with the duration of TV viewing in children and adolescents after controlling for age, gender, ethnic group, physical activity and SES. However, this latter study was cross-sectional. In a prospective observational study over a two-year period the authors found that in 12 year olds, with each hour's increase in television viewing there was an additional consumption of 167 kcal/d (95% CI 136 – 198, $p<0.001$) (167).

In a study undertaken among Australian adults, it was found that cumulative exposure to TV food adverts influenced participants' fast food consumption (138). In children, exposure to food adverts produced substantial and significant increases in energy intake in all children ($p=0.001$) and the increases were largest in obese children ($p=0.04$). Both normal- weight and overweight children increased their consumption of high-fat or sweet, energy-dense snacks in response to the adverts ($p=0.001$) (168).

In this thesis, data on snacking while watching TV is assessed.

1.8.5 *Soft drinks*

The term 'soft drink' refers to sweetened beverages or sugar-sweetened beverages such as fruit drinks, colas and iced tea (169). Trend data from the US showed that soft drink consumption has increased by 2.35 times between 1977 – 2001 (170). Similar trends were found in Sweden, with soft drink consumption doubling between 1990 – 2005 (171). In the UK soft drink intake accounts for the largest single source of non-milk, extrinsic sugar consumption in the diets of children and adolescents (49); this use displaces milk and therefore calcium, which is of concern among adolescents since generally, calcium intake has been shown to be low (49, 51), which could compromise adult bone-mass density.

An average can of soft drink (340 ml) contributes 150 kcal and about 40 g sugar. One proposed mechanism for the link between soft drink consumption and adiposity is that high consumption simply leads to an excessive energy intake and positive energy balance. However, it is unclear if the energy imbalance is a result of a difference in satiety properties between liquids and solid food (59).

Systematic reviews focus on a single question which tries to identify, appraise, select and synthesise research evidence relevant to that question. Malik et al. (169) undertook a systematic review of 30 studies assessing the intake of sugar-sweetened beverages and weight gain across all age groups. Studies included cross-sectional, longitudinal and three experimental feeding trials. Their inclusion criteria were limited to studies published between 1966 and 2005. Longitudinal studies were required to have a minimum of a 6-month follow-up period. The exposure of interest covered a range of sugar-sweetened beverages and the outcome included one or more endpoints evaluating body size. Overall, the authors concluded that the evidence supported the link between the consumption of sugar-sweetened beverages and the risk of overweight or obesity. However, they did stress that the interpretation of the data was complicated by several methodological issues including sample sizes, (short) follow-up periods, limited repeated measures in diet exposures and outcomes.

Six of the 13 cross-sectional studies, involving children and adolescents, found positive significant associations between the intake of soft drinks and overweight and obesity, three found non-significant positive associations and three studies found no association between the two variables. The largest cross-sectional study, the *Growing Up Today (*GUT) study (n=16 679), showed that soft drink consumption was positively associated with increased weight in

girls only (0.06 increase BMI/serving/day; p=0.04) (172). In the *NHANES III* study, consumption of soft drinks contributed a higher proportion of energy in overweight than normal-weight subjects (in 12 – 19 year olds) 10.3% versus 7.6% in males and 8.6% versus 7.9% in females (p-values not reported) (173).

Four of the six cited longitudinal studies on children and adolescents demonstrated significant positive association between intake of soft drinks and overweight or obesity. The largest study (n=11 654) (172), also the largest among the cross-sectional studies, showed a positive linear association between sugar-added beverage intakes and weight gain in boys only (+0.03 kg/m^2 per daily serving, p = 0.04). Furthermore, with each unit increase in daily servings of soft drinks there was an associated BMI increase (+0.04 kg/m^2; p = 0.016). However, adjustment for energy intake attenuated estimated effects, which became non-significant. Therefore the authors concluded that consumption of soft drinks may contribute to weight gain in adolescents but is probably due to their contribution to total energy intake. In a smaller study (n=548) of 12 year-olds over 18 months, Ludwig et al (174) found that after adjusting for fat intake, total energy intake, physical activity and television viewing, BMI increased by 0.18 from baseline for each additional serving consumed per day (95% CI:0.09, 0.27; p = 0.02). However, it is important the note that the consumption of soft drinks may be a marker for other dietary habits or other lifestyle factors which are associated with obesity. In addition, larger adolescents' overall energy intake will be greater than their smaller peers, and thus the intake of other dietary factors will also be greater.

Experimental studies on adults were included in the review and all supported the hypothesis that intake of sugar-sweetened beverages is positively associated with weight gain and obesity

(169). Raben et al (175) and Tordoff and Alleva (176) assessed the effects of sucrose and high-fructose corn syrup against a non-energy sweetener on energy intake and body weight. In both trials those who were supplemented with artificial sweeteners experienced significant weight loss ($p<0.05$) compared with those who consumed sugar-based sweeteners.

1.8.6 *Food at school*

There is increasing concern that the consumption of confectionery and snack items are associated with poor diet quality and an increased susceptibility to obesity (177). Evidence has shown that fat and sugar levels are especially high in snacks bought from school tuck shops. The role of schools in influencing adolescent dietary practices has been studied in developed and developing countries (177-179). Few guidelines governing the sale of foods at school are in place in South Africa or other countries. This is a concern since adolescents spend a large proportion of their time at school and although it is important to acknowledge adolescent autonomy, research shows that food availability has a significant influence on adolescent food choices (38, 180).

In the US, a study of high school students assessed lunch patterns (n=1 088) and showed that 71% of respondents did not bring a lunch box to school, average tuck shop purchases were 0.7 (SD 1.2) days per week, and mean soft drink purchase was 1.6 (SD 1.7) days per week (from vending machines) (178), however nearly two-thirds of students reported purchasing soft drinks at least one day/week. Interestingly, the authors compared lunch patterns between students who attended schools whose students were not permitted to leave the school grounds during lunchtime to those of children who were allowed, and found that fast food intake was higher in those who attended schools with an open policy (0.8 (SD 0.8) per week vs 0.7 (SD 1.3) per

week). Conversely, lunch box usage was higher among those who attended a school with a closed policy. It is thought that food contained within lunch boxes is healthier than that obtained from making purchases at school.

New and Livingstone (177) did not find an association between confectionery consumption (from vending machines at school) and poor diet quality among UK teenagers. However, they speculated that vending machines at schools would not have been the primary source of confectionery or snacks, but would rather be the 'local shop' located between home and school.

Little research has been undertaken on food consumption in schools in South Africa (either assessment of food brought from home or purchases made at school), but one study evaluated food items consumed by 289 Pedi students in a poor rural area of Limpopo Province in the north of South Africa (56). In this study, it was found that only 10% of students took lunch to school, whereas 22% regularly bought snacks at the school tuck shop.

More recently, Temple et al. (181) assessed food items consumed by students attending schools in Cape Town; 69% of subjects bought food at school tuck shops and of those, 70% bought unhealthy food and 73% purchased two or more unhealthy items. Students from higher socio-economic backgrounds were more likely to bring in their own food from home, but were not more likely to buy healthier foods from the school tuck shop. In this same study ~50% of respondents brought food to school. It is thought that bringing food from home to school is healthier than purchasing items available at the school tuck shop, but the authors found this not to be the case as 'unhealthy' items outnumbered 'healthy' items by 2:1 in lunch boxes.

1.8.7 *Fast food*

Fast foods can be defined as convenience foods obtained in self-service or take-away eateries with minimal waiting, and are usually characterised as energy-dense, high in saturated fats, low in micronutrients and fibre, high in simple sugars and salt, generally larger in portion size than conventional home-cooked or restaurant foods (182, 183), and highly palatable (73). Research indicates that fast food consumption can displace healthier food options, and is associated with poor diet quality (184), decreased intake of fruit (184), and lower micronutrient intake including calcium, vitamin C and folate. In children and adolescents, Guthrie et al. (39) found that foods prepared away from home were higher in total and saturated fatty acids and lower in calcium, iron and fibre than foods prepared in the home. In the *Eating Among Teens* (EAT) study in the USA, adolescents who reported eating fast foods three or more times in the previous week had a 38.5% higher energy intake than those who did not consume fast foods (185). As their name implies, this food encourages rapid consumption of energy and being highly processed, the time required to chew it is much reduced, allowing for rapid consumption of energy which may impede satiety feedback mechanisms (186). One proposed mechanism by which fast foods may contribute to obesity risk is via energy density. Energy density, expressed as kJ 100 g^{-1}, is defined as the energy content per unit weight of foods, meals or diets, usually minus beverages since they have a differing effect on satiety (187). Energy-dense foods are likely to disrupt normal appetite control systems and the hypothesised mechanism involved relates to passive over-consumption whereby the body cannot down-regulate intake after consumption of an energy-dense meal (187).

An important study, *The Coronary Artery Risk Development in Young Adults* (CARDIA) study (182), showed a strong positive association between frequency of fast food restaurant visits and increases in bodyweight and insulin resistance in young black and white adults (aged 18 – 30

years, n=3 031) over a 15 year period (182). And compared to infrequent consumers, frequent consumers' average weight gain was 4.5 kg and they also had a two-fold greater increase in insulin resistance. This study thoroughly assessed confounding factors which may have been on the causal pathway between fast food intake and these body composition measurements. The authors adjusted for total dietary intake, total fat intake (including SFA, TFA), soft drink consumption, refined carbohydrate consumption, alcohol consumption, energy expenditure, TV viewing time, smoking and educational status, age and gender. It is interesting to note that no association was found between year 0 fast food frequency and year 0 bodyweight or HOMA insulin resistance in either black or white participants. Furthermore, the authors devised a healthy lifestyle score which showed a strong inverse association with fast food intake in white participants, but not their black counterparts. However, as with all self-reported observational studies on lifestyle and dietary intake and their habits, one is reliant on the honesty and recall ability of the participant and further, residual confounding does not exclude definitive conclusions about causality. But this study's strength was the length of follow-up and thorough confounder adjustments.

Among adolescents, fast food consumption has been linked to increased total energy intake, (184) however the association with increased weight gain is inconsistent (188, 189). Rosenheck (183) conducted a systematic review of 16 studies across all age groups (six cross-sectional studies, seven prospective longitudinal studies and three experimental studies) which sought to "examine the evidence investigating an association between fast food consumption and increased caloric intake leading to weight gain and obesity". Those studies, pertaining to children and adolescents, are now presented:

Of the cross-sectional studies, two related to children and one related to children and their parents. The first study of 6 212 nationally representative participants aged 4 – 19 years old assessed total energy consumption only (188). The results showed that those who reported eating fast food consumed an additional 187 kcal/day than their counterparts who did not consume fast food. Fast food consumers also ate significantly more total fat (including SFA), more total carbohydrate, more added sugars and more sweetened beverages and less fruit and vegetables. The data also showed that fast food consumption increased with age, with 25% of 4 – 8 year olds and 39% of 14 – 19 year olds consuming fast food on a given day. French et al. (185) found that although the frequency of fast food use was not significantly associated with BMI status for either gender, BMI was significantly lower among males who reported frequenting fast food outlets on three or more occasions per week, compared with those who reported less fast food outlet use. Although Boutelle et al. (190) did not find an association between fast food consumption and BMI among children and adolescents, they did find that there was an association with parental BMI: parents who reported buying fast food for family meals three or more times per week were more likely to be overweight ($p<0.01$) than parents who reported less frequent purchases of fast food.

Of the seven prospective studies cited in the Rosenheck (183) review, two relate to children and adolescents. Schmidt et al. (191) assessed the effects of fast food on diet quality among black and white girls, over a 10-year period. Fast food intake increased with age, and it was positively associated with energy and fat intake. There was a mean 127 kcal/day difference between the low consumers (<1 time/week) and high consumers (four or more times/week) ($p<0.01$). Furthermore, across all ages black participants consumed fast food more regularly than white participants. Unfortunately this study did not assess BMI as an outcome measure. Thompson et al. (192) assessed food eaten away from home (FAH) and its association with change in BMI z-

score among female participants aged 8 – 12 years (n=196). Median follow-up time was six years. Between baseline and follow-up those that ate FAH increased from 71% to 86% of the study participants and on average, FAH increased from two to three times per week. After controlling for baseline BMI z-score the likelihood of an increase in BMI z-score increasing over time was significantly larger among those who ate FAH twice or more per week at baseline compared with those who ate it less often.

Possible reasons for why the abovementioned studies did not show a consistent association between fast food consumption and BMI may relate to sample size and follow-up duration, methodological issues relating to dietary intake methods (see section 1.9) and residual confounding (is fast food consumption a proxy for other, less healthy behaviours which cumulate to increase weight?) (183). For example, low physical activity levels, sedentary behaviours such as watching TV, using computers, neighbourhood socio-economic status and total energy intake and dietary patterns should be adjusted for. In the two cited longitudinal studies, the authors did not adjust for any of these confounders. Furthermore, among adolescents issues around growth may also obviate the relationship between fast food consumption and obesity risk.

1.9 Methodological approaches to assessing dietary intake and dietary behaviours

While traditional dietary assessment methods (DAM) are not utilised in this study it was felt to be relevant to briefly describe them in this section so as to contrast the techniques used against those of alternative methods applied in this body of work.

1.9.1 *Traditional dietary assessment methods*

DAMs generally consist of either the collection of observations from a number of separate days' enquiry as in records, checklists and 24-hour recalls, or by obtaining the mean dietary intake by assessing the frequency of food consumed, as in a food frequency questionnaire (FFQ) or a diet history. With each method, an estimate of the weight of the food consumed is needed in order that nutrient and macronutrient composition may be determined, usually with locally-produced food composition tables or by chemical analysis. DAMs can either be prospective as in current diet or retrospective as in diet history and recall. Each method has its strengths and limitations (see Table 1.9.1). Prospective assessments are direct observations of intake and can be varied according to the aim of the study. They can, however, be labour-intensive and require a high degree of commitment from the respondent as well as requiring literacy and numeracy skills. Retrospective methods are less expensive, quick, and do not demand much from the subject other than a short period of time for an interview. The downfall of such methods is that they do not show habitual intake and can result in underestimating nutrient intake.

Valid dietary assessment is essential for studying the dietary determinants of obesity and related chronic diseases. However, difficulties in measuring true intake relate to large day-to-day variations of food and nutrient intake, biased reporting associated with weight status (flat

slope syndrome) and the intricacies relating to confounding factors. All DAMs depend on the subject's ability to provide accurate information, which is not easy to substantiate (since there is no 'gold standard' or reference DAM) (123, 193). Thus researchers validate one method of dietary assessment against another method; known as relative validity (123); usually diet records are used as a reference for FFQs, or 24-hour recalls.

In most validation studies the correlations between nutrients assessed by FFQs and diet records or repeated 24-hour recalls range from 0.4 – 0.7 (depending on the nutrient being assessed) (194). These limited correlations are a result of the inability of the assessment methods to fully capture the complexity of diets and the lack of a true 'gold standard' with which to compare them (194, 195). Repeating measurements potentially improves the validity of dietary measures by reducing random error. However, systematic error cannot be reduced by repeated measures, since if a DAM is imprecise at measuring true intake then this can only be improved by modifying the instrument in use.

Given that internal reference methods of validation are limited, external validation techniques have been employed, such as biochemical markers (123), or with measuring energy expenditure with doubly-labelled water (55) which give a more objective assessment (non-reliance on memory recall) and increase reliability (67), however such techniques add considerable expense to studies thereby limiting their use.

Table 1.9.1 Dietary Assessment Methods (DAMs), adapted from Gibson (123) and Hu (67).

Methods and procedure Retrospective	Uses	Limitations
24-hour recall **Participant recalls food intake of previous 24 hours in an interview (telephone or face to face). Quantities estimated in household measures using food models as memory aids or to assist with quantifying portion sizes.**	Single 24-hour recall interview unlikely to yield usual intake, omits infrequently consumed foods, so repeated interviews at random required. Provided sampling is truly representative and that days of the week are adequately represented, a useful method for assessing usual intakes of large populations. Inexpensive, quick (less than 30 minutes), low respondent burden, useful in illiterate populations.	Under- or over-reporting of foods due to reporting processes (e.g. alcohol and fruit). Not representative of usual diet due to insufficient number of days. Inaccuracy of portion size reporting due to conceptualisation and recall bias.
Food Frequency Questionnaire (FFQ) **Uses comprehensive or specific food item list to record intakes over a given period (day, week, month, year). Data obtained either by interview or self-administered questionnaire. Quantities obtained either with or without use of food models, schematic diagrams.**	Obtains qualitative descriptive data on usual intakes of foods over a long duration. Useful in epidemiological studies for ranking individuals into broad categories of intakes of specific foods, food components, or nutrients. Used to identify dietary patterns. Depending on the population method can be rapid with low respondent burden and a high response. Inexpensive.	Lacks detail, and specificity of diet records may not provide accurate estimates of absolute intakes. Requires cognitive estimation skills of the participants and recall bias. Subject to random and systematic errors.
Dietary History **Interview method consisting of a 24-hour recall of actual intake, plus information on overall usual eating patterns, followed by a FFQ to verify and clarify initial data. Portion sizes recoded in household measures.**	Used to describe usual food and nutrient intakes over a relatively long period of time. Labour-intensive, time-consuming and results depend on interviewer skills.	Interviewer bias. Portion size inaccuracy due to conceptualisation and recall bias. Errors in reporting of frequency; over-reporting of foods listed separately (e.g. individual fruits). Requires regular eating habits.

Table 1.9.1 Dietary Assessment Methods (DAMs) cont/d.		
Prospective		
Estimated Food Record **Record of all food/beverages consumed 'as eaten' over periods of days, from one to seven. Household measures used to estimate quantities.**	Assess actual or usual intakes of individuals depending on number of days assessed.	Accuracy depends on conscientiousness of participants and their ability to estimate portion sizes. A longer period of data collection burdens the participant, literacy required.
Weighed Food Record **All food/beverages consumed during study period to be weighed and recorded. Leftover food also weighed. Food samples or duplicate portions of foods may be stored for chemical analysis.**	Assess actual intakes. Accurate but time consuming. Setting must permit weighing. Participants risk changing their usual intakes to simplify the weighing process.	High respondent burden – respondents required to be motivated and committed to the process. Literacy and numeracy skills required. Expensive.

1.9.2 *Dietary pattern analyses*

A relatively new avenue of research relates overall dietary patterns to obesity and chronic diseases risk (196). Pattern analysis is based on similarity of habitual food use, which minimises confounding by other food nutrients. Therefore co-linearity of nutrients can be used as an advantage. Hu argues that categorising subjects according to their overall eating patterns (by assessing how foods and nutrients are consumed in combination) yields a larger contrast between exposure groups than analyses based on single nutrients (67). Furthermore, pattern analysis might be more useful to individuals, as people would interpret patterns more easily than single nutrients (67). However, pattern analysis is usually based on FFQ data which has certain limitations, as outlined in Table 1.9.1 and in section 1.9.3.

1.9.3 *Limitations of dietary assessment methods*

There is no perfect DAM so the researcher should consider each method's advantages and limitations as highlighted in Table 1.9.1. However, in a transition country setting such as South Africa, further obstacles need to be considered before embarking on dietary assessment studies.

A large proportion of the South African population is illiterate and a standard FFQ (often a 'self-complete' questionnaire in a developed setting such as the US) sent by post is not applicable in this environment. For a start, postal services are unreliable in South Africa. Yet, more importantly, conceptualising dietary intake notions such as frequency of intake and portion sizes is difficult, particularly among adolescents (personal observation and (197)). There is also the element of social desirability which comes with certain foods such as meat intake (personal observation). Furthermore, language barriers and terminology prevent detailed questioning at times. Hence in a setting such as Soweto, an interviewer-led FFQ is more appropriate than a self-complete questionnaire. However, the implications of using an interviewer to assess diet include the increased requirement of financial resources and the training of fieldworkers. Furthermore, in pilot work undertaken to assess the feasibility of using the interviewer-led FFQ it took between 1 – 2½ hours to interview the group of adolescents on their previous week's dietary intake. A final important consideration is the coding of the FFQs post-interview, which can only be done by a trained individual with an interest in nutrition and with good numeracy skills. These are important considerations that can delay the output of results.

1.9.4 *Assessment of dietary behaviours*

It is not possible to quantify energy intake and energy expenditure on a daily basis at an individual level with enough accuracy to deduce which aspects of these two variables are responsible for the rise in obesity (186). Thus an alternative approach would be to assess behavioural aspects that underpin the propensity to excessive energy intake (186). Such methods would also enhance the validity of dietary intake studies and would measure dietary behaviours or habits associated with food choices. For example Kristal et al. (198), suggested that researchers could develop hypotheses around dietary behaviours, suggesting that usual practices may be easier to remember and be accurately recalled than frequencies and portions of foods contained in a list. Assessment of food choice behaviour such as whether a participant skips breakfast or snacks while watching television is an alternative to dietary intake assessment and is a useful way to capture eating behaviours and relate them to obesity risk. Furthermore, Greenwood and Stanford (133) also believe that behaviours around food choices are easier to conceptualise for subjects, and also for health workers to communicate health information effectively[6]. A more qualitative approach which focuses on specific behaviours around food intake might be an effective approach in clinical and research settings (133); respondents would find the concept of a habit around an eating practice easier to comprehend than trying to recall servings of a particular food. Furthermore, the general population would find it easier to understand recommendations based on buying patterns and servings of foods, as opposed to nutrients (67). Thus research into dietary habits (and behaviours) may complement DAMs by emphasising areas of potential risk of poor eating behaviours.

[6] An example of this would be the move towards educating the public in terms of food-based dietary guidelines as opposed to disseminating nutritional information in terms of nutrient intakes which are often difficult to interpret.

Modifiable risk factors associated with obesity encompass diet and behaviours around food choice and are not mutually exclusive; energy intake is intrinsically related to behaviour and habits (e.g. choosing and eating of particular foods, television viewing which might influence food intake) in which internal and external influences are exerted (199). These factors include features of food supply, knowledge, attitudes to food and emotional state, among others.

1.10 Summary and research gaps

There is an unfortunate lack of dietary intake data among adolescent groups in South Africa. Table 1.5.1 shows also that the studies have been infrequent and some are quite old, dating back as far as 1990, which may be out of date in a country undergoing rapid transition. Furthermore, only one nationally representative study (51) carried out 11 years ago, assessed the diets of 1 – 9 year olds, thus it requires the extrapolation of the findings to older age groups. The two most recent studies, which were not nationally representative but did relate to adolescent intake showed the following: Kruger et al (54) found overall energy intake was below the RDA and total fat contribution met international prudent guidelines of <30%[7]. On the other hand, Zingoni et al (58), found that on average the energy intake of urban Birth to Twenty 15-year girls was slightly higher than the recommendations, but that boys fell slightly short. Furthermore, fat intake ranged between 30% – 34%, above the prudent guidelines of <30%. Due to the different ages of the population groups studied, and the differing methods of assessment employed, it is difficult to compare the outcomes of these studies. It may well be the case that these differences (in terms of meeting the recommendations) are true, and thus also highlight the diversity in terms of the population groups under study and the environments in which they live.

[7] Most dietary assessment methods have not been developed to compare against dietary references thus these comparisons should be interpreted with caution.

This leads to two points mentioned earlier: South Africa is undergoing rapid socio-economic transition and there are regional differences in how South African populations live, their lifestyles and the effects of urbanisation on eating habits. Thus the findings of a study undertaken in a rural population cannot necessarily be extrapolated to an urban population; both populations will likely be affected by transition but will be experiencing it at different stages. Of interest, though, is that all the mentioned studies cite that the diets were high in starchy staples (especially maize meal, bread and in some areas, rice). Other key components of the local diet include bread, tea, sugar, whole milk and brick margarine. All studies noted low fruit and vegetable intakes and thus low micronutrient intakes. A further point for consideration is that most of the studies undertaken were on black ethnic groups (who make up 79% of the SA population), thus the other ethnic groups will likely have different dietary patterns which we know little about.

There have been more studies published on overweight and obesity prevalence than on dietary intake among South African adolescents, covering ages 10 - 12 and 10 - 15 years old (101, 105, 107). From the available data it can be seen that overweight and obesity are significant problems among younger people in this country, with a national prevalence of 17% among 1 – 9 year olds and with regional studies showing a range of 0 – 34% among those 2 to 15 years of age, depending on the geographic area assessed and population group scrutinised. What is apparent among all the surveys is that girls are affected by obesity more than boys, irrespective of the environment in which they reside. Since obesity tracks from childhood to adulthood, this pattern can be expected to follow into adulthood. Indeed, these figures are reflected in the adult statistics for combined overweight and obesity, with women being more overweight than men.

Although most studies did not address SES specifically, in South Africa, due to the legacy of apartheid, ethnic groupings might reflect different SES groups. In a transitional country such as South Africa, urbanisation often represents groups of higher SES and these studies did show that children living in urban areas had the highest prevalence of overweight and obesity. SES in those studies which addressed it was usually defined as parental education and household durable variables. Those purporting lower SES had a lower risk of obesity, which is in contrast to developed-country data. Conversely, those in lower SES groups had higher risk of stunting. Of interest, Kruger et al. (54) showed that obesity was equally prevalent in children of low and high SES, which might be a reflection of transition affecting rural and urban populations equally.

Both Kruger (54) and Armstrong (101) reported differences in overweight and obesity between ethnic groups. Overall, the prevalence of overweight and obesity was highest among white children, followed by black, Indian and mixed ancestry. However, when the samples were stratified by gender, black girls were most at risk.

Dietary patterns and behaviours have been shown to track from adolescence to adulthood. Developed country research has focused not only on dietary intake data of adolescents but also on dietary behaviours around food choices. It is argued that focus on behaviour around choice of food is easier for respondents to conceptualise than recalling quantities of specific food items. However, as with total dietary intake methods, their association with obesity risk is somewhat equivocal. Specific dietary habits associated with obesity risk among adolescents have focused on breakfast habits, meal skipping, consumption of food while watching TV, snacking, food intake at school, eating the main meal with the family, fast food and soft drink consumption (136-142).

This literature review examined environmental modifiable risk factors associated with obesity, namely total dietary intake, and also dietary habits and practices associated with food choice and socio-economic factors. The prevalence of overweight and obesity was also presented for adults, children and adolescents, both worldwide and specifically in populations in South Africa. However, it is evident that data on South African adolescents remains sparse. A national survey of dietary intake data among adolescents is lacking and furthermore, very little research has been conducted in South Africa on habits around food choice, other than two studies on breakfast habits and food eaten at school. Thus, in order to draw conclusions regarding obesity risk and how these statistics may be reduced, we need to gain more insight into risk behaviours around eating practices and habits.

1.10.1 *Relevance and justification*

Obesity, with its related illnesses, is a worldwide problem with much investment going into its research. However, most nutrition research is based on population groups in developed countries experiencing different stages of the epidemiological transition therefore the outcomes may not be relevant to populations undergoing rapid transition, such as those in South Africa. The Bt20 cohort provides a unique opportunity to explore emerging risk patterns of obesity since it is the longest and largest longitudinal study of childhood and adolescence in South Africa. It is hoped that data from this research will highlight some of the dietary habits and eating practices associated with obesity risk in this adolescent population, which will bring us a step closer to curtailing this catastrophic disease.

The nutrition transition, associated with rapid urbanisation and consequent lifestyle changes, is now severely affecting the South African population, with obesity and its associated chronic

diseases becoming a major public health concern. Of importance is that black South African women, especially those with lower educational attainment and socio-economic status, are the most affected.

Adult obesity has its origins in childhood and adolescence but there is a large gap in our knowledge of adolescent eating habits and practices, particularly in South Africa from where only two studies have discussed dietary habits, including breakfast habits and school lunch behaviours. In order to provide insights into possible factors responsible for the rising increase in adult obesity it is vital to understand the potential modifiable dietary habits and patterns, and the risk factors during adolescence. This knowledge is also required to develop effective public health policies and interventions aimed at disrupting the current high prevalence of obesity in South Africa.

1.10.2 *Aims and objectives*

Overall aim:

To investigate the impact of dietary habits and practices on the risk of obesity among urban adolescents living in Soweto.

Specific objectives:

1. To assess the availability and consumption of fast foods in an urban and a rural setting.
2. To describe the dietary habits and practices of adolescents over a 5-year period, in the home, school and community environments.

3. To assess the association between longitudinal dietary habits and practices and obesity risk in 17-year olds.

1.10.3 *Study Hypotheses*

Specific research hypotheses are as follows:

1. Fast food intake is high in urban adolescent 17-year olds, and fast food is available in a rural setting in South Africa.

2. Dietary habits and practices change with increasing age, and gender differences exist, among urban adolescents.

3. Longitudinal dietary habits and practices are associated with obesity risk in 17-year old urban adolescents.

Chapter 2 Study context

This chapter describes how this study was undertaken and it provides details on the contextual relevance of the two environments in which the work took place, both in an urban and a rural setting. It also outlines the history of the two study sites. This is followed by a synopsis of how each study component was undertaken and a description of the main study instrument used in this work.

2.1 South Africa

South Africa is closely connected to global markets through commodities trading. South Africa, middle-income country, has enormous socio-economic contradictions and imbalances that exist between race and gender groups. This is partly due to the legacy of apartheid (200), but is also the result of the failure of the current democratic government to remedy the problems (201). South Africa experiences large disparities in income distribution – one of the most unequal in the world, with a Gini coefficient of 0.57 in 2000 (0 represents total equality and 1 represents total inequality) (202).

2.2 Migration

Apartheid legislation played a major role in shaping household structures and patterns of movement. Historically, population movements took on a particular form and significance in response to the country's political and economic conditions. Government policies forced South Africa's black population to reside in rural 'homelands' (203, 204). This gave rise to a pattern of recurrent circulation between rural homes and urban places of work (205). The labour migration system created during the apartheid era has been a profound force of instability and change in

African family life. An extensive literature documents the effects of government policies on family-building, living and care arrangements, and livelihoods (see for example, (205-208).

As a result of the fragmentation of the health services between the homelands and 'white' South Africa, and the underdevelopment of homeland services, large numbers of women came from rural areas to deliver their children in the cities. This pattern could also have been due to a number of other reasons, including better services in urban centres, to ensuring that the child had a birth certificate entitling them to live and work in an urban area under apartheid law, to wanting the child's father, a migrant labourer, to witness his child's birth and thus secure support for the child (209).

The 1952 Pass Laws Act which was in effect until 1986, made it illegal for African adults to stay in an urban area without employment and accommodation (210). Ethnographic studies of family life under apartheid conditions describe the harsh, chaotic, and insecure conditions in which families lived (211). The effect of men's absence from the rural family home, the challenges faced by families in urban areas, and the high levels of female participation in the labour market have been shown to exacerbate the poor quality of gender relationships in South Africa (212).

2.3 Health Systems Context

Fragmentation has occurred within the health sector, following from past racial discrimination and segregation of health care services. The health care sector of that period has been described as inequitable, inefficient and expensive (200, 213) (214). While a full range of services was provided by Soweto clinics in the early 1990s, including - family planning,

antenatal care, acute and chronic diagnosis/treatment, social work facilities, labour wards, casualty wards, immunisation programmes and elderly care - the infrastructure, including water supply and ablution was generally in a poor condition. In addition, clinics were largely under-resourced with regard to medical supplies and transport facilities. Furthermore, many clinics were unable to operate overnight due to security concerns for staff travelling to and from clinics (215).

After 1994, health services improved, with free access to health care for children and pregnant women. The post-apartheid government successfully implemented a clinic infrastructure renewal programme in which 1 345 new clinics were built and 263 upgraded nationally. Primary health care was made available without cost to users and the availability of key drugs in public health care facilities was improved (200).

While substantial advances were made in the formulation of policy and the formal integration of the health system, by 2007, inequalities in total national health expenditure between public and private expenditure had marginally increased, rather than decreased. The inequality in expenditure is reflected in the exodus of doctors (24%) and professional nurses (16%) from the public provincial health structures (200).

Health care expenditure has reduced (due to inflation and underfunding) concurrently with an increasing burden of disease within the country – which falls mainly upon the poorer segments of the population (200). It has been said that while South Africa spends more on health than any

other African country, mortality in children younger than five years has actually increased since 1990 (due mainly to HIV/AIDS) (216).

2.4 Soweto

Soweto (an acronym for 'South Western Townships'), an urban environment, is located 15 km southwest of Johannesburg's central business district, (see figure 2.4.1). It was established in the 1950's with the aim of housing black labour employed in the mining industry. Soweto is the largest black residential area in South Africa, with an estimated population of 1.3 million in 2007 (217). Soweto consists of 34 suburbs and covers an area of 150 km^2 (218). All indigenous groups are represented in Soweto although Zulus, Xhosas and Sothos predominate.

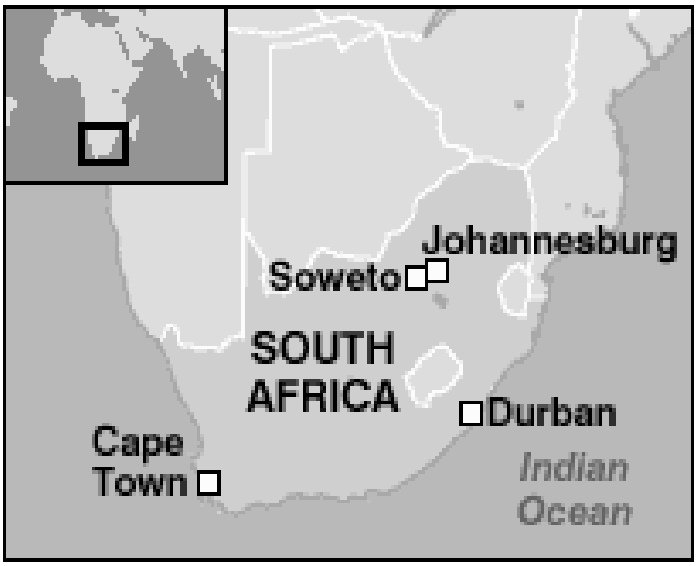


Figure 2.4.1 Map showing regional location of Soweto-Johannesburg, where the Bt20 research programme is located.

2.4.1 *Socio-economic status*

Research commissioned by the Department of Finance and Economic Development showed that there are 301 000 households in Soweto; with two-thirds of houses constructed from bricks. Twenty-eight percent of households have a combined income of <R800 per month (219). Although 97% of Soweto-Johannesburg have access to piped water, it may be that residents have access to an outside tap (50%) (220). Most of Sowetan residents had access to electricity by 1988 but many households struggle to pay for it (220).

National literacy levels are 86% (26) and in the Johannesburg area which Soweto is encompassed, 35% of residents (aged 20 and above) have high school education, and 7% are illiterate (220). National unemployment is currently 26% (25) however it is believed that this figure could be as much as 40% in Soweto (219).

2.5 The Birth to Twenty Cohort: background

In order to understand the influence of rapid urbanisation and transition on the health and development of children in an urban environment, a group of researchers in Johannesburg at the end of the 1980s put together a plan to initiate a longitudinal cohort study (the Birth to Twenty Cohort) in the Greater Johannesburg area.

2.5.1 *Birth to Twenty*

Birth to Twenty (Bt20) is both the largest and longest-running longitudinal birth cohort study of child health and development in Africa (221). Born in 1990, the children's lives span the transition to a democratic South Africa from a system of legalised racial segregation and

discrimination called apartheid. These years marked the beginning of wide-ranging legislative, political, social, economic, and cultural transformation in South Africa. Four years after their birth, Nelson Mandela became the first democratically elected (by universal suffrage) president of South Africa, as well as the country's first black African president. While the release of Mandela from prison in 1990 seemed to promise a hopeful future for democratic transition in South Africa, the early 1990s before the election were undermined by political violence and anxiety about the future stability of the country.

2.5.2 *Recruitment*

Recruitment for the study occurred in several waves; at antenatal clinics, hospitals and clinics at time of delivery, and at 'well-baby' services where immunisations were given during the first 18 months of the child's life (222). Enrolment took place between 23 April and 8 June 1990, and included singleton births of infants born in the Soweto-Johannesburg metropole (n=5 449) (222). A further requirement was that the mothers resided within the metropole for at least six months after the birth (222) see migration below, so infants who were born and registered onto the cohort but then moved out of the study area were later excluded and 'lost to follow up'. The realised sample is 3 273 families.

The first 10 years (Bt10) of the study broadly collected data on children's health and development (growth, health, well-being and educational progress) while the second phase, Bt20, encompassed the same aspects but in addition sought to target, risks associated with life-style, including sexual and reproductive health, cardiovascular disease and diabetes (223). It was during years 9 and 10 that a new sub-study was introduced to assess bone health development (Bone Health Study see (224) (225)).

All major South African ethnic groups are represented in the study, but due to logistical and political reasons, at initial enrolment, middle class white children were under-represented (222). Under the previous apartheid government the private health service consumed up to 60% of resources that largely catered to the middle classes, who only made up 23% of its population (226). However, the subsequent sub-study (the *Bone Health* study) white children (n=120) were over-sampled retrospectively in order for ethnic comparisons to be made. These participants were also born during the initial cohort enrolment dates but they did not reside in the same areas as the rest of the cohort (222).

To date Bt20 has a 70% follow-up rate. Attrition occurred for a number of reasons: deaths, abandonment, adoptions and migration, the latter being the most common (222). Some demographic and health characteristics of the participants are outlined in Table 2.5.1.

Table 2.5.1 Characteristics of the Bt20 cohort (208).

Characteristics	Bt20 Cohort (n=3 273)
Ethnic Group	
African (black)	2 568 (78%)
White	207 (6%)
Mixed ancestry	383 (12%)
Indian	115 (4%)
Maternal Age at birth of index child	
<17 years	92 (3%)
17 – 19	392 (12%)
20 – 38	2 692 (82%)
+39	95 (3%)
Gravidity	
1	1 094 (33%)
2 – 4	1 875 (57%)
≥5	304 (9%)
Gestational age	
<37 weeks	388 (12%)
37–41	2 773 (85%)
42+	11 (0.3%)
Birth weight	
<1500 g	30 (1%)
1500 – 2499 g	322 (10%)
2500 – 3999 g	2 827 (86%)
4000+ g	89 (3%)

2.6 Agincourt HDSS: – Background

2.6.1 *Setting*

Data for the Scientific Letter was collected in Agincourt which is part of the Agincourt health and socio-demographic surveillance system (HDSS), run by the MRC/Wits Rural Public Health and Health Transitions Research Unit. This study was established in 1992 and follows ~70 000 people (nearly one third Mozambican immigrants) living in 11 700 households in 25 villages. Population density is 170 people/km^2 and is largely Tsonga-speaking (227).

Agincourt is a sub-district of Bushbuckridge, located 500 km northeast of Johannesburg in Mpumalanga Province, bordering the western boundary of the Kruger National Park (see Figure 2.5.1). This setting is in stark contrast to Soweto; it is a rural semi-arid environment which was once part of the former Gazankulu homeland, giving rise to plots of land too small to support subsistence farming. Infrastructure is much more restricted than in Soweto; however, development has seen improved electrification to most households and improved road networks, with a recent programme to tar all main roads. However, water piping is still problematic and is obtained from communal taps. Housing ranges from mud huts to purpose-built brick dwellings (227).

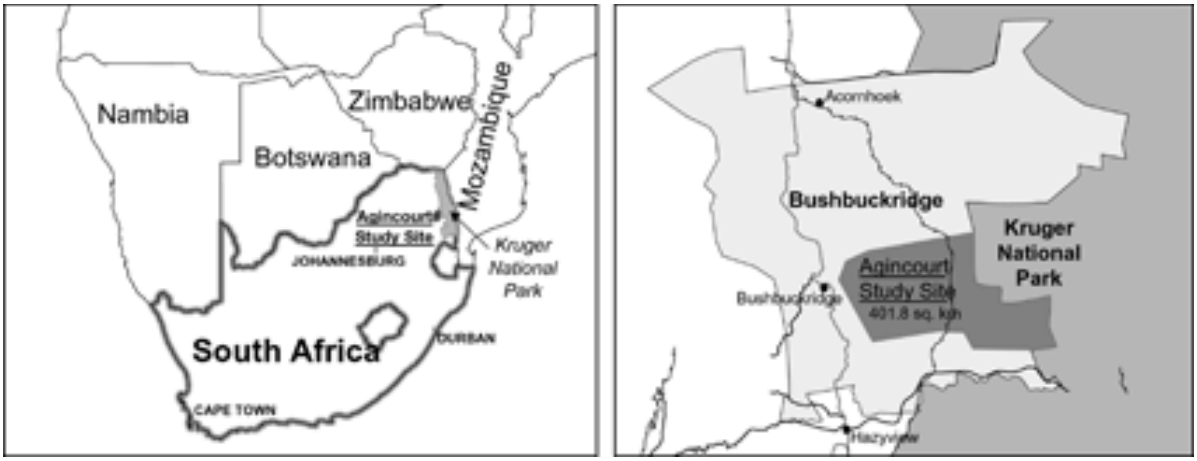


Figure 2.6.1 Maps showing regional location of the Agincourt Health and Demographic Surveillance Site (Source Kahn et al. (211)).

2.6.2 *Socio-economic status*

This area has one of the highest poverty rates in South Africa, with high levels of unemployment (86%) (25) and a high proportion of the population on government support grants, including child support grant and pensions (227). Illiteracy remains high among older populations (80%)

but has improved post-apartheid in the younger generations, mainly due to an increased number of primary and secondary schools.

2.6.3 *Health*

Health care in this area is restricted. The five primary care clinics in the area are staffed by nurses that provide free services. These five clinics refer to three district hospitals (25 – 60 km away). Traditional medicine plays a role in health care here. The quadruple burden of disease is also apparent in this area: high malnutrition prevalent in children and infants, NCDS, HIV-related disease including TB, and high levels of violence and accident-related trauma. Stunting affects 18% of 1-4 year olds, while the prevalence of combined overweight and obesity is 25% among 18 year old girls but is almost nonexistent among boys (228).

2.7 Synopsis of methods for each study component

In addition to describing the methods in each chapter here is a brief outline of how each study component was approached:

2.7.1 *Fast-food consumption among 17-year-olds in the Birth to Twenty cohort*

This was a cross-sectional study which aimed to assess the fast food consumption of the Bt20 participants. The questionnaire used was the same as that which was used for studies in Chapters 4 and 5 (see section 2.7 for details). A further objective was to assess the nutrient composition of the most popular fast food consumed by this population, the kota (quarter). In order to do this we collected 16 samples from vendors located in three suburbs nearest the Chris Hani Baragwanath Hospital (the Bt20 study site). Each component of the kota was

weighed in order to estimate energy and macronutrient compositions. This data was then compared with popular commercial fast foods.

2.7.2 *Changes in dietary habits and eating practices in adolescents living in urban South Africa: the Birth to Twenty cohort*

Data for this study was based on the dietary habits and practices questionnaire (section 2.7), collected during follow-up when the participants were 13, 15 and 17 years old respectively. Data collection was overseen when the participants were 17-years old. Thus the data used in this study was partly historical as well as prospective.

2.7.3 *Investigation into longitudinal dietary behaviours and household socio-economic indicators and their association with obesity in South African adolescents: the Birth to Twenty cohort*

This study was based on data collected for Paper 2 and additional variables used were SES data collected at birth and again when participants were 12 years old. Anthropometric data (weight and height) and fat mass (obtained from DXA scans) was collected when participants were 17 years old. The emphasis of this paper was on statistical analysis.

2.7.4 *Exploratory survey of informal vendor-sold fast food in rural South Africa Scientific letter*

This study component was undertaken in rural Agincourt with the aim of exploring the availability of fast foods in this setting. It served as a pilot study to inform other work, which is planned to be implemented in the near future.

2.8 Data Collection Instrument

The questionnaire used for Papers 1-3 is included in the appendix (p. 203). This questionnaire was developed in 2003 by Bt20 researchers (prior to my appointment), with the aim of assessing adolescent dietary habits and practices which are known to be associated with poor diet quality and obesity (see section 4.2.2 for further background details).

The questionnaire, interviewer-led, is not the typical FFQ that is used for assessing dietary intake, but is rather a structured questionnaire that asks the participants if they engage in a range of behaviours (for example, how often do you eat breakfast during the week) across three settings (home, school, community). For some variables, (such as fast food consumption, snacks while watching television, beverage and confectionery consumption, school tuck shop items and lunch box foods) the frequencies of certain food items consumed over the recall period (7 days) were recorded e.g. a hamburger, or a portion of chips.

2.8.1 *Piloting of the questionnaire*

Several steps were undertaken to ensure the questionnaire had face validity (i.e. that the participants interpreted the questions as intended):

a) Translation and back translation into seSotho and isiZulu (common African languages spoken in Johannesburg).

b) Piloting of the questionnaire with experienced local fieldworkers to ensure the questions were phrased (culturally) appropriately for the community setting being worked in.

c) Piloting with age-appropriate participants (n=20) with cross-checking probes to ensure that they understood the meaning of the questions as intended.

2.8.2 *Reliability of the questionnaire*

Reliability of the answers to the questions was tested using the test-retest method (123). The questionnaire was administered to twenty 13 year old Sowetan non-Bt20 participants, then two weeks later re-administered to the same individuals.

Kappa-coefficients for nominal data showed very strong agreement between the first and second test responses, ranging from 0.89 – 1.00 for the different question items.

It is acknowledged that the interval between the two administrations of the questionnaire was relatively short, but given the tight cycle of questionnaire development to data collection, Bt20 could not afford the delay if the questionnaire administration was to be repeated with a longer time interval between the two points. The piloting exercise revealed that the questionnaire was not complex, certainly not as complex and time-consuming as well-developed FFQ, and that the participants had ease in understanding and answering the questions pertaining to dietary habits and practices.

2.9 Ethical approval and consent

Primary caregivers gave written informed consent for their children to participate in the research at each assessment visit and each child provided written assent. Confidentiality was maintained by the allocation of an identification number for each participant which was used on all questionnaires. Ethics clearance was obtained from Witwatersrand University Committee for Research on Human Subjects (M080320) (see appendix, p. 235 for Ethics Clearance Certificate).

Part 2: Empirical Papers

Chapter 3 Fast-food consumption among 17-year-olds in the Birth to Twenty cohort.

(Published in: *South African Journal of Clinical Nutrition* 2009;22 (3):118-23)

3.1 Introduction

Fast foods can be defined as convenience foods obtained in self-service or 'take-away' eateries with minimal waiting, and are usually characterised as energy-dense, low in micronutrients and fibre, high in simple sugars and salt, generally larger in portion size than conventional home cooked or restaurant foods (182, 183), and highly palatable (73). Research indicates that fast food consumption can displace healthier food options, and is associated with poor diet quality (184), decreased intake of fruit (184), and lower micronutrient intake including calcium, vitamin C and folate. In children and adolescents, Lin et al. (39) found that foods prepared away from home were higher in total and saturated fatty acids and lower in calcium, iron and fibre, than foods prepared in the home. In the *Eating Among Teens* (EAT) study in the USA, adolescents who reported eating fast food three or more times in the previous week had a 38.5% higher energy intake than those who did not consume fast foods (185).

Fast food consumption has been linked to increased total energy intake (184) however, the association with increased weight gain is inconsistent, largely due to cross-sectional study designs (188, 189). However one 15-year longitudinal study undertaken in adults showed that fast food consumption had a strong positive association with increased weight; frequent consumers (two or more times per week) gained an extra 4.5 kg compared to those who ate fast foods once or less per week (182). One proposed mechanism by which fast foods may

contribute to obesity risk is via energy density. Energy density, expressed as kJ 100 g^{-1}, is defined as the energy content per unit weight of foods, meals or diets, usually minus beverages since they have a differing effect on satiety (187). Energy-dense foods are likely to disrupt normal appetite control systems and the hypothesised mechanism involved relates to passive over-consumption whereby the body cannot down-regulate intake after consumption of an energy-dense meal (187).

With South Africa mirroring worldwide obesity and nutrition-related chronic disease trends (229), it is important to assess changing dietary habits and eating practices (30, 54), with specific emphasis on fast food consumption. Children and adolescents living in urban areas (townships, settlements, towns and cities) are increasingly exposed to the influences of the Western lifestyle, and therefore to foods that are relatively high in fat, carbohydrates and salt and low in fibre. Townships (historically disadvantaged areas in South Africa) such as Soweto, have a wide selection of food vendors, both commercial and informal (street vendors and tuck shops) that sell fast food items including vetkoek (fried fat cakes), fried chicken, deep fried fish, fried chips and fried meats, including processed sausages.

During pilot studies with adolescents and fieldworkers in Soweto, it became apparent that a fast food item called the ‘quarter’ was popular and consumed regularly. Also, there are few studies assessing the frequency of fast food consumption in children and adolescents (39, 73, 100, 179, 185, 188, 230), with most studies based on US populations and none having been conducted in South Africa. Thus the aims of this study were: 1) to determine the frequency of fast food intake; 2) to assess the frequency of fast food outlet visits; 3) to assess the association between body mass index and fast food intake 4) to investigate the hypothesis that a local fast food known as

the ‘quarter’ is the most popular among 17 year old participants in this study and 5) to investigate the cost and macronutrient composition of the ‘quarter’ and compare it to three commercially available fast food meals.

3.2 Methods

3.2.1 *Study participants*

Birth to Twenty (Bt20) is a birth longitudinal study that was planned to track the growth, health, well-being and educational progress of urban children across the first two decades of their life and includes research relating to the risks associated with life-style. Enrolment took place between 23 April and 8 June 1990, and included singleton births of infants born in the Soweto-Johannesburg metropole who had resided in the catchment area for at least six months after birth (224). This current study was a cross-sectional survey which included a sample of 655 black subjects (51.1% females) from the larger cohort of Bt20. The Bt20 participants were consecutively assigned a visit date for their annual data collection at one of the Bt20 sites. For this study, the first 655 participants visiting the Chris Hani Baragwanath facility between September 2007 and May 2008, who had complete data, were included in this analysis.

3.2.2 *Study Protocol*

Participants had their height and weight measured (to determine body mass index using International Obesity Task Force cut-offs for 17.5 year olds (102)). Height was measured to the last completed 1 mm using a wall-mounted stadiometer (Holtain, UK) and weight to the nearest completed 0.1 kg, using a digital instrument (Dismed, USA). Participants completed an interviewer-assisted questionnaire on fast food item intake and fast food outlet visits. This

questionnaire was designed to include specific questions on the number of fast food items consumed in the past seven days as well as how often in the that period a fast food outlet had been visited. Fast food outlets included in the questionnaire were well known commercial outlets including international vendors (McDonald's, Kentucky Fried Chicken (KFC), Wimpy) and local national vendors (Nando's, Spur, Steers), and a space was provided for 'other' so that those unknown to the researchers could also be captured. Fast food item intake was defined as single items consumed, e.g. one burger, one portion of chips. Whether or not participants were interviewed during the school term or during the holiday period was also noted. Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects, protocol number: M080320.

3.2.3 *'Quarter' Sample Collection and Evaluation*

Sixteen 'quarter' (also known as Kota) samples were purchased from different outlets based in Soweto, mainly in the Klipspruit, Orlando and Diepkloof areas. Vendors were approached and asked if they would answer questions on the food they sold, before a sample of their 'best seller' or 'most popular quarter' was purchased. Questions posed to vendors related to the composition of their most popular 'quarters' and short semi-structured interviews were held about the origins of the 'quarter'.

The components of an average 'quarter' comprise a ¼ loaf of white bread, fried chips, processed cheese, any number of processed meats or sausages, a fried egg and sauces. Each component of the 'quarter' was inventoried and weighed using kitchen weighing scales to the nearest gram. However, many of the samples contained sauces which were blended with fat and other ingredients so that they could not be thoroughly extracted, thus their weights were

estimated. Nutrient composition (energy, protein, total fat, saturated fatty acids, carbohydrate, fibre and sodium) was estimated using Foodfinder3, nutrient analysis software based on the South African Medical Research Council (MRC) food composition tables (1991). Finally, mean nutrient breakdown of the 16 samples was used for comparative purposes.

3.2.4 *Comparison of 'quarter' with Commercial Fast Foods*

Public domain data on the macronutrient composition of fast food meals from three well-known commercial fast food outlets (McDonald's, KFC and Steers) was surveyed from company websites, (231-233). Since food is usually eaten in standard measures or portion sizes governed by an outlet's standards, the fast food data was presented according to those portion sizes. Thus for comparative purposes and as with the commercial meals, a soft drink was also included with the 'quarter' meal. Macronutrient composition and energy density (calculated) of the commercial meals were compared with the 'quarter' samples. Cost was also compared as well as energy (kJ) per rand spent.

3.2.5 *Data Analysis*

Descriptive statistics (using SPSS v16) were undertaken including the calculation of means, standard deviations, ranges and means of frequency of intake for each participant for fast food item consumption and fast food outlet visits. Chi-square tests were employed to assess gender differences of fast food item consumption and frequency of fast food outlet visits. Student's t-tests were undertaken to assess if those participants interviewed during the school term versus those interviewed during school holidays were different in terms of the number of fast food items' consumption, or their frequency of visits to fast food outlets. Linear regression was

employed to assess the association between BMI (loge transformed, to reduce skewness) and number of fast food items.

3.3 Results

Descriptive characteristics of the 655 adolescents (mean age 17.7 (SD 0.04) years old, 51% female) included in the study are listed in Table 3.3.1. In males, 25.6% were underweight (BMI <18.5) and 13.1% of females were underweight. Twenty-one percent and 6.3% of females and 4.1% and 2.5% of males were overweight or obese respectively. There was no correlation between BMI and number of fast food items (0.0042) and thus linear regression did not show an association between BMI and number of fast food items (p=0.136).

Table 3.3.1 Characteristics of participants.

	Males (n=320) mean (sd)		**Females (n=335) mean (sd)**
Age	17.71 (0.04)	**Age**	17.72 (0.04)
Weight (kg)	59.3 (9.87)	**Weight (kg)**	57.8 (10.80)
Height (m)[a]	1.71 (0.66)	**Height (m)[1]**	1.59 (0.10)
BMI Categories[b]	Total (%)	**BMI Categories[2]**	Total (%)
Underweight (<18.5)	85 (26.6)	**Underweight (<18.5)**	44 (13.1)
Normal weight (18.5 – 24.72)	213 (66.6)	**Normal weight (18.5 – 24.8)**	200 (59.7)
Overweight (24.73 – 29.6)	14 (4.4)	**Overweight (24.85 – 29.83)**	70 (20.9)
Obese (>29.7)	8 (2.5)	**Obese (>29.84)**	21 (6.3)

[a] $p<0.001$; [b] $\chi 2 = 56.51$, $p<0.01$

The range of fast food item intake over seven days for the group was wide, varying from 0 – 23 times a week. Mean fast food item intake for males was significantly higher (8.1 (4.6)) than for females (7.2 (4.7)); ($p<0.01$) but average fast food outlet visits per week was significantly less for males (3.4 (3.5)) than for females; (4 (3.4) times per week); ($p<0.05$), with a range of 0 – 15 times per week for both genders. Student's t-test showed that there was no difference in number of fast food item intake or fast food outlet visits during term-time or school holidays ($p>0.05$).

Almost all participants ate more than one fast food item per week (95% and 92.2% for males and females respectively) with more than 50% of males and 38% of females eating more than eight fast food items per week (Table 3.3.2). Out of a mean frequency of 5026 fast food items consumed, the three most frequently consumed fast food items for both genders were 'quarters' (30.7%) (Figure 3.1.1) followed by chips (21.8%) and vetkoek (12%). This was followed by pies and sausage rolls (6.8%), boerewors roll (6.7%), fried fish (5.6%), hotdog (4.8%), pizza (4%), hamburger (3.9%), chicken burger (1.5%), samoosas (1.4%), pitta (0.8%).

Table 3.3.2 Fast food item consumption during the previous 7 days.

Fast Food Item Consumption During the previous week[1]	Males (n=320)	Females (n=335)	Total
0 – 1[a]	16 (5%)	26 (7.8%)	42 (6.4%)
2 – 4	54 (16.9%)	78 (23.3%)	132 (20.2%)
5 – 7	91 (28.4%)	104 (31%)	195 (29.8%)
> 8	159 (49.7%)	127 (38%)	286 (43.7%)

[a]0 and 1 times per week combined due to low numbers; $^{2}\chi 2 = 10.854$, $p<0.05$; refers to gender difference

More males (23%) than females (14%) stated that they did not frequent fast food outlets during an average week (Table 3.3.3). For the group, 40% stated they frequented a fast food outlet between 1 – 3 times per week, while 39% of females and 31% of males frequented fast food outlets between 4 – 10 times per week. Out of a mean frequency of 2430, the three most frequented fast food outlets for the sample were KFC (16.8%), McDonald's (13.7%) and 'other' (12.8%), which included both commercial and informal outlets not listed in the questionnaire. Three other fast food outlets that primarily sell chicken accounted for 17.5% and the remainder of outlets (Spur, Steers, Anat, Something Fishy, Romans, Debonairs, Wimpy and Chinese takeaways) accounted for the remaining 39.2%.

Table 3.3.3 Frequency of fast food outlet visits in an average week.

Fast Food Outlet Visits per week[a]	Males (n=320)	Females (n=335)	Total
0	74 (23.1%)	46 (13.7%)	120 (18.3%)
1 – 3	129 (40.3%)	135 (40.3%)	264 (40.3%)
4 – 10	100 (31.3%)	131 (39.1%)	231 (35.3%)
> 11	17 (5.3%)	23 (6.9%)	40 (6.1%)

[a] $\chi 2 = 11.392$; $p<0.05$

As a result of conducting semi-structured interviews with half of the 16 Sowetan vendors contacted, there is some anecdotal evidence to suggest that the 'quarter' evolved from the 'bunny chow'[8] in the late 1970s to early 1980s, but initially it was composed of bread, mashed potato, mince meat, atchar and often included a cooked chicken's foot. This version is still available today in Soweto but is more popular among older generations than younger people.

[8] A popular Indian dish that has its origins in Durban, which usually comprises a quarter or half loaf of white bread with the inner soft bread removed and filled with meat or vegetable curry, the removed bread is used to dip in the curry sauce

Most of the vendors spoke of first seeing fried chips in the ‘quarter’ around the late 1980s and from that point onwards other food items were gradually introduced. Thus the ingredients of a ‘quarter’ are not necessarily standardised, but there are some key attributes that make it a ‘quarter’: ¼ loaf of white bread, a portion of fried chips, a slice of processed cheese, any number of processed meats including, but not exclusively, polony, russian sausage, vienna, mangola, white liver, and ‘special’ (the latter three are fatty processed meats), a fried egg and sauces including tomato sauce, mustard, chilli sauce, and atchar. Occasionally lettuce, fresh tomato and/or chakalaka (a spicy vegetable relish) is added.



Figure 3.3.1 Example of a Sowetan ‘quarter’.

Table 3.3.4 shows the nutrient breakdown of the 16 ‘quarter’ samples; energy ranged between 3 093 kJ – 8 015 kJ, total protein ranged between 26 g – 62 g. Total fat ranged between 15.1 g and 88.1 g and saturated fatty acids (SFA) between 5.3 g and 22.2 g. Total carbohydrate

ranged between 102 g – 202 g. Total dietary fibre ranged between 6.8 g – 15.2 g. Sodium content ranged from 1 108 mg – 4 402 mg. Table 3.3.4 shows the cost of the 'quarter' samples obtained; mean cost was R9.16 (SD 2.89) within a price range of R5.00 – R15.00.

Table 3.3.4 Energy and nutrient breakdown of 'quarter' samples.

Sample	Energy (Kj)	Total Protein (g)	Total Fat (g)	SFA[a] (g)	Total CHO[b] (g)	Total Dietary Fibre (g)	Na (mg)	Price (R)
1	3 093	38.7	15.1	5.3	103.6	6.8	1 108	6.00
2	3 838	46.3	32.7	9.5	102.2	6.1	1 586	13.00
3	4 606	41.2	43.7	10.6	125.2	9.4	1 463	15.00
4	4 701	30.8	39.3	7.8	148.8	11.3	1 600	5.00
5	4 704	26.2	36	6.3	159.8	12.4	1 532	6.00
6	4 933	44	42.4	10	143.1	10.8	1 430	10.00
7	4 966	31.7	45.3	11.7	150.3	11.4	2 011	9.00
8	5 128	34.5	51.6	13	144.1	10.6	2 453	7.00
9	5 208	42.1	48.4	12.2	147.2	11.7	1 443	6.50
10	5 210	33.3	49.1	10.9	154.2	12	2 089	9.50
11	5 449	47.1	63.1	18.7	127	9.1	3 338	8.00
12	5 892	50.1	65.7	20	143.2	10.3	3 499	8.50
13	6 341	36.3	59.9	11.8	191.2	15	2 097	10.00
14	6 490	40.5	65.4	15.7	184.4	14.5	2 611	8.00
15	7 329	52.6	77.7	20.3	194.9	14.4	3 812	12.00
16	8 015	62.2	88.1	22.2	202.3	15.2	4 402	13.00
Mean	5 369	41.1	51.5	12.9	151.3	11.3	2 279	9.16

[a]Saturated fatty acids; [b]Carbohydrates

A nutrient and price comparison between the 'quarter' and three popular meals from commercial fast food outlets was undertaken (Table 3.3.5) with a medium sized 'Big Mac Meal from

McDonalds, a ‘Dagwood Burger Meal’ from Steers and a ‘Street Wise II’ from KFC for comparative purposes. Since a soft drink is usually included in a commercially available fast food meal a coke (340 ml) was also included with the ‘quarter’ meal. The ‘quarter’ meal contained the most energy and carbohydrate (5 970 kJ and 188.1 g respectively) but the Steers meal had the highest fat, SFA and protein content; (54.5 g, 18.7 g, and 44.5 g respectively). Highest total dietary fibre was found in the ‘quarter’ meal (11.3 g) and sodium was highest in the Steers meal (2 771 mg).

Price was also assessed for the meal combinations (Table 3.3.5) and the ‘quarter’ meal was by far the cheapest (R16.66), followed by the KFC meal (R24.40) then the McDonald’s meal (R26.95), with the most expensive being the meal from Steers (R48.85). In terms of energy per rand spent, the ‘quarter’ meal yielded 358 kJ, the KFC meal 151 kJ, the McDonalds meal 150 kJ, while the Steers meal yielded only 100 kJ per R1 spent.

Table 3.3.5 The nutrient comparison between the average 'quarter' and three popular commercial fast food meals and their prices.

	Portion	Energy (kJ)	Protein (g)	Fat (g)	SFA[a] (g)	CHO[b] (g)	Dietary Fibre (g)	Na (mg)	Price (R)
'Quarter'	462 g	5 368.	41.1	51.5	12.9	151.3	11.3	2 279	9.16
Coke	330 ml	598	0.0	0.0	0.0	36.8	0.0	4.0	7.50
Combination		5 967	41.1	51.5	12.9	188.1	11.3	2 283	16.66
Mcdonald's Big Mac Meal									
Big Mac Burger	214 g	2 340	27.7	24.9	9.2	49.3	4.6	801.9	16.95
Fried chips	117 g	1100	4.0	10.7	2.5	41.3	5.0	44.5	9.95
Coke	350 ml	598	0.0	0.0	0.0	36.8	0.0	4.0	8.00
Combination		4 038	31.7	35.6	11.7	127.4	9.6	850.4	26.95
Steers									
Dagwood Burger	297 g	2 949	39.1	41.8	15.2	45.7	0.6	2 261	28.95
Fried chips	150 g	1 341	5.5	12.7	3.6	48.5	0.1	505.7	11.95
Coke	330 ml	598	0.0	0.0	0.0	9.6	0.0	4.0	7.95
Combination		4 888	44.5	54.5	18.7	103.7	0.8	2 771	48.85
KFC Street Wise II									
Chicken wing	52 g	711	12.0	11.0	2.5	8.0	1.0	15.0	9.50
Chicken drumstick	60 g	669	12.0	10.0	2.0	6.0	0.0	15.0	9.50
Fried chips	135 g	1 724	5.8	20.0	-	47.4	4.7	-	8.90
Coke	330 ml	581	0.0	0.0	0.0	10.9	0.0	4.0	7.50
Combination		3 686	29.8	41.0	4.5	72.3	5.7	34.0	24.40

[a]Saturated fatty acids; [b]Carbohydrate

Energy density for each meal, excluding beverages, was also calculated. It was found that per 100 g the KFC meal contained 1 257 kJ, the 'quarter' 1 162 kJ, the McDonald's meal 1 039 kJ and the Steers meal 960 kJ.

3.4 Discussion

Underweight in this group was higher in males than in females and combined overweight and obesity in males was 6.9% and in females 27.2%. For females this is 5% higher than the national average (80). Interestingly, no association was found between BMI and fast food item

intake however, this study was only cross-sectional and assessment of fast food intake only gives us part of the total picture. Estimation of total dietary intake and energy expenditure will allow us to determine the proportion of energy that fast food contributes to total energy intake and thus we would be able to assess more clearly the risk of overweight and obesity in this population group.

When compared with other studies, this study found that mean fast food item intake and frequenting of fast food outlets was high in this group. For example, in the USA, Larson and colleagues (230) found that only 23% of adolescents (mean age 15.9 years) consumed fast food items on three or more occasions in the previous week and 75% ate fast food once per week. In another study, the *Continuing Survey of Food Intakes of Individuals* (CSFII, 1989-1991), on average, 11 – 18 year olds visited fast food outlets twice a week (39). In the present study fast food outlet visits were nearly twice that of the US teenage group (230). In a later CSFII, 38.5% of 14 – 18 year olds reported eating fast food during the recall period of three days (188). In China, 10% of 12 – 14 year old males from a higher socio-economic group stated that they ate hamburgers on a daily basis, compared to only 2.8% of boys from a lower socio-economic group. For girls the figures were 5.7% and 3.8% respectively (179). Possible reasons for these differences between this study and the others may relate to the concept of a fast food outlet. In developed countries such as the USA, these are commercial (usually franchised) outlets, whereas in South Africa fast food outlets include both commercial as well as informal outlets such as street vendors and tuck-shops, either in the community or at school.

The nutrition transition may give some insight into why this South African group of adolescents consumes more fast food than their American counterparts. The nutrition transition relates to the

large shifts in dietary patterns with a substantial increase in the consumption of fat, sugar and refined foods (11). Popkin (15) proposed that although different countries are at different stages of transition, there is evidence to suggest that developing countries such as South Africa are undergoing transition at a much more rapid rate, i.e. over a decade or two, than what occurred in higher income countries, which underwent the transition over many decades or even hundreds of years (15). Key features of the transition now occurring in developing countries include: rapid urbanisation with increasing numbers of people living in urban areas, who have a greater disposable income and also greater access to food; this has been shown to occur much sooner during economic growth than was faced by higher income countries in the past (15). It has also been shown that decisions around food purchases have also changed in that for the same income level the patterns of demand have shifted dramatically from earlier times (15). For example, in China, it was found that those in lower socio-economic groups spent their disposable income on foods higher in fat than those in higher socio-economic groups (234). Thus a possible explanation as to why this population consumes more fast food than their American peers may be that they spend their income differentially and as a result, purchase more fast food.

A key finding of this study relates to the most popular fast food item consumed by this group; a local item, known colloquially as the ‘quarter’. There is no documented data on this food in terms of its origins or its nutrient profile and this study describes this information. The ‘quarter’ is said to have its origins in Durban with a strong evolving history in Soweto, its popularity spans all age groups (personal observation), possibly due to price (mean R9.16). It is widely available in that it can be purchased from an array of informal food vendors known as tuck-shops. Mean nutrient analysis of the ‘quarter’ samples showed that they were high in energy, fat, carbohydrate, protein and sodium. The average daily energy requirement of a 17-year old is 10

000 kJ (235) and the average ‘quarter’ meal (with and without a soft drink) contributed to more than half of this requirement; 60% and 54% respectively.

As stated earlier, the energy density of fast foods is one proposed mechanism by which they may contribute to obesity, especially in regular consumers such as in this population. A traditional West African rural diet has an energy density of 450 kJ 100 g^{-1} thus the required amount of food to achieve the recommended daily energy intake is 2 000 g. A typical female British diet minus beverages has an energy density of 670 kJ 100g^{-1}, thus about 1 300 g of solid food is required to meet the daily energy requirements, while if a ‘quarter’ is ingested, only 800 g would be required. It has been hypothesised that as a result of evolutionary conditions, humans tend to consume the same amount of ‘bulk’ regardless of its energy density. Therefore, down-regulation of intake with energy-dense foods does not occur.

In this study, the energy density of the fast food meals (minus beverages) ranged from 1.8 to 2.4 times higher than the healthy recommendation of 525 kJ100g^{-1}(187). This would imply that consumers of these meals are required to adjust the remainder of their energy intake to compensate for this one meal. However, this is unlikely to be sufficiently lowered since this population has a propensity to consume other energy-dense foods including snacks such as chocolate and crisps, pap and meat dishes with rich gravy and very few vegetables (personal observation).

Limitations of this study are: Firstly, it is descriptive cross-sectional study with no exploration of total energy intake or energy expenditure; however, this data is currently being collected in a

follow-up study. Secondly, measurement of the consumption of fast food items and frequency of visits to fast food outlets was assessed as separate questions and as a result, a discrepancy was found between those reporting to eat fast food items 0 times per week (1.9%, data not shown) and those reporting to not have visited a fast food outlet in the previous week (18.3%). Thirdly, the fast food questionnaire was not an exhaustive list of items. Even though there was an 'other' option, the questionnaire did not have all possible chicken fast food items, such as fried chicken pieces. Consequently, given the community being researched, fast food item intake may be underestimated in this study.

This study is the first to address the dearth of nutrient data on the 'quarter'. In an area such as Soweto, undergoing rapid economic transition, it is likely that fast food contributes significantly to energy intake (236). South Africa is showing signs of an obesity epidemic, particularly among those in socio-economic groups who have increasing disposable incomes and greater access to food. In 2003 the *South Africa Demographic and Health Survey* (237) found that 32% of men and 50% of women were either overweight or obese, and in young people those averages were 13.3% and 22.3% in males and females respectively. Thus further research should focus on behaviours around food choices among those experiencing rapid urbanisation so that government may intervene with appropriate public health messages and policies to address the necessary environmental changes.

To conclude, fast food item consumption and visits to fast food outlets were high in this population, especially when compared to their contemporaries in the USA. The contribution of an average 'quarter' to total energy intake is potentially very high, contributing more than 50% of total energy, for the 17-year-old group. However, assessment of total energy intake will help to

put into context the energy contribution of this meal and thus allow us to understand its public health significance.

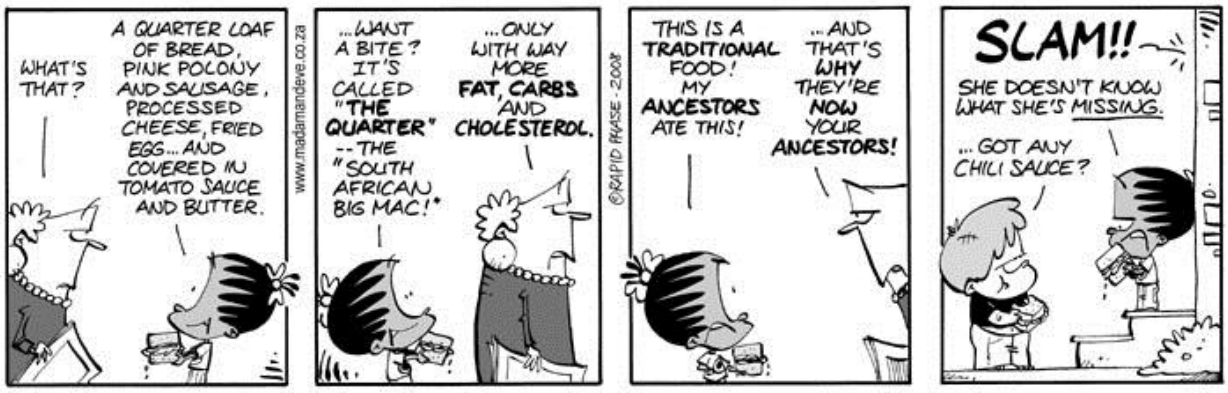


Figure 3.4.1 Madam and Eve, *The Star*, 20 October 2008.

Chapter 4 Changes in dietary habits and eating practices in adolescents living in urban South Africa: the Birth to Twenty cohort.

(Submitted to: *Nutrition*)

4.1 Introduction

Dietary patterns that develop in childhood are often maintained into adulthood (128-132). It is well established that adolescents consistently do not meet healthy eating guidelines and there is a tendency to consume high amounts of energy-dense foods and consume low quantities of fruits and vegetables (33). This nutritional inadequacy results from a complexity of socio-economic and psycho-social factors (49, 51, 238). One conceptual framework combines social cognitive theory with an ecological approach (33) and highlights the importance of the individual, the household, the school environment and the community as some of the domains which influence adolescent food choice.

Typical adolescent eating behaviours in high-income countries include: snacking (usually energy-dense foods), skipping meals (particularly breakfast), high consumption of fast food and sweetened beverages, and low intake of fruit, vegetables and dairy products; such behaviours have been found to be associated with poor nutritional quality (41, 133, 136-142). However, little research has been undertaken in low-and-middle-income countries (179, 181, 239, 240) where the pace of transition is much greater than it was in developed nations, and consequently, the environmental exposures which affect eating behaviours may be different (15). In South Africa

for example, individuals have a high exposure to fast foods since they are available from both formal (commercial franchises) and informal outlets (such as street vendors).

Since adolescents acquire their food from a number of sources (home, school, and in the community) there is risk of developing poor eating habits in all these environments. To date there has been no longitudinal study in South Africa that has assessed dietary habits and eating practices across all three settings. The aim of this study was to track dietary habits and eating practices of urban adolescents living in Soweto-Johannesburg, over a 5-year period. We hypothesised that poor dietary habits and eating practices would increase with age and there would be gender differences.

4.2 Materials and methods

4.2.1 *Study population, history*

The Birth to Twenty (Bt20) cohort monitors children's health and well-being (241) and is comprised of all singleton children (n=3 273) born between April and June 1990, resident for at least six months in the Soweto-Johannesburg municipality after birth, and whose parents gave consent to be enrolled into the study. The cohort, demographically representative of long-term residents in Soweto-Johannesburg, has been followed up 16 times between birth and 20 years of age (222, 224). Attrition over two decades has been comparatively low (30%), mostly occurring during the children's infancy and early childhood. Approximately 2 200 participants remain in contact with the study (242). Primary caregivers gave written, informed consent for their child to participate in the research at each assessment visit and the child provided written assent. Confidentiality was maintained by the allocation of an identification number for each

participant, which was used on all questionnaires. Ethics clearance was obtained from Witwatersrand University Committee for Research on Human Subjects (M080320).

4.2.2 *Assessment of dietary habits and eating practices, questionnaire development*

The questionnaire was interviewer-administered to the participants during their visit to the data collection site. The questionnaire was developed and guided by a literature review to formulate questions around dietary habits and practices within three key settings (home, school and community), which have been shown to be associated with poor nutritional outcomes (41, 49, 51, 133, 238). The questions determined if participants engaged in a particular eating practice, and if they did so, were questioned about which foods they ate (from a predetermined list based on focus-group findings) and how often they had eaten them in the previous week. The questionnaire is somewhat similar to a non-quantified food frequency questionnaire approach where the frequencies of certain food items consumed over the recall period are recorded. Therefore, the questionnaire captured both eating behaviour engagement and, where applicable, what foods were consumed and their frequency.

The questionnaire used was translated into local languages (including seSotho and isiZulu), piloted, and modified in fieldwork debriefing sessions to ensure meaning equivalence of the questions. Piloting was carried out on a convenient group of adolescents to ensure understanding of questions and to test for appropriate translation to local vernacular. Reliability was assessed by using the test-retest design method, administering the questionnaire to the pilot participants (n=20) twice, one week apart. To determine the retest reliability, kappa-coefficients for nominal data were used. The kappa coefficients showed very strong agreement

between the first and second test responses, ranging from 0.89 – 1.00 for the different question items.

4.2.3 *The questions*

In the home environment we enquired about how regularly breakfast was eaten during the week (coded as irregular (<=2/week) or regular (3-5/week)) and at the weekend (coded as irregular (1 weekend day) or regular (both weekend days), how often participants ate snacks while watching TV (0,1,2,3,4 or >5/week), and what snacks were eaten. We enquired about how frequently participants ate their main meal with their family (coded as either "never/some days" or "most/everyday). In the community environment, we asked about the number (0,1,2,3,4 or >5 /week) of fast foods, confectionery[9] and sweetened beverages (soft drinks, diet drinks and squash/cordials) consumed. In the school environment, we enquired about the foods purchased from the tuck shop (TS) and how many days during the previous week a lunch box (LB) was used (coded as irregular (<=2/week) or regular (3-5/week)). Socio-economic status (SES) indicators of the household were assessed at the birth of the cohort child and included maternal education, the availability of household electricity and ownership of a TV, car and fridge in the home (243); these latter variables were used to assess differences between the analytic sample and those remaining Bt20 participants.

4.2.4 *Analytical sample and statistical analyses*

Dietary habits data was collected during cohort assessments at ages 13 (n=1 923), 15 (n=1 981) and 17 years of age (n=1 985). However, only participants with complete data at all three ages and who were black (89%) or of mixed ancestral origin (11%) were included in the analytic

[9] For the purpose of this study 'confectionery' includes items such as chocolate, crisps, sweets, ice-cream, cake, doughnuts

sample (n=1 451; 49.1% male). To assess how representative the analytic sample was of the Bt20 cohort (black and mixed ancestral participants only; excluding white and Indian participants (n=359) because of low study retention in these ethnic groups), demographic and SES variables were compared between the two groups (analytic sample n=1 451, Bt20 n=1 463). All analyses were carried out in STATA v10. Descriptive statistics were performed for the analytic sample: For continuous variables, means and standard deviations (sd) were calculated and frequency weighting determined the most popular foods. Repeated measures analysis of variance (ANOVA) was used to examine differences over time. Sphericity assumptions were first tested for all analyses: Huynh-Feldt ($p>0.9$), Greenhouse-Geisser ($p>0.9$) and Box's conservative epsilons ($p>0.5$), (time, $p<0.0001$). Friedman's test was used when sphericity assumptions were violated. Paired t-tests were used to identify between which age groups there were differences; differences between continuous variables confirmed Normality of their distributions. Gender differences were assessed using independent t-tests. Frequencies were presented for categorical variables and McNemar's tests were used to examine differences between age groups. Gender differences were assessed with chi-square tests. Change over time for 'eat main meal with family' was assessed using Wilcoxon's sign-test.

4.3 Results

4.3.1 *Descriptive Statistics*

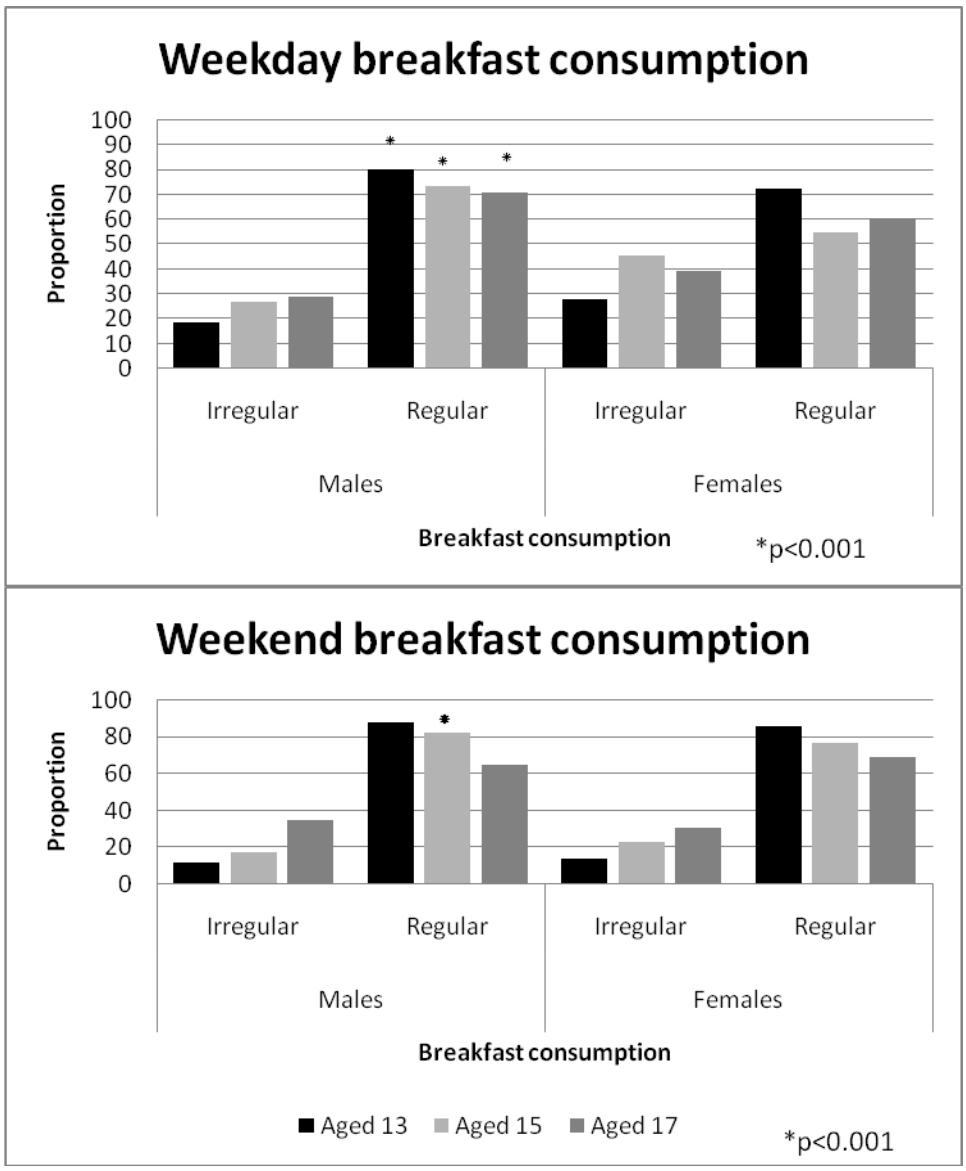
When we compared the analytical sample with those black and mixed ancestral participants not included in the study, the remaining Bt20 cohort, the analytic sample was slightly better off in terms of access to electricity (95.4% vs 87.1%) and a greater proportion had a television (78% vs 64%) and a fridge (74% vs 60%) ($p<0.001$). Maternal education was slightly better in the analytic sample as well, with 46% vs 42% ($p<0.04$) achieving a Std. 9 (schooling to aged 16) or

more. Within the analytical sample, we found no ethnic differences in dietary habits between black and mixed ancestral participants so the data was pooled.

4.3.2 *Dietary Patterns at Home*

4.3.2.1 *Breakfast*

Overall, regular weekday (at least three times) breakfast consumption during the previous week decreased across the age groups, 76.4%, 63.8% and 65.3% for the 13, 15 and 17 year old age groups respectively. Differences between ages 13-15 and ages 13-17 were statistically significant ($p<0.001$). Males consumed breakfast more regularly than females at all ages ($p<0.001$; Figure 4.3.1) and regular weekday breakfast declined with age for both genders respectively. For the whole cohort, regular weekend breakfast consumption was higher than on weekdays but also declined with age (86.8% to 79.8% to 67.3% respectively).



*p-value denotes differences between males and females

Figure 4.3.1 Frequency of breakfast consumption in the previous week.

4.3.2.2 *Snacking while watching TV*

Snacking while watching TV increased with age: with a mean of 3.6 (4.6), 4.8 (6.1) and 6.7 (5.9) snacks/week respectively (p<0.001). Females consistently consumed more snacks while

watching TV than males; aged 13: 4.0 (4.8) vs 3.3 (4.5), aged 15: 5.4 (6.6) vs 4.1 (5.6) and aged 17: 7.3 (5.9) vs 6.0 (5.8) ($p<0.01$).

The five most popular snacks, consistent at all ages, included bread (sliced) or crisps (deep fried potatoes with salt/flavourings added), fruit (e.g. an apple), sweet biscuits and chocolate, which accounted for >80% of snacks consumed (Figure 4.3.2). There was with age a small increase in the consumption of chocolate, cakes, fried chips and fruit and conversely a slight decline in crisps, bread and popcorn (made with fat and salt added) consumption.

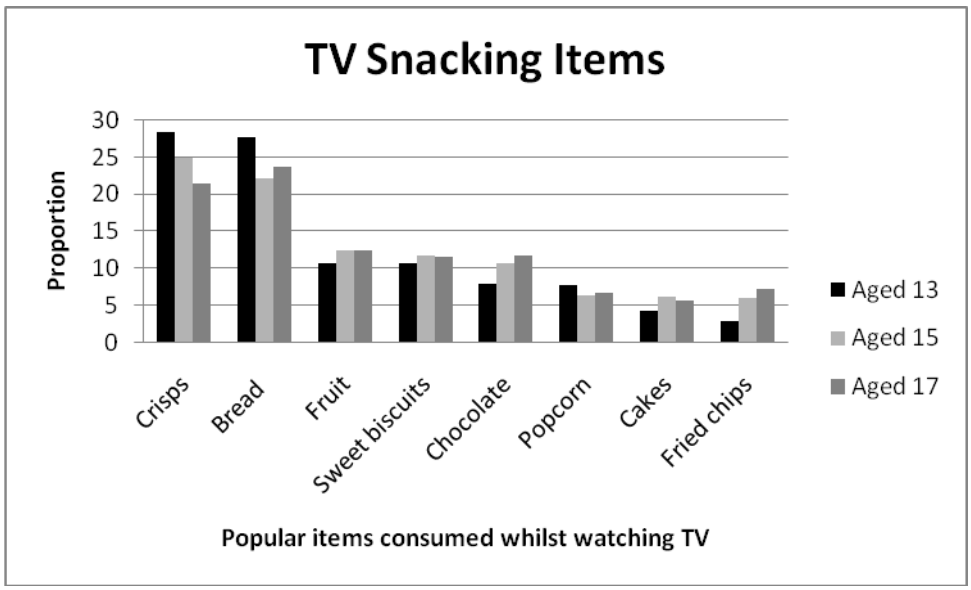


Figure 4.3.2 Snacks consumed while watching TV during the previous week.

4.3.2.3 *Family meal*

For both genders 60% of participants stated that they ate their main meal with their family on 'most or every day' at each age; however, as they grew older there was a trend towards eating less with the family (27% decrease in consuming this meal vs 24% increase (p=0.098)). Gender stratification showed that this behaviour was actually among females (28% decrease in this meal consumption vs 22% increase, p=0.018), and not males (p=1.000).

4.3.3 *Community-based dietary patterns*

4.3.3.1 *Fast food, confectionery and beverages*

Fast food intake during the week increased with age, from 4.8 (3.9), to 5.1 (4.8) and to 5.3 (4.2), for each age group respectively (p=0.001). There were no gender differences in fast food consumption except at age 17, with males consuming slightly more fast food (5.6 (4.2) items vs 5.1 (4.2); p=0.04). Fast food preferences were the same for both genders with the five most popular foods being fried chips, vetkoek (fried dough balls), fried fish (battered), pies (pastry with a filling, usually meat) and boerewors (local sausage) rolls accounting for >74% of total fast foods consumed (Figure 4.3.3).

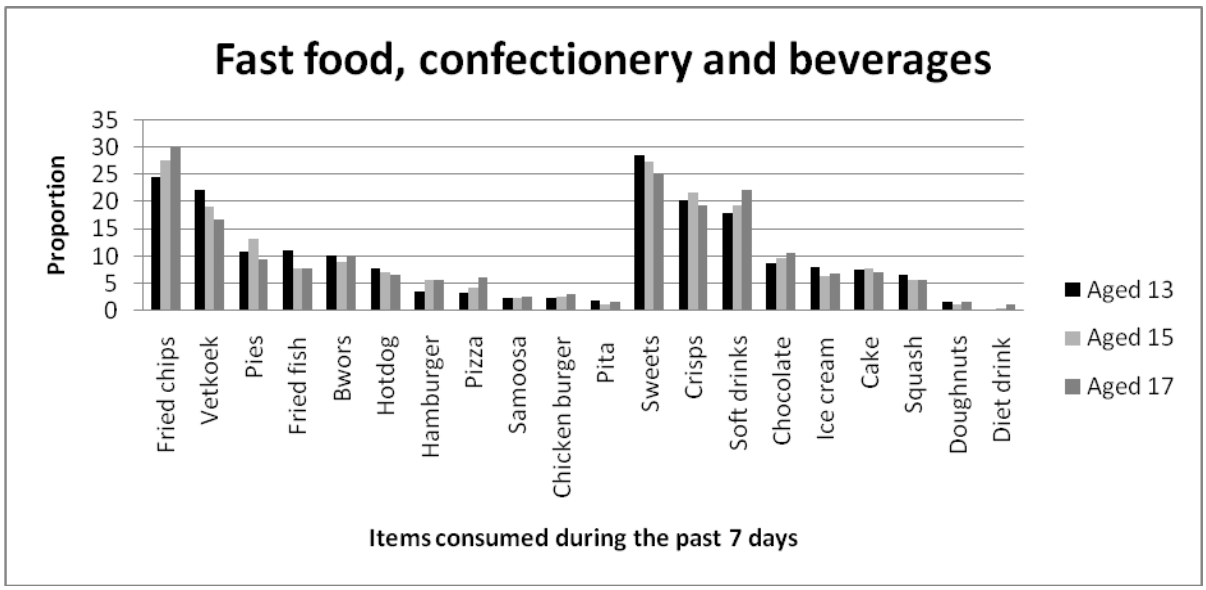


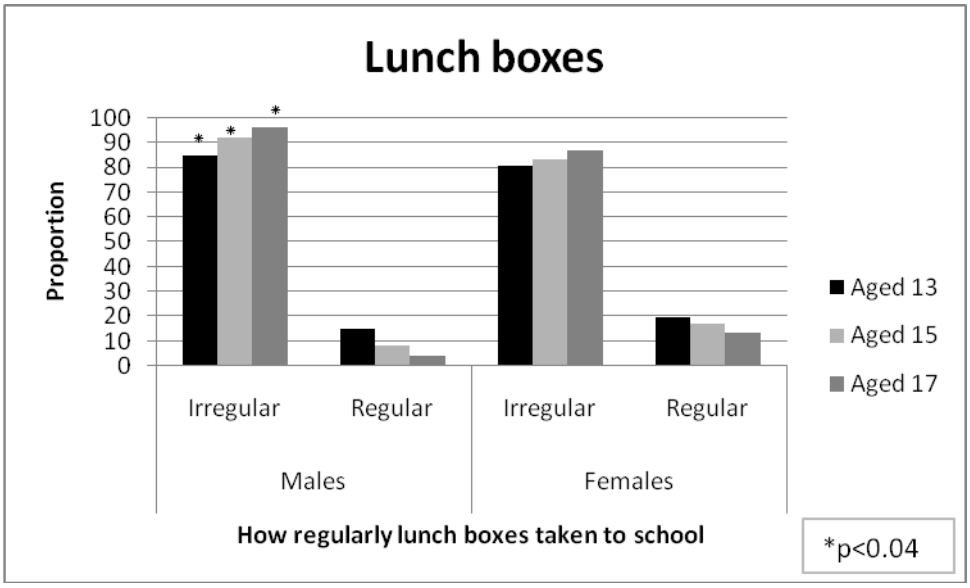
Figure 4.3.3 Popular food items in the community.

Confectionery and beverage consumption were analysed separately, but are shown together with fast foods (Figure 4.3.3). For the whole cohort, confectionery consumption/week changed little over the five years, from 9.4 (4.8) to 9.6 (5.3) and 9.5 (4.9). Girls consistently ate more confectionery than boys at each age group: 9.6 (4.9) vs 9.1 (4.6), 10.2 (5.2) vs 8.9 (5.2) and 10.1 (5.1) vs 8.9 (4.7) ($p<0.02$). Mean beverage consumption increased with age across the entire cohort from 3.1 (2.5) at 13 years to 4.0 (2.5) at 17 years ($p<0.001$). Sweets, crisps and soft drinks were the three most popular confectionery/beverage items, accounting for >65% of the total items consumed at all time points. With age, there was an increased preference for soft drinks and chocolate and a decreased preference for sweets, ice cream and squash (cordial).

4.3.4 *School dietary patterns*

4.3.4.1 *Lunch Boxes*

Regular lunch box use was not common at any age, declining from 17.4% to 12.3% and to 8.6% for each age respectively (p<0.001), but its use was significantly higher among females than males (p<0.04), (Figure 4.3.4).



*p-value denotes differences between males and females

Figure 4.3.4 Lunch box usage during the past week.

For the whole cohort, the mean number of foods/week contained within LBs increased over time: from 6.6 (3.8), to 8.4 (4.9) and 10.0 (4.8), p<0.02 at each age respectively. When assessed by gender, girls consistently had more items/week in their LBs than boys: aged 13, 6.9 (3.8) vs 6.2 (3.7) (p<0.001), aged 15 9.1 (4.7) vs 6.9 (4.7) (p<0.001), aged 17 10.3 (4.8) vs

9.0 (4.7) p=1.327. The most popular LB foods (accounting for >50% foods) at each age, included cheese, bread (white or brown), fruit and fruit juice (Figure 4.3.5).

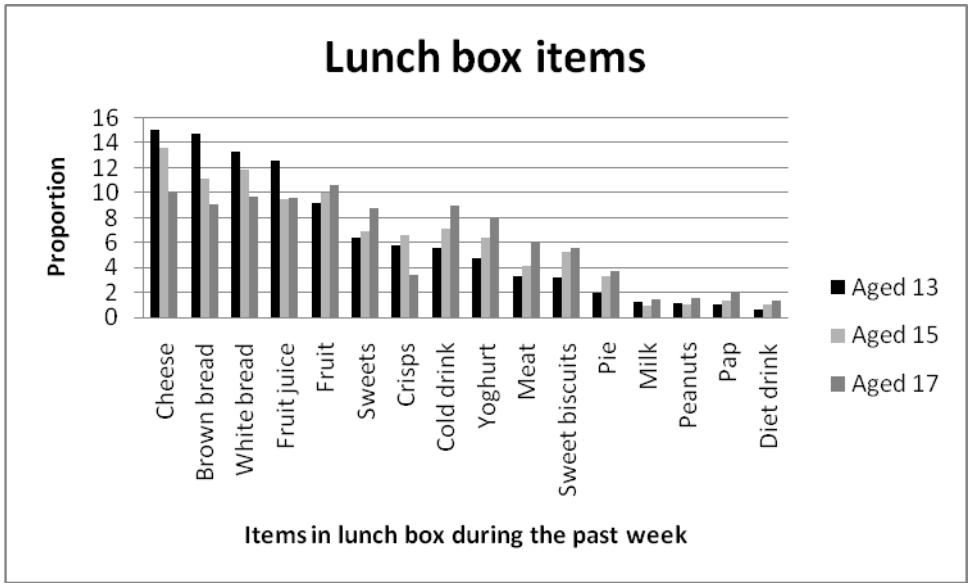


Figure 4.3.5 Lunch box items.

4.3.4.2 *Tuck shop purchases*

More than 85% of participants bought food from the school tuck shop with a mean increase with age, from 12.4 (7.8) to 12.9 (9.0) to 13.5 (10.2) purchases/week respectively (p=0.03). The difference between ages 13 – 17 years only, was statistically significant (p<0.001). When stratified by gender, girls bought more items than boys at each age but the difference was only significant at aged 13 years; 12.9 (7.6) vs 11.9 (7.8); (p=0.01).

The five most popular TS purchases at all ages included sweets, crisps, cold drinks, fried chips and white bread, accounting for 62% of purchases. With increasing age there was a decrease in

the purchase of sweets, crisps, fruit juice, white bread and pies, but an increase in the purchase of cold drinks, cake and fried chips.

4.4 Discussion

This study evaluated the longitudinal changes in adolescent dietary habits and eating practices over a 5-year period. We demonstrated that eating practices are well established by the age of 13, with poor dietary practices persisting with increasing age, and that irregular breakfast consumption, TV snacking and fast food consumption increased over time. Similarly, TS purchases increased with age, but more so among females. Regular LB use was low. Interestingly, a high proportion of the cohort consistently ate their main meal regularly with their family over the five years.

4.4.1 *Dietary Patterns at Home*

Previous South African studies have demonstrated that adolescent breakfast-skipping ranged between 13% – 22% depending on ethnicity and geographic location (181, 239). In the US similar proportions of boys (11%) and girls (14%) ate breakfast between 0 and twice per week (154). Furthermore, 31% of 14 – 18 year old boys and girls had skipped breakfast in the previous week (244). Our study showed higher levels of breakfast-skipping, particularly by the age of 17 years.

For both genders, the number of snacks consumed while watching TV increased by 86% over the 5-year period. In the US, mean daily snack intake while watching TV was 2.5 (1.4) and 2.2 (1.1) for males and females respectively ($p<0.001$) (139), which is greater than twice the

amount found in our current study. Although the association between TV viewing and obesity is partly mediated by lower physical activity, it can also influence food intake and diet quality (245). One study found that for each hour of TV viewing an additional 653 kJ/d was consumed (137).

A higher frequency of participating in family meals has been associated with a lower prevalence of obesity and is associated with other behaviours important in adolescent development (141). An American study of >90 000 adolescents found that 20% of participants rarely ate their main meal with their family (0-1 days/week), while 45% frequently ate this meal with their family, (between 5-7 d/week) (141). Another US study found that with increasing age, adolescents ate their main meal with their family less often; from 8.9% at ages 11 - 13 years to 15.4% at ages 16 - 17 years (140). Thus contrary to the above research, two-thirds of our respondents ate their main meal with their family on 'most or every day', at each age. This emphasises that the potential influences on adolescent eating practices (at least for the important main meal of the day) by their family is still strong at age 17 years, thus the notion of this influence decreasing with age, as found with US adolescents, is currently not so in a South African urban black population.

4.4.2 *Community dietary patterns*

Overall, fast food consumption increased by 10.4% and males ate slightly more than females at age 17. However, girls consistently ate more confectionery than boys. Beverage consumption increased by 29% over time for both genders. In a cross-sectional study of 17-year-olds living in Soweto (n=655), we found that mean fast food item intake was 7.6 (±4.6)/week (246); higher than our findings in the current study, which is possibly due to sample size differences. Larson and colleagues found that 22.5% of US adolescents consumed fast food on three or more

days/week, which is less than our current findings (230). For soft drinks, Ludwig et al. found that 11 - 12 year old boys and girls consumed 1.4 and 1.1 servings/day respectively (174), higher than in our current study. Indeed, snacking (which includes confectionery and soft drinks) has been shown to be on the increase in the US and may be associated with obesity. Since 1989 child snack consumption in the US has increased to three/day, with 27% of energy intake attributed to snacking (142).

Availability and access may be reasons for why fast food intake is relatively high among the cohort of this study. In a developing country like South Africa, fast foods are obtained from both commercial outlets and informal outlets (e.g. street vendors and community TSs) whereas in developed countries, they are available almost exclusively from commercial outlets. Informal outlets in Soweto sell a single vetkoek for 60c (US$0.09), and portion of chips for R8 (US$1.19), while an equivalent sized portion of chips from a commercial outlet costs R15 (US$2.22). The lower prices from informal vendors make fast foods more accessible and affordable to those on lower incomes. Availability of confectionery and beverages is also widespread both at school (TSs in or outside school grounds) and in the community (street vendors, TSs, and commercial outlets).

4.4.3 *School dietary patterns*

Regular LB usage was low and declined with age among this cohort. However, the results showed a mean increase with age in the LB food items, which is possibly a reflection of the older adolescent's higher energy requirements. In a cross-sectional survey of US adolescents (n=1 088), 72% did not use a LB in the previous week while 31% reported to purchase snack foods from school vending machines (178). The school TS in South Africa is probably an

equivalent source of snacks to vending machines in the US; such purchases increased by 8.8% over five years. Another study among South African adolescents found a higher LB usage with 50% of study participants bringing food to school. TS purchases were also high with 73% adolescents purchasing two or more unhealthy items/day (181).

Study design and questionnaire differences prevent us from making direct comparisons between our study and other international research. However, our data indicates that we ought to be as concerned about dietary habits in adolescents as health professionals are in high-income countries. Our data shows that poor dietary habits and practices increase with advancing age. Whether the desire for such food is a result of choice, environmental exposures or is part of personal development in which adolescents exert their individuality by eating away from home and with their peers, is not known (33). Qualitative work around the meanings of food showed that 'junk food' was associated with pleasure, being with friends, independence, affordability and convenience; conversely, a healthy meal was associated with family, meals, and being at home (247). Certainly, Soweto is still undergoing rapid transition, particularly in the area of economic upliftment which drives lifestyle changes, including food behaviours. Possibly the increase in these poor habits is a reflection of the context in which these adolescents live.

This study identifies future research questions: How do these dietary habits and eating practices contribute to total energy intake and affect body composition? Do the dietary habits and eating practices described here differ in adolescents of higher SES living in other suburbs of Johannesburg? A better understanding of the preparation and composition of the main family meal could guide potential interventions, since parental influence in this regard is still strong among the majority of this population. In South Africa, food available in schools is unregulated;

another possible intervention could therefore focus on schools since these settings are more contained than others within the wider community. Also, educating parents and adolescents about the importance of correct eating patterns to encourage more LB usage could be considered, especially since we found that the five most popular LB foods were relatively healthy.

A limitation of this study is that the analytical sample represents the slightly better-off black and mixed ancestral families residing in Soweto-Johannesburg and does not cover severely disadvantaged families. Also, as the questionnaire assessed frequency of foods consumed, these figures should be viewed as estimates and not absolute values since such methods are known to overestimate intake. The contributory role these eating patterns have on overall energy intake was unable to be determined. However, this study is unique in that it assessed longitudinal dietary habits and eating practices of adolescents over a 5-year period living in an urban setting undergoing transition. There is a need for such data in middle- and low-income countries, especially amid the increasing prevalence of obesity (5). This study was based on a large sample of subjects, thus we feel confident that these dietary patterns and eating practices are indicative of adolescent behaviour within this urban setting. However, what drives these patterns is unclear. Do these behaviours result from increases in advertising, in pocket money, or are they a result of the nutrition transition being affected by complex interactions between demographics, environment and economics (6)?

4.5 Conclusion

To conclude, this study identified poor eating habits in three environments of risk and in all of the environments the participants' propensity for energy-dense, micronutrient-poor foods was

high. A noteworthy outcome of this study was that dietary patterns are well established by the age of 13 years.

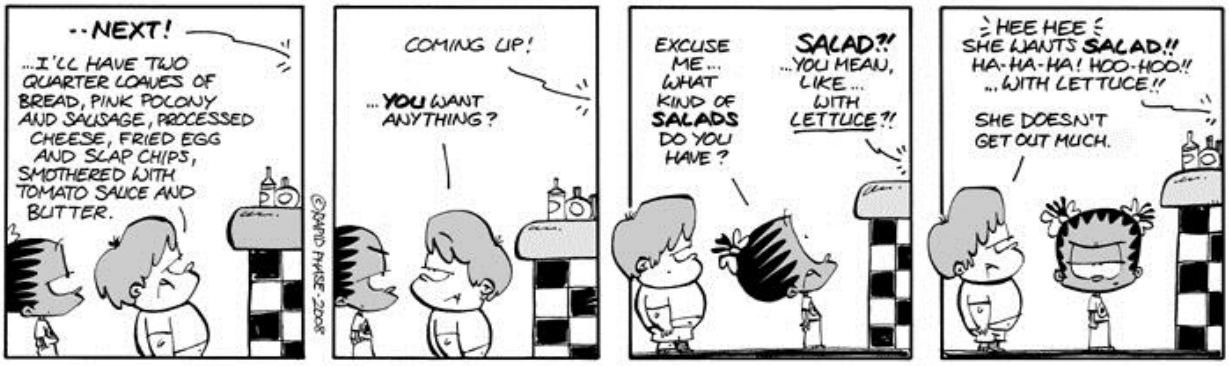


Figure 4.5.1 Madam and Eve, *The Star*, 21 October 2008.

Chapter 5 Investigation into longitudinal dietary behaviours and household socio-economic indicators and their association with obesity in South African adolescents: the Birth to Twenty cohort.

(Submitted to: *Public Health Nutrition*).

5.1 Introduction

Since the end of segregationist and discriminatory practices of apartheid in1994, South Africa has undergone profound political, social and economic transition. Parallel to these transformations have been lifestyle changes driven by rapid rates of urbanisation, from 10% in 1990 to 56% in 2005, especially among black South Africans (19). In addition to infectious diseases and a rise in non-communicable diseases, the South African population also has the added burden of a high prevalence of HIV/AIDs and violence-related trauma (66), this collection of health challenges is often referred to as 'the quadruple burden of disease'.

Urbanisation in low- or middle-income countries (LMICs) drives changes in food habits and body composition and it is associated with both health gains and risks. In South Africa, Bourne et al. showed that between 1940 – 1992 diets among the black population shifted from a prudent pattern (>50% carbohydrate, <30% total fat, ~15% protein) to one that showed a progressive increase in fat (from 16.4% to 26.2%), with a concurrent decrease in carbohydrates (from 69.3% to 61.7%) (30).

The worldwide prevalence of obesity has reached alarming levels (475 million) affecting both high-income countries (HICs) and LMICs. Furthermore, over 1 billion adults are overweight (7). Latest figures from South Africa show that among those aged 15 years and older, the prevalence of combined overweight and obesity is 30% among males and 52% among females (80). Of note is that black women experience the greatest burden of obesity (30.5%) followed by women of mixed ancestry (28%), white (24%), and Indian (20%). Among men, whites experience the highest levels (20%), followed by mixed ancestry (9%), Indian (8.7%) and then blacks (7.7%). Overweight and obesity are also on the increase among younger generations and overweight has been shown to track from childhood into adulthood (248). In a South African nationally representative study (aged between 1 – 9 years of age) it is shown that the national prevalence of combined overweight and obesity (denoted by a BMI (>25 kg/m^2) is 17.1% (79). It is suggested that dietary patterns developed in childhood are maintained into adulthood, and poor dietary habits predispose individuals to obesity and related metabolic diseases later in life (100).

Among the lifestyle determinants of obesity, socio-economic status (SES) has also been given attention (249, 250). Briefly, SES and obesity relate to each other differently depending on the gross national product (GNP) of a country. Among women in HICs a higher likelihood of obesity is found in those of the lower socio-economic strata (249), while in LMICs the burden of obesity shifts towards lower SES groups as a country's GNP increases. The shift of obesity towards women within low SES groups seems to occur at an earlier stage of economic development than it does among men. The switch to higher rates of obesity in women of lower socio-economic strata has been shown to occur when the GNP per capita is about $2 500 (250).

There is little longitudinal data and none in South Africa assessing the association between dietary behaviours developed in childhood and adolescence and overweight and obesity. Thus, using longitudinal data from urban South African adolescents at ages 13, 15, and 17 years part of the Birth to Twenty cohort, we investigated dietary habits and household SES indicators and their associations with BMI z-score and fat mass.

5.2 Subjects and Methods

5.2.1 *Study population, design and sample size*

Data for this study were obtained from a longitudinal birth cohort study; The Birth to Twenty (Bt20) cohort which started in 1989 (241). Singleton children (n=3 273, 78% black participants) born between April and June 1990 and resident for at least 6 months in the Soweto-Johannesburg municipality were enrolled into the birth cohort and have been followed up almost annually between birth and 20 years of age. Attrition over the two decades has been comparatively low (30%), mostly occurring during the children's infancy and early childhood; approximately 2 300 participants remain in contact with the study (242). Assessments across multiple domains have been made of children, families, households, schools and communities during the course of the study. The assessments included growth, development, psychological adjustment, physiological functioning, genetics, school performance, and sexual and reproductive health (224).

Data for this current study were collected at ages 13 (n=1564), 15 (n=1586) and 17 years (n=1621). Only black participants with complete data at all three ages were included in the analysis, (N=1298; 49.7% male). Dietary habits data for all three ages were assessed against body composition outcomes at aged 17 years.

5.2.2 *Dietary assessment and exposure variables*

Participants completed interviewer assisted questionnaires on dietary behaviours around food choices and eating practices occurring in the home, school and community, and which have been shown to be associated with poor nutritional outcomes (33, 38, 39, 147, 155, 185, 251-253). The questions determined if participants engaged in a particular eating behaviour. If they did, and when appropriate, we enquired about which foods they ate (from a predetermined list) and how often they ate them in the previous week. This is similar to an unquantified food frequency questionnaire approach where the frequency of certain food items consumed over the recall period is recorded. Further information on the tool's development and piloting can be found (254). We asked participants about eating behaviours in 3 environments of risk: In the home environment we enquired about how regularly breakfast was eaten during the week and at the weekend, how many snacks were consumed while watching TV in the previous week, and what snacks were eaten (e.g. crisps, bread, fruit, sweet biscuits, chocolate, popcorn, cakes, fried chips). We enquired about how frequently participants ate their main meal with their family. In the community environment, we asked about the number (0,1,2,3,4 or >5/week) of fast food items (for example fried chips, vetkoek (fried dough balls), pies, fried fish, boerewors (a local sausage), hotdogs, hamburger, pizza, samoosa, chicken burger, filled pita), confectionery (sweets, chocolate, doughnuts, crisps, ice-cream and cake) and sweetened beverages (soft drinks, and squash/cordials) consumed per week. In the school environment, we asked about the foods purchased from the tuck shop[10] (foods we asked about included: white bread, brown bread, fruit, pap (mielie meal), fruit juice, milk, yoghurt, cheese, popcorn, peanuts, crisps, fried chips, pie, vetkoek, sweetened beverages, sweets, cake) and how many days during the previous week a lunchbox was used. Lunch box food items we asked about included: cheese, brown bread, white bread, fruit juice, fruit, sweets, crisps, sweetened beverages, yoghurt, meat,

[10] Which may have been a food vendor selling foods within or outside the school grounds.

sweet biscuits, pies, milk, peanuts, pap (mielie meal). Over the period of data collection, meals were not provided by schools.

Dietary behaviours at each age (breakfast during the week, breakfast at the weekend, snacking while watching TV, eating main meal with family, lunch box use, number of tuck shop purchases, fast food consumption, confectionery consumption and sweetened beverage consumption) were categorized into binary variables, i.e. a poor eating habit (e.g. infrequent breakfast consumption or the purchase of a high number of items from the tuck shop etc.) = 1 and a 'healthier' eating habit (e.g. frequent breakfast consumption or the purchase of a low number of items from the tuck shop or a low number of fast food or confectionery items) = 0.

5.2.3 *Anthropometric measurements at birth and at 17 years of age and body composition*

Birth weight was retrieved from maternity records. Birth weight z-scores were calculated using The World Health Organization (WHO) 2006 growth standards (255). Weight (digital scale from Dismed, USA), to the nearest 100 g, and height (stadiometer from Holtaine, UK), to the nearest millimeter, were measured with subjects wearing light clothing and no shoes. Body composition of the total body less head (TBLH) was determined by dual energy X-ray absorptiometry (DXA; Hologic QDR Discovery W) according to standard procedures of the International Society of Clinical Densitometry (software version 11.2:3) (256) . For the purposes of this study, only fat mass was used.

Body mass index was calculated (kg/m^2) and internal gender specific z-scores were calculated as an alternative to using actual BMI values since BMI z-scores provide a relative measure of adiposity adjusted for sex and age-specific growth. Internal z-scores were used for intra-population comparability. BMI z-score was calculated as the difference between the participant's

BMI and the mean BMI divided by the SD of the cohort BMI for each gender. Fat mass (kg) was adjusted for height [the power coefficient was obtained from the regression analysis of fat mass (kg) on height (m)] as described by Prentice et al (257). This measure was log transformed to improve normality. As shown by others (175, 258), birth weight z-score was found to be associated with the outcome measures for both genders therefore the outcome measures were adjusted for birth weight z-score by deriving the coefficient from the regression analysis of outcome on birth weight z-score.

5.2.4 *Socio-economic indicators*

SES indicators in the form of household durables data were collected from the mother at the time of the child's birth and again when the cohort child was 12 years old. The information collected included maternal education, household electricity, and ownership of a television, washing machine, landline telephone, car and fridge.

SE household durables were categorized into binary variables; having a particular household durable item = 1, not having this household durable item = 0. Maternal education was categorized into those mothers who achieved a grade 10[11] or above = 1 and those who achieved less than this educational level = 0. Gender differences were assessed with chi square tests.

Confounding was assessed by regressing individual SE household durable variables (collected at birth) against the outcome variables and the individual dietary habits. If the SE household variable was significantly associated with the outcome and exposure variable then is was considered a confounder and adjusted for in the regression models. The use of individual SE indicators resulted from preliminary exploratory analyses whereby a composite score (factor

[11] Equivalent to grade 11 in the US and the legal point of exiting the education system in South Africa

scores) of SES was derived. The score became non-significant when tested as a confounder. Upon doing factor analysis we noted that fridge ownership contributed the greatest amount (factor loadings) to the composite score. The rotated orthogonal Kaiser-Verimax factor analysis showed that 23% of the variability was explained by the first factor which had an Eigen value of 1.39, with fridge ownership having the greatest loading of 0.97. Therefore it was decided to use individual SE household variables in the regression models.

For each SE variable a new variable was created to assess the change in SES status between birth and age 12 years; that is if the participant 'acquired' a particular household variable between the two time points or if they 'never' had that particular durable item over the two time points. These two variables were compared to the reference variables 'always' having a particular durable item over the two time points. This variable was used in the multiple variable analyses.

5.2.5 *Ethics*

Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects, protocol number: M080320. Primary caregivers gave written informed consent for their child to participate in the research at each assessment visit and the child provided written assent. Confidentiality was maintained by the allocation of an identification number for each participant which was used on all questionnaires

5.2.6 *Statistical analysis*

All statistical analyses were performed using STATA version 10.0 (259). Demographic and SES variables were compared between the analytic sample and the remaining Bt20 cohort

(n=1 975). For the analytic sample, descriptive statistics were performed for each variable, which for continuous variables was the mean and standard deviation. For categorical variables frequencies are presented and associations were assessed using Pearson's Chi square tests. Gender differences were assessed with Student's t-test for Gaussian continuous variables.

5.2.7 *Univariate and multiple variable analyses*

We used a generalised estimating equation (GEE) approach to fit our univariate and multiple variable models, details given as an addendum (p. 153). For the Gaussian family-based outcomes BMI and adjusted fat mass, we used the identity and log link functions respectively, with independent covariance structure. The Binomial family was used for the socio-economic variables with independent covariance structures and a logit link function (260). First, individual dietary habit variables were inserted individually into the statistical model, then if significantly associated ($p<0.05$), multiple variable analysis was carried out with the inclusion of the confounding SES household durable variables (previously assessed by univariate analysis).

5.3 Results

5.3.1 *Basic characteristics and outcome variables*

The analytic sample was better off at birth than the remaining Bt20 cohort in terms of having electricity (96% vs 90%, $p<0.001$), however the Bt20 cohort not included were better off in terms of car (32% vs 25%, $p<0.001$) and washing machine (20% vs 8%, $p<0.001$) ownership. No differences were found in the ownership of TV, fridge or phone, or in maternal education. However, for marital status, 50% of the Bt20 parents were either married or cohabiting compared with only 32% of the parents of the analytic sample ($p<0.001$).

Descriptive characteristics of the two gender groups are described in Table 5.3.1. Females had a lower mean birth weight than males ($p<0.001$). At 17 years of age, females were shorter than males ($p<0.001$) with a similar weight, thus their mean BMI was greater than males ($p<0.001$). Furthermore, mean fat mass (less head) was 2.4 times higher in females than in their male counterparts ($p<0.001$). Combined overweight and obesity in this cohort was 8% in males and 27% in females ($p<0.001$); this was a decrease in boys and an increase in girls respectively, from when they were 13 years old ($p=0.038$).

Table 5.3.1 Descriptive characteristics of the cohort stratified by gender

Variable	Males (n=607) Mean (SD)	Females (n=616) Mean (SD)	p-value
Birth weight (g)	3128.7 (504.8)	3012.8 (491.6)	<0.001
Birth weight z-score[a]	-0.52 (1.1)	-0.54 (1.1)	0.639
Age (years)	17.7 (0.3)	17.7 (0.3)	1.000
Height (cm)	170.6 (7.9)	159.7 (6.0)	<0.001
Weight (kg)	59.3 (9.7)	58.5 (12.2)	0.253
BMI (kg/m^2)	20.4 (3.2)	22.9 (4.4)	<0.001
Total Fat mass (kg) less head	7.7 (4.8)[b]	18.5 (7.6)[c]	<0.001
Overweight/obese aged 17[d] (n,%)	43 (8.1)	152 (27)	<0.001
Age (years)	13.7 (0.2)	13.7 (0.2)	1.000
Height (cm)	154.3 (8.5)[f]	155.7 (6.2)[g]	<0.001
Weight (kg)	44.5 (9.8)	50.0 (11.6)	<0.001
BMI (kg/m^2)	18.6 (3.2)	20.6 (4.3)	<0.001
Overweight/obese aged 13[e] (n,%)	52 (9.8)	115 (20.5)	0.038

[a]WHO 2006; [b](n=592); [c](n=594); [d]Using International Obesity Task Force (IOTF) cut-offs for 17.5-year olds (102); [e]Using International Obesity Task Force (IOTF) cut-offs for 13.5-year olds; [f](n=529); [g](n=561)

Table 5.3.2 shows dietary habits and eating practices stratified by gender, at all ages: 13, 15 and 17 respectively. With age, both boys' and girls' irregular breakfast consumption increased (both weekday and weekend), with girls consistently skipping breakfast more often than boys ($p<0.05$). Between 30% – 40% of the cohort ate their main meal with their family infrequently (never/some days), throughout the follow-up period. Over two-thirds consumed fast food and sweetened beverages on three or more occasions per week. Over two-thirds consumed confectionery on seven or more occasions per week, with girls consuming them more than boys at ages 15 and 17 respectively ($p<0.05$). Generally, lunchbox usage was low (5% – 20%) with girls using them more regularly than boys, at all ages ($p<0.05$). Between 50% – 70% of participants purchased 10 or more tuck shop items per week.

Table 5.3.2 Dietary habits variables stratified by gender, by age.

Age	**13**		**15**		**17**	
Exposure	Males (n=645)	Females (n=653)	Males (n=645)	Females (n=653)	Males (n=645)	Females (n=653)
Home	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Irregular breakfast weekday (<2/wk)	136 (21.1)	188 (28.8)[c]	176 (27.3)	304 (46.6)[c]	193 (29.9)	268 (41.0)[c]
Irregular breakfast weekend (1 day)	79 (12.3)	91 (13.9)	107 (16.6)	148 (22.7)[b]	220 (34.1)	180 (27.6)
Irregular eat with family (never/some d/wk)	220 (34.2)	244 (37.4)	222 (34.6)	254 (38.9)	269 (41.7)	257 (39.4)
TV snacks (>3/wk)	353 (54.7)	400 (61.2)[b]	329 (51.0)	395 (60.5)[c]	380 (58.9)	450 (68.9)[c]
Community						
Fast foods (>3/wk)	438 (67.9)	454 (69.5)	440 (68.2)	422 (64.6)	415 (64.3)	395 (60.5)
Confectionery (>7/week)	386 (59.8)	422 (64.6)	415 (64.3)	495 (75.8)[c]	380 (58.9)	435 (66.6)[b]
Soft drinks (>3/week)	431 (66.8)	451 (69.1)	452 (70.1)	466 (71.4)	431 (66.8)	450 (68.9)
Schools						
Lunch boxes (</=2/wk)	539 (84.3)	519 (79.7)[a]	581 (92.1)	531 (85.5)[c]	618 (95.8)	563 (86.2)[c]
Tuck shop purchases (>10/week)	461 (64.5)	452 (69.2)	438 (49.9)	445 (68.2)	434 (67.3)	427 (65.4)

[a]Gender difference p<0.05, [b]Gender difference p<0.01, [c]Gender difference p<0.001

There were no gender differences in socio-economic household indicators or maternal education at the birth of the cohort participants. At that time, most of the cohort families had electricity in the home (96%), and a television (80%), and fridge (76%). A smaller proportion owned a landline phone (<58%), car (<26%) or a washing machine (8%). Nearly half the

mothers (44%) had schooling to Grade 10 or above, with only 7% of this group having had post-school education.

5.3.2 *Univariate analysis*

5.3.2.1 *Dietary habits and practices*

Univariate GEE analyses between the body composition outcome measures at age 17 years and each longitudinal dietary habit and practice variable were assessed. All GEEs were stratified by gender since gender differences were shown for the outcome and exposure variables.

The univariate analyses showed that among males longitudinal sweetened beverage consumption was positively associated with both BMI z-score [β=0.050 (95% CI 0.014 - 0.085); p=0.007] and fat mass [β=0.035 (95% CI 0.007 - 0.063); p=0.015], while infrequent consumption of the main family meal was negatively associated with fat mass [β= -0.06 (95% CI -0.052 - -0.001); p=0.038].

Among females, positive associations were found between irregular weekend breakfast consumption and BMI z-score [β=0.044 (95% CI 0.0135 - 0.075); p=0.005] and fat mass [β=0.030 (95% CI 0.000 - 0.060); p=0.047]. As with boys, infrequent consumption of the main family meal was negatively associated with fat mass [β= -0.026 (95% CI -0.052 - -0.001); p=0.038].

5.3.2.2 *Confounders*

Socio-economic household durable variables were regressed against the exposure and outcome variables separately (Table 5.3.3). Among males only, fridge ownership was significantly associated with both BMI z-score and fat mass and with one exposure variable, soft drink consumption ($p<0.05$). No other SES variables were associated with either exposure or outcome variables for either gender.

Table 5.3.3 The significant associations (β, 95% CI) estimated by the GEE 'univariate' analyses regarding the SES household durable measures (stratified by gender) in relation to the individual dietary habits and eating practices and outcome variables (BMI z-score and fat mass).

	Fridge		Television		Car		Electricity		Washing machine		Phone		Maternal Education	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Male	Females
Irregular Breakfast weekday	x	X	x	x	x	X	x	0.122 (0.005 – 0.239)[a]	X	-0.010 (-0.182 - - 0.023)[b]	x	-0.061 (-0.107 - - 0.016)[b]	x	X
Irregular Breakfast weekend	x	X	x	x	x	X	x	0.104 (0.004 – 0.203)[c]	x	x	x	x	x	X
TV snacking	0.108 (0.055 - 0.160)[c]	0.067 (0.017 – 0.118)[b]	0.056 (0.001 – 0.112)[c]	x	x	X	0.127 (0.012 – 0.242)[c]	X	x	x	x	0.058 (0.014 – 0.103)[b]	x	0.062 (0.019 – 0.104)[c]
Irregular Eat Family	x	0.055 (0.003 – 0.106)[c]	x	x	x	0.064 (0.015 – 0.114)[b]	x	X	x	x	x	X	x	X
Fast food	x	X	0.055 (0.002 – 0.108)[a]	-0.056 (-0.110 - - 0.002)a	0.077 (0.027 – 0.128)[b]	X	x	X	0.086 (0.009 – 0.167)	x	x	x	x	0.052 (0.010 – 0.095)[b]
Confectionery	x	X	x	x	x	X	0.164 (0.052 – 0.276)[b]	X	x	x	-0.050 (-0.096 - - 0.004)[c]	x	x	X
Soft drinks	0.088 (0.039 – 0.137)[c]	0.057 (0.009 – 0.106)[b]	x	x	0.059 (0.010 – 0.109)[b]	X	0.138 (0.031 – 0.246)[b]	X	0.120 (0.042 – 0.195)[b]	x	x	x	x	0.103 (0.063 – 0.144)[c]
Lunch boxes	x	X	x	x	x	X	x	X	-0.078 (-0.126 - - 0.031)[c]	x	X	-0.042 (-0.078 - - 0.006)[b]	-0.035 (-0.061 – 0.009)[c]	x
Tuck shop	x	X	x	x	x	X	0.167 (0.058 – 0.276)[b]	X	x	x	x	x	x	X
No food	-0.039 (-0.067 - - 0.011)[b]	X	x	x	x	X	-0.114 (-0.175 - - 0.053)[c]	X	x	x	x	-0.027 (-0.050 - - 0.004)[b]	x	x
BMI z-score	0.079 (0.044 - 0.113)[c]	X	x	x	x	X	x	X	x	0.069 (0.196 – 0.119)[b]	x	x	x	-0.031 (-0.058 - - 0.004)[a]
Fat mass	0.064 (0.34 – 0.094)[c]	X	x	x	x	X	x	X	x	0.095 (0.045 – 0.145)[c]	0.062 (0.036 – 0.089)[c]	x	x	x

[a]p<0.05; [b]p<0.01; [c]p<0.001

5.3.2.3 *Birth weight z-score*

Linear regression showed that birth weight z-score was positively associated with BMI z-score and fat mass at 17 years of age (p<0.001) for both genders (Table 5.3.4). Therefore, in the multiple variable analyses each outcome variable was adjusted for birth weight z-score.

Table 5.3.4 Association of birth weight z-score with BMI z-score and fat mass (unadjusted and adjusted for height) at 17 years old.

BMI z-score	**ß[a] (95%CI)**	**ß (95%CI)**
Males	0.150 (0.084 – 0.216)[b]	-
Females	0.128 (0.063 – 0.193)[b]	-
Fat mass	Unadjusted for height	Adjusted for height
Males	0.702 (0.354 – 1.049)[b]	0.268 (0.119 – 0.417)[b]
Females	1.092 (0.577 – 1.607)[b]	0.772 (0.382 – 1.161)[b]

[a]Regression coefficient; [b]p<0.001

5.3.2.4 *Multiple variable models*

Multiple variable GEEs were conducted separately for both outcome measures (BMI z-score and fat mass) and all exposures and confounders.

For BMI z-score in the unadjusted model, only sweetened beverage consumption was positively and significantly associated with BMI z-score. Furthermore, after adjustment for confounders (SE household assets, in this case fridge ownership) the association between sweetened beverage consumption and BMI z-score remained (p<0.05), (Table 5.3.5). For fat mass, in the unadjusted model, sweetened beverage consumption was also positively and significantly associated, and after adjusting for confounding the relationship remained the same (p<0.001), see (Table 5.3.5).

Table 5.3.5 BMI z-score (males), SD then each adjusted model and the final multiple variable model

	Unadjusted model	Adjusted models
BMI z-score	ß[a] (95%CI)	adj. ß (95%CI)
Soft drinks	0.019 (0.005 – 0.032)[c]	0.019 (0.005 – 0.034)[c]
Fridge, never		-0.025 (-0.066 – 0.015)
Fridge, acquired		-0.037 (-0.055 - -0.019)[d]
Fat mass		
Soft drinks	0.014 (0.002 – 0.025)[b]	0.014 (0.002 – 0.025)[b]
Fridge, never		-0.027 (-0.059 – 0.004)
Fridge, acquired		-0.026 (-0.041 - -0.011)[d]

[a]Regression coefficient; [b]p<0.05; [c]p<0.01; [d]p<0.001

5.4 Discussion

The aim of this study was to investigate adolescent dietary behaviours and their association with BMI z-score and fat mass. Among males only, in both the unadjusted and adjusted models we found that sweetened beverage consumption was positively associated with both BMI z-score and fat mass respectively (p<0.001). These findings reflect the importance of sweetened beverage consumption in terms of the quantity and range consumed (in terms of their energy content) and their relationship with obesity. In this cohort, 76% of participants owned a fridge which differentiates them from poorer households. Other studies have shown the use of multiple individual measures of SES when assessing children's nutritional status (261). Furthermore in a sub-study of the Bt20 cohort, individual household durable variables were shown to act as a proxies for higher SE strata (262). Among males, those from higher socioeconomic strata at birth in this environment were more predisposed to overweight (denoted by BMI z-score and fat mass) than those from lower income groups.

Other studies have found an association between adolescent soft drink consumption and obesity in both LMICs and HICs. Cross-sectional associations have been found for soft drink consumption and obesity in Saudi boys (263) and then both Jamaican males and females respectively (264). Unlike cross-sectional studies, longitudinal studies are able to account for the temporal criteria of causality in that repeated observations are possible. However some US longitudinal studies have found an association between soft drink consumption and obesity (174) but others have not (172). Perhaps the equivocal findings relate to the concept that soft drinks may be a marker for other dietary factors or other lifestyle factors which are associated with obesity, or due to study design and questionnaire nuances, including the definition of a soft drink.

Research into specific dietary habits associated with poor diet quality and obesity risk among adolescents has focused on breakfast skipping, snack behaviours (including the influence of TV viewing on snacking), food intake at school, eating the main meal with the family, fast food and sweetened beverage consumption (139, 140, 142). While a number of cross-sectional analyses have shown positive associations between eating behaviours (breakfast skipping, fast food intake, soft drink consumption and eating the main meal with the family) and obesity these relationships have been attenuated and become statistically non-significant in some longitudinal analyses (169, 183). However other longitudinal studies have shown positive relationships with obesity, namely with fast food intake and soft drink consumption and breakfast skipping, among adult populations (182) and adolescent populations (149, 192).

The longitudinal dietary patterns of this cohort show that with age both boys and girls have increasingly irregular breakfast (weekday and weekend) consumption, with girls consistently

skipping breakfast more often than boys, findings corroborated by other studies in developing countries (265). Eating the main meal with the family decreased slightly when participants were 17 years old. In the US however, older adolescents eat with their families less frequently than younger adolescents, furthermore advancing age has been associated with irregular family meal consumption and poorer diet quality (156). Although cross-sectional analyses have shown that the family meal had a protective effect against obesity, longitudinal analyses have not confirmed this (140).

Increased TV viewing has been shown to be associated with reduced fruit and vegetable consumption, and more snacking (139). One study found that every additional hour of TV viewed equated to an additional intake of 653 kJ/d (137). In our study, the number of snacks eaten while watching TV increased with age and girls consistently consumed them more frequently than boys ($p<0.01$).

US ecological data have shown that snacking (including confectionery) in adolescents has increased between 1977 and 2006 with around 3 snacks eaten per day which account for up to 27% of total energy intake (163). In our cohort a higher proportion of girls consumed confectionery >7 times per week than boys at all ages.

It is thought that bringing food from home to school is healthier than purchasing items available at the school tuck shop but in this cohort lunch box usage was low (5 – 20%) across all ages with boys using them less regularly than girls ($p<0.05$). However we did show that of those who

took lunch boxes to school, the five most popular items were relatively healthy (brown and white bread, cheese, fruit and fruit juice) (254).

SES can influence dietary intake and eating behaviours through purchasing of foods. In a developing environment such as Soweto those in higher income strata have a greater disposable income to purchase relatively expensive fast foods and snacks. However what is unique about this environment is the access to informal food vendors which makes such energy dense foods also available to those in poorer income strata. We have observed the sale of cheap snacks and fast foods both in poorer rural and more affluent urban environments (246, 266).

The prevalence of combined overweight and obesity was significantly higher in females than in males, which is consistent with other South African research (80). However the data show that dietary patterns are not mediated by SES among this female group which is contrary to other research undertaken in HIC and LIMCs (249, 250). Perhaps the lack of evidence of a relationship between SES and obesity among females might reflect the choice of indicators used in this research, for example it has been demonstrated that in men at least, the SES/obesity relationship depended on the indicator under assessment (249). Another possible reason why no associations were found among females in this cohort is because we are witnessing a change in social patterning of overweight/obesity, as suggested by Monteiro (250). For example, in some countries, for certain SE indicators the association with obesity was more often negative than positive suggesting that the social patterning of overweight is possibly undergoing transition in middle-income-countries (250) and reflecting those of developed

countries. Another possibility is that the cohort did not reflect a very wide distribution of SES since most can be defined as poor as compared to HICs.

An alternative hypothesis suggests that the greater prevalence of obesity among females (both in this population and others in South Africa (77, 96)) relates to nutritional programming in utero whereby a relationship exists between the environment during critical windows of development and the progression of disease in adult life (267). Studies have shown that perinatal nutritional deficits predispose adult offspring to increased fat accumulation and other metabolic outcomes. Another explanation for our lack of a finding in girls might relate to physical activity. Other South African research has reported declines in physical activity with girls exercising less often than boys (75).

Further limitations; the findings from this study cannot be extrapolated to other sub-groups in South Africa since we only assessed black South African adolescents in Soweto reflecting a particular social stratum. This study did not investigate total energy intake or energy expenditure.

To conclude, we showed that among males longitudinal sweetened beverage consumption was positively and significantly associated with both BMI z-score and fat mass at age 17 years. Furthermore fridge ownership at birth (a proxy for higher SES in this cohort) was shown to be associated with BMI z-score and fat mass respectively.

Statistical analysis

The Generalised estimating equation (GEE) model structure

The data for Paper 3 (Chapter 5) was longitudinal since it was collected at time points 13, 15 and 17 years. As such, the observations are correlated on individual level. We thus employed the GEEs which are an extension of the Generalised Linear Models (GLMs) that can handle the correlation in the data. The model, which follows from the exponential family of distributions, GLMs introduced, has the link form:

$$g(\mu_i) = g(E[Y_i]) = x_i'\beta \ ,$$

where x_i is a $p \times 1$ vector of covariates for the i^{th} subject, and β is a $p \times 1$ vector of regression coefficients, $g(.)$ is the link function which can take any form of the exponential family and Y_i is the outcome of i^{th} subject(260).

In the GEE extension of this model for repeated measures we model the average response for observations sharing the same covariates (marginal expectation) as:

$$g(\mu_{ij}) = g(E[Y_{ij}]) = x_{ij}'\beta \ ,$$

where x_{ij} is a $p \times 1$ vector of covariates for the $i^{th} = 1, 2, \ldots . n$ subject at the $j^{th} = 1, . . , t$ outcome, and β is a $p \times 1$ vector of regression coefficients, $g(.)$ is the link function which can take any distributional form and Y_{ij} is the outcome of i^{th} subject at the j^{th} outcome whose mean and variance are characterised as the GLM (268).

The correlated observations have a certain working correlation matrix $\mathbf{R}(\alpha)$ of the forms: independent, exchangeable, unstructured, time series auto-regressive orders, user defined and many others. Assuming no missing data, the $\mathbf{t} \times \mathbf{t}$ covariance structure for $\mathbf{Y_i}$ is with $\mathbf{A_i}$ a matrix of variance functions and ϕ the GLM dispersion parameter:

$$\mathbf{V_i} = \phi \mathbf{A_i}^{1/2} \mathbf{R}(\alpha) \mathbf{A_i}^{1/2}$$

In Paper 3 we fit our models using three link functions, the identity ($\mathbf{g(E[Y_{ij}]a) = E[Y_{ij}]}$) for the BMI-z score, the log link function ($\mathbf{g(E[Y_{i}ij\,]) = log(E[Y_{i}ij\,])}$) for the fat mass adjusted for height and the logit link ($\mathbf{g(E[Y_{i}ij\,]) = log(E[Y_{i}ij\,]/(1 - E[Y_{i}ij\,])}$) for binary socio-economic variables. Families of distributions used were the Gaussian and the Binomial. The working correlation was the identity matrix for the independent covariance structure.

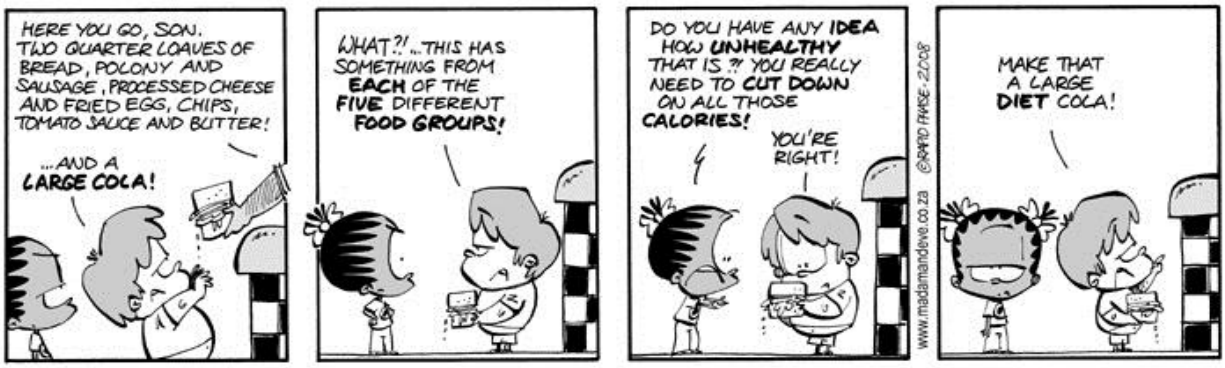


Figure 5.4.1 Madam and Eve, *The Star*, 22 October 2008.

Chapter 6 Exploratory survey of informal vendor-sold fast food in rural South Africa.

(Scientific Letter in review: *South African Journal of Clinical Nutrition*).

6.1 Introduction

Obesity, a marker of nutrition transition, is high in urban South Africa. Evidence suggests that rural areas are also undergoing the nutrition transition with increasing obesity prevalence mimicking urban areas. Among 17-year-old girls in Soweto, the prevalence of combined overweight and obesity was 27.2% (246), while in a rural site in Mpumalanga Province the prevalence was 20% (228). Understanding food availability within urban and rural contexts is important; in particular, the extent the environment may promote or prevent an individual's health-promoting choices (44, 45). It has been shown that fast food[12] consumption is high among teenagers in Soweto, with an average >7 fast foods/week consumed, the most popular items including hamburgers, 'kotas'[13], fried chips and vetkoek (246). This finding may be in part due to the ease of accessing vendors[14] in the community. This study aimed to explore the availability of fast foods in a rural South African setting.

[12] Defined as convenience foods obtained from 'take-away' vendors, and are usually characterised as energy-dense, low in micronutrients and fibre, high in simple sugars and salt.
[13] A typical 'kota' consists of a quarter-loaf of white bread, chips, processed cheese and any number of processed meats and sauces, and yields more than 50% of the daily energy requirement of an average 17 year old (5970 kJ).
[14] A non-commercial outlet selling food, in some cases from a converted garage or a home, or a purpose-built structure

6.2 Methods

6.2.1 *Study setting and protocol*

The study was conducted in rural north-east South Africa, Mpumalanga Province. A convenient sample of four villages was selected, all part of the MRC/Wits Agincourt Health and Socio-demographic Surveillance System (HSDSS). The HSDSS monitors 84 000 inhabitants in 14 000 households across 25 villages where the annual income of 73% of households falls below R9 600 (269). The villages were selected based on HSDSS data to ensure variation in socio-economic status: village A was the most economically developed with a trading centre, followed by CB, C and KB. A marginal number of the total available vendors were accessed in this study.

The study protocol entailed driving through each village and stopping at vendors who sold fast food. Informed consent was obtained from the vendor, and two study components were completed: An interview with the vendor to ascertain what fast food items were available, which item was the most popular with adolescents, and its cost. Via the procurement of the most popular fast food item, estimation of the energy and macronutrient content was determined.

Each sample was inventoried and weighed using household weighing scales to the nearest 1 g. Nutrient composition (energy, total fat, carbohydrate and protein) was estimated using FoodFinder3, nutrient analysis software based on the South African Medical Research Council food composition tables (270). The mean nutrient breakdown of the samples was used for comparative purposes. Ethics clearance was obtained from the Witwatersrand University Committee for Research on Human Subjects (M080320).

6.3 Results

All vendors had electricity but no running water. Vendors either sold foods from their converted garages or from purpose-built concrete buildings of basic construction. Only 15 food samples were collected from 18 vendors identified in the villages as selling fast food (five vendors for village A, five for village CB, two for village C, and three for village KB), as three vendors had sold out of food. An inventory of the samples is presented in Table 6.3.1. The most common items available for purchase were fried chips and vetkoek, followed by 'kotas'. Other foods obtained included bread, polony, atchar[15], chakalaka[16], boiled eggs and fried fish. The macronutrient breakdown of the fast food items are presented in Table 6.3.2. Vendor's reasons for the limited range of fast foods related to restricted resources, customer preference and difficulty in keeping food 'fresh' (no refrigeration). One vendor noted that "since the introduction of the National School Nutrition Programme teenagers no longer want 'kotas', they just buy chips to supplement their food from school". Grocery items that were sold by vendors but not assessed included tinned goods, packet soups, oil, soft drinks, and packets of crisps.

[15] A pickle made with unripe green mangoes and chillies prepared in oil.
[16] A relish made with carrots, tomatoes, chillies, onions and prepared in oil.

Table 6.3.1 Villages from which food items were obtained; description of immediate environment; type of outlet visited[17]; specific sample purchased and its cost

Village	Description of surrounding environment	Type of outlet	Sample purchased	Cost (R)
A	At an intersection of a busy through road	FF only	Kota	9
A	At an intersection, busy through-road, next to a grocery shop	FF only	Vetkoek	0.5
A	Along a main road, some distance from dwellings/other buildings	FF and groceries	Vetkoek	0.5
A	Along a main road, some distance from dwellings/other buildings	FF only	Kota	10
A	High school	FF	Brown bread, chakalaka, soup	8
KB	Very rural, no other vendors near	FF and groceries	Chips	10
KB	Next to a shebeen	FF only	Vetkoek	0.5
KB	High school	FF	White bread, atchar, polony	5
CB	Next to a grocery shop	FF and groceries	Vetkoek	1
CB	Adjoining another FF outlet	FF only	Chips	12
CB	100m from a high school	FF and groceries	Chips	7
CB	<100m from a high school	FF and groceries	Vetkoek	1
CB	~500m near high school	FF and groceries	Chips & boiled egg	12.50
C	Adjoining a shebeen and grocery shop	FF only	Chips	10
C	High school	FF/snacks18	Fried fish, battered	2

[17] Sold fast food only [FF] or both FF and groceries.
[18] Crisps, fruit, single item sweets.

Table 6.3.2 Energy and macronutrient breakdown of fast food samples.

	Mean weight (g) range	Mean energy (kJ) range	Mean protein (g) range	Mean CHO[a] (g) range	Mean fat (g) range
Kotas (n=2)	530 (485 – 575)	6300 (5711 – 6889)	14 (12 – 15)	158 (128 – 187)	60 (48 – 73)
Fried chips (n=4)	469 (401 – 506)	5987 (5120 – 6461)	20.2 (17.2 – 21.8)	164.4 (140.8 – 177.6)	69.4 (59.3 – 74.9)
Vetkoek (n=5)	62 (48 – 96)	943 (731 - 1463)	4.3 (3.5 – 6.9)	26 (20.3 – 40.7)	11 (8.5 – 16.9_
Fried chips, boiled egg (n=1)	354	4157	19.8	105.6	44.3
White bread, atchar, polony (n=1)	174	2036	11.3	67.3	17.2
Brown bread, chakalaka, soup (n=1)	300	1468	15	55	3.4
Fried fish, battered (n=1)	63	538	11.8	3.8	7.3

[a]carbohydrate

6.4 Discussion

South Africa is experiencing dramatic increases in obesity in both urban and rural areas. It is important to understand access to food and how this influences food choice in rural environments. The results of this study highlight the availability of fast foods through village vendors. Of note is the limited variety of foods sold by vendors of which a striking two-thirds were either vetkoek or fried chips which on average yielded 943 kJ – 5 552 kJ and 11 g – 64 g fat. We found that rural vendors also sold the local fast food item, the ‘kota’. When compared to the Sowetan samples the rural ‘kotas’ contained more energy and fat (6 300 kJ, 60 g fat vs. 5 369 kJ, 51.5 g fat) (246) which can be attributed to the higher amount of fried chips contained within those samples. Fried foods such as these are micronutrient and fibre-poor, energy-dense, and have high amounts of fats. Using a 17-year-old as a reference (daily energy requirements

are around 10 000 kJ (235) of which <30% of energy should be derived from fat (~92 g fat/day)), these fast food items may contribute significantly to energy intake. One vetkoek would contribute 12% of daily fat, and a portion of fried chips and a 'kota' could contribute up to 70% of total daily fat requirement respectively.

As an exploratory study, the results are limited, but the study does provide an opportunity for hypothesis generation. The study's hypothesis is that the fast food items described may become a regular part of the local diet because healthier options are less accessible. For households, this easy access to fast food may influence cooking practices: home cooking may become less frequent with increasing dependence on fast foods, especially where there are long distances and high transport costs to larger villages with formal vendors or trading centres. However, from a community perspective, food vendors are an important aspect of local communities and a livelihood strategy.

In conclusion, given that rural South Africa is undergoing rapid health, social, and nutrition transitions (271), this study signals the need for more comprehensive research to improve our understanding of the contributory role of fast food and its connection with both livelihoods and the burgeoning obesity epidemic in poorer rural areas. It is through better research and greater understanding that we can work with communities and local government to improve access to more nutrient-rich foods that are less energy-dense. Partnership programmes that draw on the natural environment to benefit local dwellers (e.g. food garden projects) need to be evaluated as possible ways of improving healthier food access. We cannot discount the local fast food vendor and therefore need to better understand the parameters that influence vendors' choice of foods to sell and how receptive they would be to selling healthier alternatives.

Part 3: Discussion and conclusion

Chapter 7 Discussion

The specific findings of the individual papers have been discussed within their relevant chapters. Therefore this final section of the thesis is a consolidation of the findings from the aforementioned chapters with the development of three key themes: 1) fast food intake, 2) poor dietary habits and practices, and 3) associations between dietary habits and practices and obesity. The following section further expands on these key themes and develops three emerging themes which result from this body of research, including: 1) the environment, 2) socio-economic status and 3) the development dietary habits and practices. This is followed by the theoretical and contextual relevance, the study limitations, future research and finally, the overall conclusions.

7.1 Consolidated findings

Table 7.1.1 Summary table of objectives and findings

No.	Objective	Main findings	Chapter
1	Availability and assessment of fast food.	Fast food consumption was high, with at least 5 items per week consumed, from the age of 13 years in urban township children. The kota was the most popular fast food item among the Bt20 cohort and on average it provides 5 370 kJ, 51 g fat (of which 13 g SFA), 151 g carbohydrates, 41 g protein, 11.3 g fibre and 2 280 mg sodium. The kota was cheaper and contained more energy and fat than other commercial fast foods. Fast food was found to be available in a relatively impoverished rural area in Mpumalanga.	3, 4, 5
2	Describe the changes in dietary habits and practices of adolescents over a 5-year period.	Breakfast consumption during the week and at the weekend declined for both genders, with females eating breakfast less regularly than males. Snacking while watching television increased with age, with females consistently consuming more snacks than males ($p<0.01$). Two-thirds of participants ate their main meal with their family but among girls, with increasing age, there was a trend towards eating this meal less regularly. Confectionery consumption remained constant, around 9 items/week for males and 10 items/week for females ($p<0.02$). Lunch box usage declined with age, with females consistently using lunch boxes more often than males. Conversely, the number of tuck shop purchases increased with age.	4
3	Assess the association between longitudinal dietary habits and practices and obesity risk at 17 years old.	Soft drink consumption was associated with obesity measured by BMI z-score and fat mass ($p<0.05$). In the final multivariate model, soft drink consumption remained non-significantly associated with both outcomes and ‘acquiring’ a fridge over the 12-year period remained negatively associated with fat mass ($p<0.001$).	5

7.2 Fast food intake

Regular fast food consumption is a consequence of living in a modern environment, with both rural and urban settings being affected, as reflected in Chapters 3 – 6. Although the cross-sectional analysis showed a higher mean weekly frequency of fast food item consumption (~>7 items/week) than in the longitudinal analysis (~5 items/week), this is most likely due to sample size differences between the two studies. In spite of the differences in mean weekly consumption of fast food items the results overall indicate that adolescents eat fast food regularly (at least five items/week) from as early as 13 years of age, with boys appearing to consume slightly more than girls.

This finding was somewhat unexpected; some fast food consumption had been anticipated but not to this degree, taking into consideration the socio-geographic location of this study. Soweto is relatively impoverished compared to an average Johannesburg suburb (what were once the former white suburbs) and as a result, it was thought that there would be insufficient disposable income for adolescents to buy prepared foods. From the perspective of this study they are thought to be luxury items to be eaten only occasionally, perhaps less than a couple of times per month. However, as shown in section 7.5 (The Environment), people are influenced by the environment in which they live and Soweto has developed a vibrant culture of street vendors, hawkers and informal outlets where one can buy a range of foods to suit all budgets. The data from all the papers showed that the popular fast food items included kotas, fried chips and vetkoek, which can all be purchased from informal outlets such as spazas, discussed in detail in section 7.5 (Emerging Themes) and onwards.

It is important to understand the nutrient composition of fast food foods so that their potential contributions to energy and macronutrient intake can be assessed. As an example, an average kota meets 50% of a 17 year olds energy needs. Furthermore, if one uses the 30% recommendation of daily energy from fat (95) then a 17-year-old's total fat requirement would be around 79 g and one kota would contribute almost 65% of total daily fat intake. Thus if no down regulation of food intake occurs this food item could contribute to the development of obesity. A more alarming finding is that the kota was found to have greater energy and macronutrient content than three other well-known commercial fast foods. Energy density calculations also showed that the kota had the second highest energy density of 1 162 kJ $100g^{-1}$. Even though we obtained only two kota samples in the rural study, we did find that their energy and fat content was slightly higher than the samples in Soweto (6 300 kJ and 60 g fat).

As a result of the WHO report *Diet, Nutrition and the Prevention of Chronic Disease* (272) the fast food industry has committed itself to modifying its processed products with respect to reducing fat (including trans-fatty acids), simple sugars and sodium. However, this study highlights that many foods available in Soweto and Mpumalanga are unregulated as they are provided by the informal sector. Thus it makes it difficult to monitor and influence the ingredients and macro/micronutrient content. For example, the daily reference value (DRV) for sodium is 2 300mg for an average adult consuming a daily energy intake of 8 400kJ; the data from Paper 1 clearly shows that one kota contributes almost the entire daily limit of sodium for an adult. This is troubling particularly when one considers that South Africans of African descent have a genetic propensity to retain sodium which is a likely cause of their high prevalence of hypertension, which in turn contributes to stroke (273). One study showed that 59% of black South Africans have hypertension (defined as having a blood pressure of ≥140/90 mmHg) (273).

Since it is the informal sector that is unregulated it would be unrealistic to recommend that food labelling and food legislation extend its remit to this sector. However, many informal food providers who make kotas use ingredients which they purchase from food manufacturers (e.g. polony, cheese, bread) and these items could be more strictly regulated. The responsibility would then be removed from the informal food provider and referred back to food manufacturers who have the resources to undertake product reformulations to reduce salt or fat or sugar, for instance. Furthermore, this sector is already somewhat regulated under the food labelling legislation (274).

The affordability of fast food has been shown to be a major factor in its popularity. A cost calculation showed that the kota (and the kota meal which included a sweetened beverage) was by far the cheapest food option in the Soweto study; >R32 cheaper than the most expensive commercial meal and nearly R8 cheaper than the cheapest commercial meal. Indeed, in Mpumalanga we showed that 50c can go a long way; it can buy a vetkoek with between 731 – 1 460 kJ, depending from where it was purchased. This is an astonishingly high amount of energy for such low cost if compared to an apple which can also be bought for 50c, and which provides much less energy (approximately 270 kJ for an apple of 80 g). Consumers are driven by taste and satiety and the perception is that a vetkoek, for example, is far more satisfying than an apple (247). Can individuals be influenced to purchase the less energy-dense micronutrient rich items over the energy-dense foods? Perhaps the answer is by making them more desirable or significantly cheaper than prepared foods.



Figure 7.2.1 Vetkoek (fried dough balls).

Neither the cross-sectional analysis nor the longitudinal analysis showed an association between fast food consumption and obesity; this corroborates other research undertaken among adolescents which infrequently shows the link between fast food consumption and BMI (183). This lack of an association could reflect that adolescents are continuing to grow and thus have increased energy requirements. Or perhaps a more appropriate hypothesis relates to positive energy balance; only a small energy surplus over time is required to gain weight which is extremely difficult to measure. However, there is evidence of the prevalence of obesity in this cohort (8% in males and 27% in females), which implies that there is an imbalance between energy intake and energy expenditure. In this study total dietary intake or physical activity data was not collected. Estimation of dietary intake and energy expenditure will allow for determining more clearly the associated risk factors of overweight and obesity in this population group. The longitudinal analyses clearly show that fast food intake increases with age and that these

behavioural patterns could put this cohort at risk of obesity later in life, when energy requirements reduce.

7.3 Poor dietary habits and practices

The results from paper 2 indicate that poor eating habits and practices are well established by the age of 13 and furthermore, these poor habits track with increasing age. We documented an increase in the number of food items consumed as the cohort aged (TV snacks, tuck shop purchases, fast food and soft drinks). Since it is well established that obesity and dietary intake track into adulthood it follows that dietary habits and practices also track into later life as habits and behaviours become routine. However, energy requirements for moderately active girls increase by only 125 kcal/d between the ages of 13 and 17 years old (from 2 375 kcal/d to 2 500 kcal/d) and for boys in the same age range by 625 kcal/d, from 2 775 kcal/d to 3 400 kcal/d (55). Furthermore physical activity levels usually decline with age, particularly among girls (75) which results in a reduction of total energy expenditure. Although we do not have total dietary intake or energy expenditure we can speculate that the poor dietary habits of these individuals set them up to over-consume their energy requirements which would put them at risk of obesity in adulthood.

Furthermore, the results from Paper 2 demonstrate that energy-dense foods are available in all three environments; at home, at school and in the community, which confirms that there is wide access to these foods in all settings.



Figure 7.3.1 Some of the foods sold outside a high school in Mpumalanga by a street vendor (bread, polony, atchar, avocados).



Figure 7.3.2 Snacks (maize crisps) and fruit sold by a street vendor inside the grounds of a high school in Mpumalanga.

The concern is that increased and regular consumption of energy-dense, micronutrient deficient (except for sodium) foods poses health risks. These risks may be particularly apparent in impoverished, less-educated communities in which access to relevant information is limited and knowledge about appropriate food choices is restricted. Additionally, and more importantly, such foods are perceived as 'good value for money' which makes them attractive, especially in the situation of today's rapidly increasing food costs.

Fiscal policies could be developed to incentivise individuals to purchase healthier foods. For example, applying a ‘fat tax’ or ‘sugar tax’ to certain prepared foods or soft drinks or confectionery, which is then diverted to subsidise healthier lower energy foods may be one answer to encouraging people to healthier diets. It has, however, been argued that a tax like this would fall disproportionately on the poor (275), and in a country such as South Africa with a large proportion of the population below the poverty line, these taxes would affect a majority of the population which is already under financial strain. A ‘fat tax’ may penalise those who need high-energy intakes, i.e. those in manual jobs or rural workers who are often from poorer backgrounds (276).

Nevertheless, the statistics, which show that almost two thirds of South African women and about a third of men are either overweight or obese, cannot be ignored. It is well known that weight loss and its maintenance is very difficult. For example, only 20% of overweight individuals are successful at long-term weight loss (defined as losing 10% of their body weight and maintaining that for at least one year) (277). Therefore it would be more efficient to prevent overweight and obesity and subsequent NCDs both for the individual and for the government.

7.4 Association between dietary habits, socio-economic indicators and obesity risk

The prevalence of combined overweight and obesity denoted by BMI cut-offs and fat mass was much greater among females than males (chapter 5). The data also showed that members of this cohort had a greater prevalence of overweight and obesity than the national statistics, for both genders.

The main finding from Paper 3 was that after inclusion of change in SES confounders, soft drink consumption was positively associated with both BMI z-score and fat mass ($p<0.05$) in males only. This corroborates the findings of Berkey et al. (172) in a developed country setting. Univariate analysis showed that having a fridge at birth was positively associated with BMI and fat mass at age 17 years. Furthermore, in the final multivariate model, having 'acquired' a fridge over the 12-year period was negatively associated with BMI z-score/fat mass in the presence of soft drink consumption ($p<0.001$). An 'acquired' fridge is a reflection of the duration that the participant's family had had this household durable item which was less than 12 years, showing how, at least in boys, change (improvement) in SES was associated with obesity. However important questions relate to why having a fridge at birth and 'never' having a fridge were not related to obesity, in the multivariate analysis?

Soft drink consumption is mediated by SES as it possibly reflects a large enough disposable income to purchase these products. Alternatively, owning a fridge and soft drink consumption might be markers for other behaviours associated with obesity for example fridge owners might have other foods contained within or simply have more food available, which is associated with increased obesity. The NFCS showed that having a flush toilet in the home conferred a higher risk of overweight and a lower risk of stunting among children (79).

No associations were found between dietary habits and practices and obesity risk among females which is disappointing, since women and adolescent girls are more prone to obesity than males, both in South Africa and in many other countries. The data shows that dietary patterns are not mediated by SES among this female group, which is contrary to other research undertaken in developed and developing countries (249, 250, 278). This could be a true finding,

or possibly it reflects that the lack of evidence relating SES to obesity among females may be due to the indicators used in this research. For example, it has been demonstrated that in men at least, the SES/obesity relationship depended on the indicator used in the particular country (249).

A further reason for the lack of a finding may be that the families were relatively homogeneous in terms of SES, but the families of males in this study had very similar SES to the families of females, and no gender differences were found for any SES indicator. Therefore the question remains as to why there were findings for males, but not for females.

Perhaps what we are witnessing, among the girls at least, is a number of stages of the nutrition transition taking place concurrently, which is dissimilar to the diagram depicted in Figure 1.2.1 whereby the stages of nutrition transition follow a more linear pattern with one stage followed by another. Instead, in this environment, some individuals experience 'receding famine' and others experience 'degenerative disease' and others undergo 'behavioural change' at the same time, in one geographic location (see Figure 7.4.1).

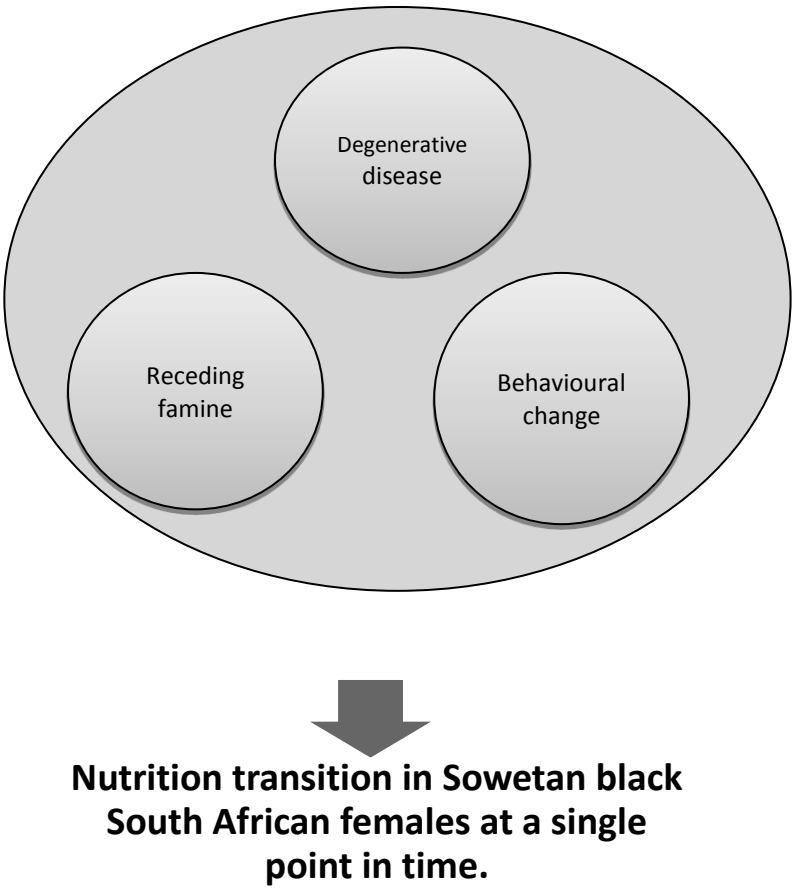


Figure 7.4.1 Nutrition transition in Sowetan black South African females at a single point in time.

Another important course of research suggests that the greater prevalence of obesity among females relates to nutritional programming *in utero.* This concept of nutritional programming is derived from two hypotheses: a) the Thrifty Phenotype or Barker hypothesis (267) and b) the Predictive Adaptive Response (PAR) hypothesis (279). The Thrifty Phenotype hypothesis proposed that *in utero* under-nourishment produces permanent and damaging changes leading to the development of diseases later in life. Studies have shown that perinatal nutritional deficits predispose adult offspring to the metabolic syndrome, including obesity, cardiovascular disease (CVD), hypertension, and type 2 diabetes. The PAR hypothesis, asserts that it is not only *in utero* constraints that affect outcomes later in life, but also the mechanisms by which the foetus

uses early environmental cues to ‘predict its future’ by adopting an appropriate developmental pathway. However, if the environment into which the child is born is a mismatch to its predicted pathway, disease will develop in later life.

One can envisage this process taking place in a developing country like South Africa where adults and older adolescents who are now experiencing higher energy intakes and more sedentary behaviours were born when maternal nutrition was insufficient, causing higher rates of low birth weight and increased growth faltering. Thus as South Africa has undergone economic development, especially since 1990, the effects of adverse childhood exposures are exacerbated by adopting the modern lifestyles of Western countries.

Vorster et al. (271) have proposed that nutritionally compromised mothers produce stunted offspring who are more vulnerable to obesity when they are exposed to a ‘Western’ diet. Evidence comes from a study of pre-menarche black South African girls (10 - 15 years) which assessed the ratio of fat mass to body weight, the ratio being similar in both stunted and non-stunted girls. Conversely, in the post-menarche period, this ratio increased markedly and significantly in the stunted but not in the non-stunted girls (54). This ‘metabolic programming’ increases susceptibility to obesity and related NCDs when groups who had previously experienced under-nutrition are exposed to a diet of ‘affluence’.

Other international research has shown that factors acting during pubertal development influence obesity risk in females, for example a Finnish longitudinal study showed that by 30 years of age the prevalence of obesity among those who had an early menarche (< 11years of

age) was 15%, compared with those who reached menarche after 15 years of age, in whom it was 4% (280). Interesting animal studies have shown that early-life malnutrition affects body weight and fat cell size differentially in male and female animals, suggesting that sex hormones modulate the effects of early-life malnutrition (281).

Fascinating research based on data from adults born during the 1959-61 China Famine showed that among women, those exposed to famine had a higher mean BMI (by 0.84 kg/m^2) than those not exposed to famine (282). However, there was no evidence that the increase in BMI was differentially greater for those famine cohorts who were exposed to an 'affluent' food environment in adulthood than for the famine cohorts who were not. Analysis of individual dietary intake data and energy expenditure showed that the increase in BMI for famine-exposed women was neither due to higher energy or fat intake, nor due to higher sedentary behaviours. This leads one to conclude that a biological mechanism appears to underlie the association between early-life malnutrition and later obesity.

Thus this female effect for programming of obesity appears to be multi-factorial, resulting from a combination of *in utero* and environmental insults which take place over the early-life course and culminate in the development of obesity. The interface between these poorer early-life years and later, more affluent years of excessive energy intake and moderate energy expenditure, exacerbate the problem further.

7.5 Emerging Research Themes

7.5.1 *The environment*

In recent years, emphasis has shifted from holding individuals entirely responsible for their overweight status to accepting that the broader environment plays a significant role in the ensuing obesity epidemic (272). There has been a growing interest from key stakeholders on how the environment modulates obesity risk, for example the UK government commissioned research to investigate the environmental influences of obesity (283). A concluding yet controversial remark from the Foresight research was that “obesity is a normal ‘passive’ biological response to our changed physical and food environment”. In other words, to be thin in an obesogenic environment is highly unusual. The findings of this current research emphasise that energy-dense foods are consumed in the community and in schools, both external environments to the home, but further research is required to directly link them to the prevalence of obesity.

The modern food environment has seen changes in food systems, the cost of food and also the social norms around eating practices. Food systems (including food production, storage and transport) have ensured an abundance of cheap and attractive energy-dense foods. Environmental cues which stimulate individuals to consume more include the availability (outlets are numerous and have long opening hours) and palatability of fast foods, and their promotion via media stimuli. As an example of the expansion of the fast food industry within South Africa, one commercial fast food chain recently announced that by 2014 it will double the number of its outlets in South Africa from 600 to1 200. The company also acknowledges the expanding market in the rest of Africa and plans to open a further 200 outlets on the continent (284). Until

relatively recently[19] food costs in South Africa and worldwide have been comparatively low, with research showing that the lowest unit costs have been for processed, energy-dense foods served in larger portion sizes (i.e. fast foods) (285). Certainly, the results from Paper 1 support this as the kota was found to be the cheapest and most energy-dense fast food available in that study.

Social changes have occurred concurrently with food system and cost changes. In the US, 25% of meals are consumed outside of the home (39); grazing and snacking are more common and contribute significantly to energy intake (199). Portion sizes have increased for both snacks and meals and there is evidence to show that individuals consume more when presented with larger portion sizes (199).

Prior to the mid-1990s little economic investment had been made in Soweto[20], giving rise to the growth of a small informal business sector. A commonality among all informal settlements is the spaza shop, mentioned briefly in Paper 1 (see Figure 7.5.1 for an example). Prior to economic development in Soweto and in other areas such as Agincourt, these areas survived on informal small businesses such as general stores, spaza shops (or 'spazas'), shebeens, taverns and street vendors.

Spazas are defined as "small retail enterprises operating from a residential stand or home and engaged in the trading of consumer goods" (286). The number of spazas in Soweto has not

[19] The global financial crisis which developed in 2008 has had an influence on recent food price increases worldwide.
[20] Since then, in 2006 and 2008 respectively, two shopping malls have been opened in this area.

been documented, but in 2000 it was estimated that of the >100 000 spazas in South Africa, approximately 40 000 were in Gauteng (287). Such businesses sell some or all of the following products: soft drinks, tobacco, paraffin/candles, maize meal, alcoholic beverages, bread, sugar and also prepared (fast) foods such as fried chips, vetkoek and kotas, as highlighted in Paper 1 and the Scientific Letter. Ligthelm estimated that spazas accounted for nearly 3% of retail trade in South Africa which equated to R7.4 billion in 2000 (287). This figure gives an indication of the importance of these vendors within townships and informal settlements. Their location and proximity within residential areas and their lower prices (of fast foods especially), make them attractive to consumers and particularly to adolescents who have less disposable income. In the Soweto study, obtaining the kota samples was a relatively quick exercise since spazas were numerous in the areas visited, but at least three spazas were sold out of kotas, a further indication of their popularity.



Figure 7.5.1 A Spaza in Diepkloof, Soweto. Discussions with the proprietor of this business revealed that she owned three spazas which only sold prepared foods and that their biggest seller was the kota.

A further important source of food for adolescents in urban townships and rural villages is the street vendor (found both in the community and at schools). Street foods include snacks and confectionery and 'ready-to eat' foods and beverages sold by vendors who usually cluster around places of work, schools, hospitals, railway stations, bus terminals and taxi ranks, see Figures 7.5.2 and 7.5.3 respectively. Food obtained from a street vendor is often inexpensive when compared to food from the formal sector and in fact, is often less expensive than home-cooked food (288). In their technical report the FAO found that street foods had significant

nutritional implications for consumers, especially for low- and middle-income groups (288). Factors which influenced the purchase of street food included cost, convenience, and type of foods available. This latter point highlights the fact that street foods in Soweto and Mpumalanga can often be traditional foods (such as chicken feet, chicken heads, ‘pap and meat’, kotas) or more modern snack items such as sweets, soft drinks and confectionery items which are often cheaper than their equivalent at a commercial outlet. One report found that the reasons why street food is popular in South Africa include easy accessibility, variety in taste, low cost and freshness (288).



Figure 7.5.2 Street vendors selling snacks outside Chris Hani Baragwanath Hospital next to the taxi terminal in Soweto.



Figure 7.5.3 Street food being sold at a taxi terminal in Mpumalanga (the vendor was selling stewed Mopani worms).

Although the informal food sector has in recent years undergone review in terms of health and safety practices (289), there has been little focus on addressing cooking practices or the quality of ingredients used to make up the prepared foods on sale. Paper 1 and the Scientific Letter highlight this issue; a portion of fried chips, in terms of its weight and consequent energy and macronutrient composition varied greatly depending on where the food was bought. This is an issue for consumers as there is no information reporting the constituents of a dish or what the energy or nutrient breakdown of that food is, thus they are unable to make informed choices when it comes to their food consumption. However, one might argue that all individuals do not

necessarily read food composition labels and thus their food intake is not influenced by them. The portion size of the food may be more significant in influencing the purchase of that food item. However, at the very least, instituting food labelling within the informal food sector would perhaps influence food manufacturers to improve the quality of their products and in time, the consumer would benefit.

It is well known that foods bought away from home are usually larger in size and therefore contain more energy and fat than home-cooked versions of the same meals. Furthermore, our research showed that compared to foods from the commercial sector, foods bought from informal vendors were cheaper and larger in portion size, thus containing more energy and more fat.

On the other hand, from the consumer's perspective it is appealing to obtain more energy per rand spent, but in terms of health consequences, herein lies the conflict: the vendor sells food to earn a living and the consumer buys food to obtain energy and often the consumer will choose the best value for money. The vendor is aware of this and needs to attract customers while still maintaining a certain profit margin – and in order to do this they will most likely buy ingredients that offer them the best value for money – and often this equates to products which are higher in added ingredients such as fat, sugar and salt.

This will not change unless legislation is introduced that sets limits on the energy and nutrient content of prepared foods sold by the informal sector. However, this is unlikely to occur since by definition the 'informal sector' implies that it is unregulated and evolved as a consequence of the

lack of jobs in an under-resourced country. Even if regulation could be enforced it is likely to result in price increases for vendors and consumers alike and this does not seem realistic in the current environment. An alternative approach would be a campaign to make the consumption of energy-dense foods anti-social, as we have seen happening with tobacco, or to emphasise the risks associated with certain food behaviours or other lifestyle behaviours. Another solution would be to change perceptions about being overweight. This latter idea is a challenge since in South Africa it is desirable to be larger, as size is associated with affluence and happiness (103) and is thought to reflect a husband's ability to care for his spouse (80). However, instead of focusing on body size, individuals should be educated on the importance of eating a healthy, high-quality diet. This should contain sufficient energy and nutrients but limit the amount of fats, sodium and added sugars. The diet should also include large quantities of fruits, vegetables and unrefined cereals. This approach implies that individuals maintain responsibility for their lifestyle choices and ensuing health outcomes (276); probably a better policy model than the state adopting a more interventionist approach, which is likely to alienate individuals and communities.

In South Africa the *Food Based Dietary Guidelines* (FBDG) were developed in 2001, an 80-page document which as yet has not been translated into a user-friendly format for laypeople to understand (290). However, plans are underway to publish *The South African Food Guide* (291), a translation of the FBDGs which will be an important step in educating the public on healthy eating practices.

7.5.2 *Socio-economic status*

The association between SES and obesity varies depending on the GNP of a country (278). Among women in more industrialised countries a higher likelihood of obesity is found among those of lower socio-economic strata (249) but the relations among men and children in such settings are inconsistent. In LMICs a strongly positive association between SES and obesity is found in women and children (249). However, several authors who have scrutinised MIC data have found that for certain SES indicators (education, occupation, and area-level indicators), the association was more often negative than positive, suggesting that the social patterning of overweight is undergoing transition in MICs and reflecting those of a more developed country (250). Indeed, research has shown that in those countries with a GNP per capita >$2 500, poorer groups, particularly women, are more likely to experience higher obesity. In poorer countries, being poorer bestows protection against obesity; in a lower-MIC, obesity risk can either increase or decrease among poorer groups, and in upper-MICs being poorer is a strong risk factor for obesity. South Africa is classified as an upper-MIC, as the per capita GNP is $5 000. Perhaps the reason why no associations were found among females in this cohort is because we are witnessing the changing social patterning of overweight/obesity, as suggested by Monteiro et al. (250).

SES can influence dietary intake and eating behaviours through purchasing of foods. In a developed country the procurement of expensive, high nutritional value foods is possible, as is access to other facilities such as gyms. However, in a rapidly changing society such as that of Soweto, those in the higher income strata are able to purchase energy-dense, micronutrient-poor foods. These foods are often ‘value’ foods which are attractive to shoppers on a low budget. In a recent South African survey of 341 Sowetan adults, the authors found that >50% of those sampled consumed fast food at least once per week and 49% of the sample spent >R200

per week on such foods, but their mean monthly income was only R5 000. Of concern was the finding that the lowest income group consumed the most fast food (292).

As stated in the literature review, South Africa is a diverse nation with high intra-country variability in terms of SES with many sub-groups experiencing extreme poverty. Economic predictors of obesity are complicated by ethnicity, geographic location and education. Findings from a rural study (in Agincourt) showed that BMI increased in adolescents if parents had a higher educational attainment (293). However, the SADHS showed that the BMI of women who had no schooling or who were tertiary educated, was lower than that of women who had some schooling. The same research showed that those with no schooling worked in more manual occupations which would likely result in higher energy expenditure. Furthermore, the authors hypothesise that the reason for low BMI in women with the highest education relates to acculturation and the internalisation of media imagery which values thinness. Among men, those with eight or more years of schooling had on average a greater BMI than those with less or no schooling (80).

The geographic area (Soweto) in which the present study was undertaken is relatively well-off compared to other historically black townships in South Africa but not when compared to a developed-country setting or the formal suburbs in greater-Johannesburg.

Maternal education was not found to be associated with obesity outcomes but it was positively associated with three eating behaviours in the female group (TV snacking, fast food and soft drink consumption) ($p<0.05$), and negatively associated with lunch box usage ($p<0.01$) in males.

The final multivariate analyses from Paper 3 showed that SES at birth was an important predictor of obesity, especially in males. Other research supports the notion that childhood SES has an independent effect on adult health and health-related behaviours, regardless of their current SES (294).

Exploring the relationship between individual SES, household SES and community SES and the impact on health-related behaviours, including dietary behaviours, would be worthwhile since there is growing evidence which demonstrates that neighbourhood SES is related to obesity risk in adults and children (295). For example, social disadvantage in the broader environment (access to healthy foods, places to exercise and neighbourhood safety), not just a child's household SES, may increase obesity risk (295).

7.5.3 *The development of eating behaviours*

In this cohort the dietary habits and practices were relatively similar across the age groups; there was no tendency to improve dietary habits and practices as the cohort aged, indeed many poor practices became more prevalent, as revealed by the longitudinal analyses in Paper 2. Moreover, the data suggests that poor dietary habits and practices are well established by the age of 13 years, therefore it becomes necessary to investigate when dietary habits become permanently fixed in a child's development, particularly if we are to endeavour to encourage improvements.

Birch's review article thoroughly explores early-life factors and experiences that influence a child's food preferences and eating behaviours, "from the genes parents give the infant to the

food environment they create" (252). Birch argues that due to the early exposure children have to foods an important role is played in establishing a hierarchy of food preferences and food selection. In addition to food exposures, parental food preferences, knowledge, values and beliefs also affect their offspring's food preferences. One small study that assessed neophobic responses to foods of children and their parents (n=117 pairs) found that the child/parent responses were significantly related (r=0.3) (296). Gibson et al. (297) showed that children's consumption of certain foods was related to the mother's nutritional knowledge and that certainly, children's confectionery consumption was predicted by maternal partiality to confectionery.

It has been shown that food preference resemblance between parents and children is weak among pre-schoolers (298) but similarities of preference increase as offspring grow older (299, 300). This may be a result of the older child having shared a longer environmental history with their parents and therefore share their taste preferences, and that they have achieved a similar degree of socialisation with regard to eating practices. Such findings suggest that family environment plays a much larger role than genetics in the development of food preferences (252). In more recent work however, it was found in a US white population of 177 families, that parents' eating and activity behaviours clustered within families to create obesogenic versus non-obesogenic family environments (301). Longitudinal analyses showed that these early family environments had long-term effects on children's weight status and their dietary and activity patterns. The data revealed that in comparison with girls from non-obesogenic families, girls from obesogenic families showed greater increases in BMI z-score from ages 5 to 7 years that were maintained from ages 7 to 11 years. In addition, girls from obesogenic families had a higher percentage of body fat and had diets higher in fat. These results were independent of parental BMI. Although this was a small sample and the findings cannot be extrapolated beyond

this particular cohort, this data suggests that obesity prevention efforts should focus on families and before children are at school-going age.

There is a natural tendency to prefer sweet or salty energy-rich foods over micronutrient-rich alternatives and Birch contends that this predisposition is useful in children where high energy intakes are important for growth. However, in our current environment where energy-dense foods are easily accessible, this predisposition to prefer energy-dense foods may promote overweight and obesity among children. Thus the need for parents to direct children to healthy food options is highlighted; if children are to learn to enjoy eating healthy foods, they need repeated positive experiences with those foods as well as opportunities to observe others consuming them (251, 252, 302).

Parental behaviour in many societies can frequently undermine children's self-regulation of energy intake by modelling over-consumption, exerting controlling feeding practices, offering large portion sizes and high-energy foods (302). It has been found that in girls (aged 3 – 5 years) energy regulation related to adiposity, with thinner girls being able to regulate their energy intake more precisely than their heavier counterparts (303). The authors also showed that a high degree of parental control was associated with a lower degree of child self-regulation.

An obvious yet important point is that since food preferences are learned, they can be modified. Data from the abovementioned studies suggest that the best chance for cultivating healthy food patterns would be when children are very young, probably before they are of school-going age.

This implies that interventions should include both the child and parents within their home environment, especially since children model their parent's behaviour. However it would also be prudent to create healthy school environments so that children may have the best chance of replicating a good home environment in their school environment.

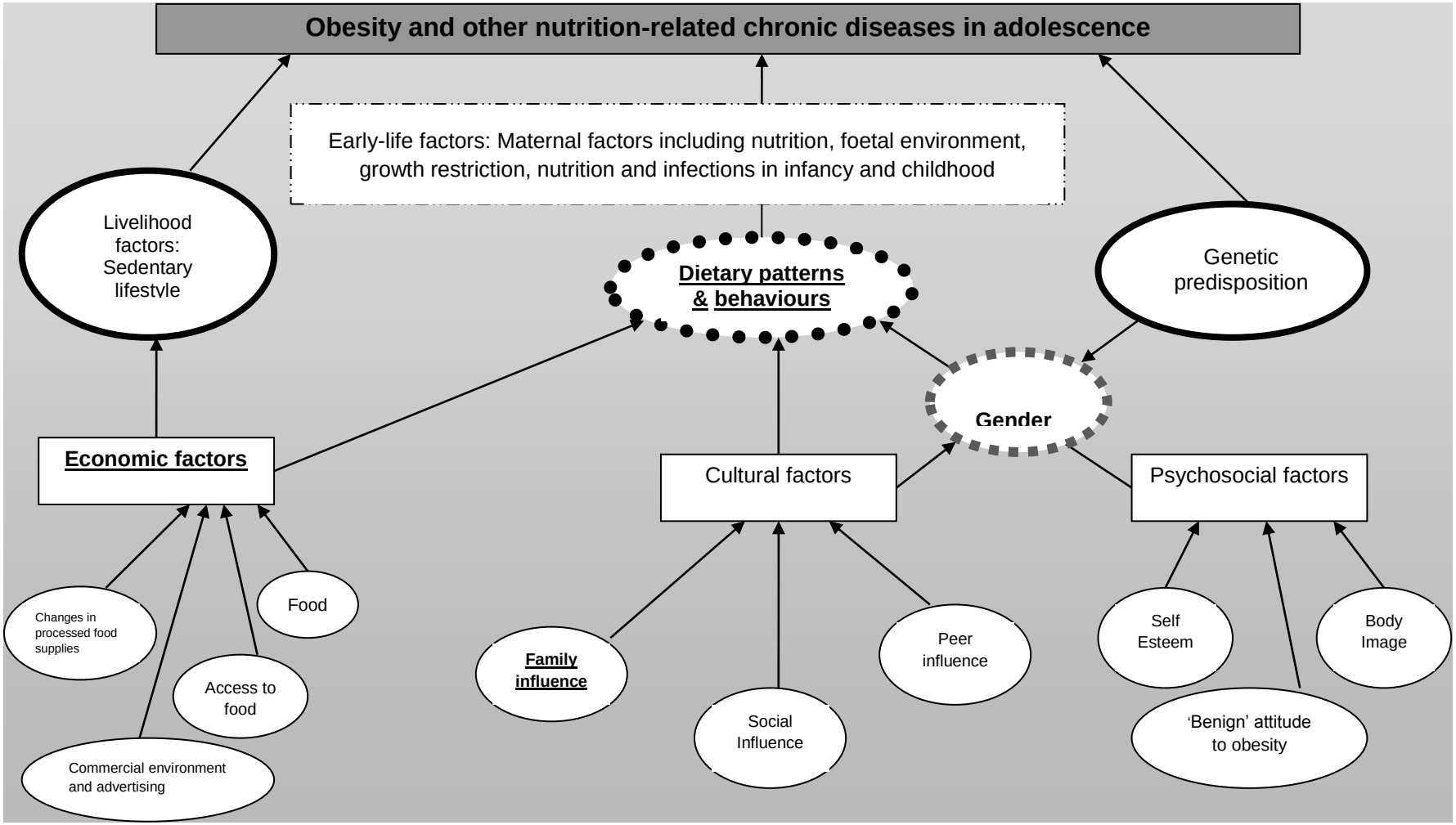
7.6 Theoretical Relevance

Conceptual framework 1 (Figure 1.2.1) is a useful overview broadly highlighting the factors associated with obesity risk among adolescents in a developing country. This study confirmed to a degree some dietary behaviours associated with obesity risk, namely soft drink consumption – but in males only. This study also highlighted that in males at least, socio-economic factors are important when considering obesity risk.

One modification to the conceptual framework worth considering would be the addition of gender. Gender differences occur with regard to the prevalence of overweight and obesity in this cohort, which is corroborated by research in both developed and transitioning countries. Moreover, gender differences occur in dietary habits and behaviours as shown in this thesis, and in international research. The modified conceptual framework (see Figure 7.6.1) now has gender included; the arrow from 'genetic predisposition' may relate to familial links with obesity, and it points to gender since as discussed in this section, females particularly are prone to obesity. One can also see that 'psychosocial factors' run through gender to dietary patterns and behaviours. And finally, 'cultural factors' has an arrow which runs to gender and then on to 'dietary habits and behaviours'. The positioning of gender in the conceptual framework highlights the genetic differences (in terms of fat mass accumulation), the psychosocial factors (larger women are regarded as more beautiful in developing nations) and cultural factors

(cooking is undertaken by more women than men, for example) which influence dietary patterns and behaviours differentially depending on gender. The placing of gender within the conceptual framework also highlights that further in-depth gender research is required.

Figure 7.6.1 Adapted conceptual framework 1, with 'gender' added.



7.7 Contextual Relevance

7.7.1 *Local and national relevance*

In this study we established that the prevalence of combined overweight and obesity is high for both males (8.1%) and females (27%). Furthermore, we documented that poor dietary habits and practices among this cohort are embedded by the age of 13 years. We also found an association between soft drink consumption and obesity among males. However, soft drink consumption may be a marker for other lifestyle factors associated with obesity (SES or other eating behaviours, such as fast food consumption, or it may be a marker for other lifestyle behaviours associated with obesity). Parents need to become aware of these issues so that they can address them within the home environment.

Many studies, including this one, have documented the high prevalence of overweight and obesity among South Africans, young and old. However, the difference in the prevalence of overweight and obesity depends on the setting; for example, extremely rural areas have a much lower prevalence than do urban settings (80). However, economic development is accompanied by a rising prevalence of obesity. Therefore it is imperative that the government prioritise the prevention of obesity, with particular emphasis on our younger generations, as it has been shown that obesity tracks into adulthood.

In South Africa there is a dearth of dietary intake and dietary habit data. In this study we established that dietary habits were poor but we need to understand if such poor dietary habits are pervasive in other communities, and among different ethnic groups. This additional research

will provide more detail on how an intervention or governmental policy may be approached on a national level.

7.7.2 *Low- and middle income countries and high-income countries*

Other LMICs are mirroring the obesity trends seen in South Africa. However there is also a lack of dietary intake data in developing-country settings, which needs to be addressed before policy interventions can be implemented. It is apparent that economic development is accompanied by a rise in obesity, thus policymakers will have difficulty in addressing one without influencing the other.

Socio-economic development is on a continuum with HICs at the fore of development, thus our findings confirm what has taken place historically in a HIC, in that obesity affected higher income groups before it transitioned to lower income groups.

7.8 Limitations and Future Research

Limitations of the individual study components have been discussed within each respective chapter. However, there are some broader limitations pertaining to the overall study that require consideration. These can be grouped into four broad areas: Systematic errors or bias, validity, generalisability and the population sample used in this work.

7.8.1 *Systematic errors or bias*

Bias is defined as a condition that causes a result to depart from the true value in a consistent direction (123). The errors that stem from bias reduce the accuracy of a measurement by altering the mean or median value. However, if bias does not affect variance, this means that the reproducibility or precision of the measurement tool is unaffected (Himes, 1987 in Gibson, 2005). As with many studies, there is concern about measurement (or misclassification) bias.

The questionnaire was developed by Bt20 to assess dietary habits and practices (appendix, p. 204). Due to the nature of the topic under investigation, social desirability bias may occur. In developed countries it has been shown that BMI is inversely associated with the reporting of 'low nutrient dense foods' (304). However in this context (a MIC), the social desirability may be reversed. For example, during dietary intake interviews undertaken in 2007, discussions about certain foods seemed to elicit great enthusiasm among some participants, in particular meat and meat products, fast foods and confectionery foods (personal observation). Other researchers have found that among adolescents certain foods such as fast foods are seen to be 'cool' which might lead participants to over-report the consumption of such items (33). Conversely, other work has shown certain populations under-report such 'unhealthy' foods (305).

Recall bias is another potential issue relating to measurement bias which unfortunately is difficult to overcome as recall of certain dietary behaviours might be recalled differentially by different groups. For example, overweight people might recall their dietary habit behaviour differently to normal-weight or underweight people. However, the questionnaire devised by Bt20 to assess behaviours around food intake may actually have improved participants' memory recall since the recollection of a repeated behaviour is often easier to remember rather than it is

to recall in a 24-hour dietary intake questionnaire which may involve questions about whether or not a particular food was consumed and the size of the portion consumed.

7.8.2 *Validity*

Validity describes the degree to which a tool measures what it is intended to measure (123). In dietary intake research one can at best hope for 'relative validity' whereby one method is compared with another method, since there is no true 'gold standard'. The tool used to assess dietary habits and practices among this cohort was assessed for repeatability (described in Chapter 4), but not for validity.

The questionnaire was interviewer-led which would have minimised participant mis-understanding. For example, any terms not understood would have been translated into local vernacular. FFQs, which most closely resemble this dietary habit questionnaire, are known to overestimate dietary intake. Thus it is possible that this questionnaire overestimated certain habits. However, it is still a useful tool which allows for the classification of individuals into groups.

7.8.3 *Generalisability*

By definition a birth cohort is demarcated by a particular point in time. The subjects in this study represent black South Africans who were born in an urban environment (Soweto) in 1990 and who remained living there for a long period of time (up to 17 years). Although it cannot be said that this cohort is representative of all adolescents in South Africa, the results are indicative of similar behaviours of adolescents living in other urban settings. A relatively large sample of

black South African adolescents was used and it is plausible that other developing urban areas mirror the findings in this study, especially since it has been established that urbanisation is accompanied by increases in poor dietary patterns and obesity.

7.8.4 *Population Sample*

One of the inclusion criteria for the two longitudinal analyses (Papers 2 and 3) required complete dietary habits data from three time points, which meant that there was a reduction in the sample due to incomplete data at one or more time points. The longitudinal analyses used a relatively large sample size (Paper two n=1 451; Paper three n=1 298) but there were losses due to incomplete data at all three time points.

When compared to the remaining Bt20 cohort, the analytic samples used in the longitudinal analyses were slightly better off in terms of the following SES variables assessed at birth: electricity (95% vs 87%), fridge ownership (74% vs 61%), and phone ownership (55% vs 44%) ($p<0.01$). Maternal education was slightly better in the analytic sample as well: 40% vs 36% ($p=0.006$) achieved Std. 9 or more (equivalent to AS level in UK or twelfth grade in the US). However, 66% of the analytic sample had mothers who were single, either divorced/widowed/separated, compared to the remaining Bt20 sample which was 56% ($p<0.001$).

This clearly shows that the analytic sample was different to the remaining Bt20 sample with regard to some parameters, but whether or not this has any meaningful impact on the interpretation of the results is questionable.

7.9 Future Research

This study used an unusual approach to assess the dietary behaviours of adolescents and link them to obesity. However it is acknowledged that the tool used in this research had shortcomings in that it should have included a more comprehensive list of other dietary habits and practices and food items which reflect healthy choices, such as the consumption of fruit and vegetables, this should be developed for future research. However, it would be useful to compare these findings with dietary intake data to assess validity; this data was collected when the participants were 17 years old, but limited resources prevented coding and assessing these data. However this will be addressed as part of a post-doctoral project.

To find no dietary habit and obesity associations among the female participants was disappointing, especially since the prevalence of overweight and obesity is much greater among females both in this cohort and in the greater South African population. Further research should entail physical activity assessment, as it is speculated that there are significant gender differences in terms of energy expenditure. Additionally, incorporating participants from a greater spread of social backgrounds may yield differences among females.

The composition of the diet is an emerging aspect of metabolic research that shows that the influence of sucrose and high-fructose corn syrup as having a negative influence on obesity risk, especially as it is consumed in large quantities (from processed foods to soft drinks) thus it would be invaluable to develop future research relating to this important field.

Black participants were the primary focus of the study and mixed ancestry participants, who made up only 10% of the sample, were included in Paper 2. There are ethnic differences in terms of the prevalence of obesity and probably in terms of health behaviours, thus inclusion of these groups in the future will be useful. Research on dietary intakes in other populations in different settings will help policymakers to develop guidelines and policies to curtail this rising epidemic.

The availability of fast foods in rural South Africa has been highlighted and other research conducted in this area showed that the prevalence of obesity among females is similar to the findings in the Sowetan cohort (228); these are clear indications of a rural population undergoing nutrition transition. Future work, currently underway, will concentrate on dietary intake and behaviours which increase obesity risk in rural populations, so as to prevent the escalation of other metabolic disease, especially since this is a particularly under-resourced group.

7.10 Conclusion

This study set out to assess the availability of fast foods in an urban and a rural setting; to describe dietary habits and practices associated with obesity risk among urban adolescents over a 5-year period; and to assess the association between longitudinal dietary habits and practices and obesity risk in 17-year-olds.

Key findings reveal that in the cross sectional analysis adolescent fast food intake is high with 8.1 (4.6) items and 7.2 (4.7) items/week consumed for males and females respectively (p=0.01).

Furthermore the kota (or quarter) is the most popular fast food item and on average it provides more energy and is more affordable than other commercial fast food equivalents.

Longitudinal dietary habits and practices are relatively poor, are embedded by the age of 13 years and are characterised by relatively high fast food consumption, a decline in breakfast consumption, an increase in snacking while watching television and among girls a decreasing trend in eating the main meal with the family. Confectionery consumption is relatively high and remains constant with age. Lunch box usage declines and conversely the number of tuck shop purchases increase with age.

Of concern was the finding that fast foods are available in a relatively impoverished rural area in Mpumalanga, which may indicate that this rural area is undergoing nutritional changes such as we have seen in urban environments.

The prevalence of combined overweight and obesity was higher than the national statistics for both boys and girls at the age of 17-years. This research adds to the body of work that implicates dietary habits and socio-economic status in the development of obesity, particularly in males. This research confirmed to a degree that some dietary behaviours are associated with obesity risk namely soft drink consumption – but in males only. This study also highlighted in males at least, that socio-economic factors are important when considering obesity risk. However soft drink consumption may be a marker for other lifestyle behaviours associated with obesity (SES or other eating behaviours, such as fast food consumption, or other lifestyle behaviours).

With urbanisation and economic transition, households experience a change in SES and these changes drive behaviour which can either enable or disable health outcomes. In this study SES improvement, e.g. fridge ownership seems to enable certain behaviours which can be obesogenic. We cannot halt development in this context but we must devise ways to improve lifestyle choices which will promote health rather than impede it.

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Appendices

Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Feeley

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080320**
PROJECT	The impact of dietary habits and practices during adolescence on the risk of obesity: The birth to Twenty Cohort
INVESTIGATORS	Miss ABB Feeley
DEPARTMENT	Faculty of Health Sciences
DATE CONSIDERED	08.03.25
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 08.05.07 **CHAIRPERSON** .....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

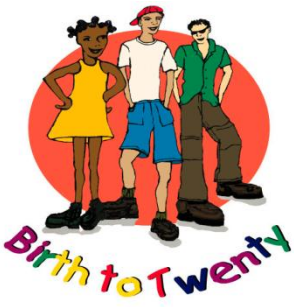
cc: Supervisor : Dr S Norris

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Questionnaire



Department of Paediatrics and Child Health

BIRTH TO TWENTY BARA SITE: 17TH YEAR

ADOLESCENT HEALTH SERVICES QUESTIONNAIRE

DATE : Day Month Year

BTT ID NUMBER :

BONE STUDY ID NUMBER :

Consent Table

Components	Yes	No
Adolescent Questionnaire		
Food Frequency Questionnaire		
Measurements		
Pubertal Assessment Questionnaire		
DXA scan		
Fracture Questionnaire		
OGTT		
VCT		

Contact details of relative or friend who will **always** know where you live (different to info on contact sheet):

Name: _____ Relationship: _____

Landline number: _____ Cell number: _____

Work number: _____ Other: _____

Email: _____

Informed Consent

I agree to myself being a participant in the Birth to Twenty study.

The goals and methods of Birth to Twenty are clear to me.

I understand that the study will involve interviews, measures of growth, a DXA scan, Oral Glucose Tolerance tests, eating habits and school reports. All the details and purposes of these tests have been explained to me. I understand that I have the right to refuse to participate in the study.

I, the undersigned, hereby declare that I understand:

1. That the University of the Witwatersrand, Johannesburg (hereafter referred to as "the University" has insured itself against the acts and omissions of persons acting on its behalf insofar as it is liable in law therefore and that its registered students and staff are insured during the course and scope of their registered courses and/or within the scope of the University business, where the fault can be attributed to the University or its affiliates.

2. That in cases where no fault can be attributed to the University, I hereby indemnify, absolve and hold harmless the University, its officials, employees, students and invitees in respect of any damage to the property, death or bodily injury to/of myself and/or third parties, whether on/off the University precincts, or whilst engaged in any activity related to the University.

3. And undertake, for any period during which I am on the university precincts or during my participation in the Birth to Twenty Study, to be bound by the rules and regulations of the University for the time being in force and by any requirements or conditions imposed by the University on me.

I agree to participation in the study on the condition that:

1. I can withdraw from the study at any time voluntarily and that no adverse consequences will follow on withdrawal from the study.

2. I have the right not to answer any or all questions posed in the interviews and not to participate in any or all of the procedures / assessments.

3. The Committee for Research on Human Subjects at the University of the Witwatersrand has approved the study protocol and procedures.

4. All results will be treated with the strictest confidentiality.

5. Only group results, and not my/my child's individual results, will be published in scientific journals and in the media.

6. The Bt20 scientific team are committed to treating participants with respect and privacy through interviews conducted in private and follow-up counselling available on request.

7. I will receive a referral note to a health service if any result is out of the normal range or a problem is detected in the course of the study.

Adolescent: _____ Research Assistant : _____

Date: ____/_____/_____

The FIRST section of the questionnaire we are going to talk about…

EATING HABITS AND PRACTICES

SECTION A: Breakfast habits

1. On how many weekdays do you usually eat breakfast? **Mark one only**

Never	1	
1-2 days	2	
3-4 days	3	
Every weekday (5)	4	☐

2. How often do you usually eat breakfast on a weekend? **Mark one only**

Never	1	
Saturdays only	2	
Sundays only	3	
Saturdays and Sundays	4	☐

3.1 What best describes the way you usually eat during the week? **Mark one only**

3 or more meals a day	1	
2 meals a day	2	
1 meal a day	3	☐

3.2 What best describes the way you usually eat over a weekend? **Mark one only**

3 or more meals a day	1	
2 meals a day	2	

1 meal a day	3	☐

4. How many times do you eat snacks in a day? **Mark one only**

Just once a day	1	
Twice a day	2	
3 or more times a day	3	
Never	4	☐

SECTION B: Fast foods

1. How often during the **past week** (past 7 days) did you eat any of the following takeaways? **Tick each item**

	0 x last week	1x last week	2x last week	3x last week	4x last week	5+ last week
Hamburger						
Chicken Burger						
Fried fish						
Fried chips						
Pizza						
Vetkoek						
Pies or sausage roll						
Samoosas						
Pita bread						
Hotdog						

Boerewors roll						
Doughnuts						
Sweets						
Cake						
Chocolates						
Chips e.g. nik naks						
Ice cream						
Soft drinks e.g. Coke						
Squash e.g. *Drink-o-pop/Oros*						
Diet drinks						
Other:						

2. How often do you usually eat at a friend's house? (In a week) Tick where applicable.

0 x per week	1x per week	2x per week	3x per week	4x per week	5+ x per week

SECTION C: School lunch box (if applicable)

Think about a typical school week and answer the following questions about your lunch box that you take to school.

1. How often do you generally take a lunch box to school? **Mark one only**

0 x per week	1x per week	2x per week	3x per week	4x per week	5 per week

2. Do you share or exchange what you have in your lunch box with friends?

Yes	No
1	2

3. Which foods do you often have in your lunch box? **Tick each item**

	0 x per week	Less than 2x per week	More than 2x per week
White bread or rolls			
Brown bread or rolls			
Fruit			
Chips (hot)			
Crisps			
Pap			
Meat or chicken			
Pie / sausage roll			
Cold drink			
Diet cold drinks			
Fruit juice			
Milk or sour milk			
Yoghurt			
Cheese			
Sweets or chocolates			
Biscuits or cookies			

Peanuts			
Other:			

4. Who prepares your school lunch box (yourself, mother, father etc)

_____

5. Do you get money to spend on food / snacks at school? **Mark one only**

Yes	No	Sometimes
1	2	3

6. How much money do you usually get to spend at school per week on food?

Mark one only

Transport	No money	**Lunch**	No money	1
	R10 or less		R10 or less	2
	R20 or less		R20 or less	3
	More than R20		More than R20	4

7. Which of the following foods did you buy at school (tuck shop)? **Tick each item**

	Did not buy	**Bought 1 time**	**Bought 2 times**	**Bought 3 times**	**Bought 4 times**	**Bought 5 times or more**

White bread or rolls						
Brown bread or rolls						
Fresh fruit						
Crisps						
Pap and Meat or chicken						
Chips (hot)						
Pie / sausage roll / samoosa						
Vetkoek						
Cold drink						
Diet cold drinks						
Fruit juice						
Milk or sour milk						
Yoghurt						
Cheese						
Sweets or chocolates						
Cakes/ donuts/ éclairs						
Hot dogs						
Hamburger (beef or chicken)						
Popcorn						
Peanuts/nuts						

1. How often do you snack when you are watching TV? **Mark one only**

Every day	1
More than three days a week	2
Less than 3 days a week	3
Never	4

2. Which snacks did you eat while watching TV last week (past seven days)? And how often?

Tick each item

	Didn't eat	1 time	2 times	3 times	4 times	5 or more times
Fruit						
Popcorn						
Chocolates						
Bread (any type)						
Crisps e.g. nik-naks						
Biscuits						
Cakes/ donuts/ éclairs						
Drinks e.g. Coke						
Fries						
Other:						

4. Do TV adverts on foods influence you to buy those food items? **Mark one only**

Never	1
Hardly ever	2
Often	3

Very often 4

5. Which food and drinks that you see advertised on TV do you buy?

   1.)

   2.)

   3.)

6. Where do you usually eat your main meal of the day? **Mark one only**

Kitchen at a table/counter (eating by yourself)	1
Dining room at a table (eating with other family members)	2
In front of the TV off your lap	3
Other	4

7. How many times do you eat dinner/supper with your family/parents/caregivers?

Never	1
Some Days	2
Most Days	3
Every Day	4

8. How much does your mother/caregiver/father control what you eat?

1.	Not at all	2.	Sometimes	3.	Mostly	4.	Completely

8. D 9. Do you ever eat outside the home e.g. at fast food shops such as Nandos, KFC and Steers?

YES	1
NO	0

9. If YES, in an average month how often do you eat at the following places?

	Frequency of visits		
	Times/week	Times/month	Rarely/never
Nandos			
Spur			
Macdonalds			
Steers			
KFC			
Chicken Licken			
Debonaire's Pizza			
Romans			
Anat			
Wimpy			
Something fishy			
Fontana			
Chinese takeaway			
Other restaurants/takeaways			

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