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Factors associated with nutritional status of children aged 0-60 months residing in Eastern Cape and KwaZulu-Natal Provinces

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ABSTRACT

Background: Poor health, death, reduced human capacity, increased risk of chronic diseases later in life and poverty are the most prominent consequences of child malnutrition.

Aim: This study sought to assess the anthropometric status of 0-60 month-old children living in Eastern Cape and KwaZulu-Natal Provinces using the new WHO child growth standards; identify risk factors of child malnutrition. In addition, assess the prevalence and associated factors of the occurrence of a stunted child with a living-in overweight mother (SCOWT).

Methods: Secondary analysis was done on household socio-economic data, child health, child feeding practices, and anthropometric measurements for 2485 children and their mothers. Logistic regression was used to determine risk factors of stunting, overweight and underweight taking into account hierarchical relationships between risk factors. The Chi-square test and analysis of variance were used to identify related variables which were significantly different between SCOWT and non-SCOWT mother-child pairs as well as between wasted and non-wasted children.

Results: Prevalence of wasting, underweight, stunting and overweight was 3.4%, 7.3%, 28.6% and 16.1% respectively. The WHO child growth standards gave higher rates of stunting and overweight but lower rates of underweight. Risk factors for child stunting were male gender (Odds ratio (OR) =1.233; p=0.019) and the fact that the mother thinks her child is growing well (OR=1.346; p=0.018). On the other hand, handouts as source of food (OR=0.719; p=0.005) and mother making important household decisions (OR=0.760; p=0.009) were protective. Underweight was positively associated with child male gender (OR=1.432; p=0.021), maternal education (minimum of 5 years of schooling: OR=1.720; p=0.002), the fact that the mother thinks her child is growing well (OR=2.526; p<0.000), still breastfeeding (in children <24 months: OR=2.022; p=0.014) and history of gastrointestinal symptoms (OR=1.527; p=0.013). Child overweight on the

other hand was positively associated with household having a regular source of income (OR=1.473; p=0.002) but negatively with maternal education (OR=0.595; p=0.001) and the fact that the mother thinks her child is growing well (OR=0.361; p<0.001). Prevalence of SCOWT was 13.9% and SCOWT mother-child pairs were more likely to be older (both mother and child), have hand-outs as source of food, have used bottle-feeds in the 24 hours preceding survey (children<24months) but less likely to increase fluid intakes during episodes of diarrhoea. The children were more likely to be males.

Conclusion: The double burden of malnutrition occurred in these poor communities, households and individual children. Other than the effect of maternal education on the risk of underweight; the most important factors associated with stunting and underweight were child male gender and the fact that the mother thinks her child is growing well. On the other hand overweight was associated with maternal BMI and household having a regular source of income.

Key words: Child malnutrition; nutritional status; South Africa; rural; risk factors; stunting; underweight; overweight

OPSOMMING

Motivering: Swak gesondheid, sterfte, verminderde menslike kapasiteit, 'n toename in die risiko vir kroniese siektes later in die lewe en armoede is die mees belangrike gevolge van kinderwanvoeding (beide ondervoeding en oorvoeding).

Doelwitte: Hierdie studie poog om risikofaktore vir kinderwanvoeding vir 0-60 maand oue kinders wat in die Oos-Kaap en KwaZulu-Natal provinsies woon, met behulp van die nuwe WGO kinder groeistandaarde, te identifiseer. Bykomend is die prevalensie en geassosieerde faktore op die voorkoms van groei belemmering met 'n inwonende oorgewig moeder (GBIOG) bepaal.

Metodes: Sekondêre analises is op huishoudelike sosio-ekonomiese data, kinder gesondheid, kinder voedingspraktyke en op antropometriese metings van 2485 kinders en hul moeders gedoen. Logistiese regressie is gebruik om risiko faktore vir groei belemmering, oorgewig en ondergewig, met in agneming van die hirargiese verwantskap tussen risiko faktore, te bepaal. Die 'Chi-kwadraat' toets en analise van variansie is gebruik om verwante veranderlikes wat betekenisvol tussen GBIOG en nie-GBIOG ma-kind pare verskil het, sowel as tussen uitgeteerde en nie-uitgeteerde kinders, te be paal.

Resultate: Die voorkoms van spieruittering, groeibelemmering en oorgewig was 3.4%, 7.3%, 28.6% en 16.1% onderskeidelik. Die WHO standaarde gee 'n hoër voorkoms van groeibelemmering en oorgewig, maar 'n laer voorkoms van ondergewig. Risiko faktore vir kinder groei belemmering was manlike geslag (Kans-verhouding (KV)=1.233; p=0.019) en die feit dat die ma dink haar kind volgens wense groei (KV=1.346, p=0.018). Aan die anderkant was voedsel wat uitgedeel is as bron van kos (KV=0.719; p=0.005) en waar die ma belangrike besluite in die huishouding neem (KV=0.760; p=0.009) beskermend. Ondergewig was positief met manlike geslag (KV=1.432; p=0.021), moederlike opvoeding (minimum van vyf jaar skoolopleiding: KV=1.720; p=0.002), die ma se persepsie oor die groei van haar kind (KV=2.526; p<0.001), steeds borsvoedend (in kinders <24 maande: KV=2.022; p=0.014) en geskiedenis van 'n

gastrointestinale simptome (KV=1.527; p=0.013) geassosieer. Oorgewig kinders was positief geassosieer met 'n gereelde bron van inkomste (KV=1.473; p=0.002), maar negatief met moederlike opvoeding (KV=0.595; p=0.001) en moederlike persepsie oor die groei van haar kind (KV=0.361; p<0.001) geassosieer. Die voorkoms van GBIOG was 13.9% en GBIOG moeder-kind pare was geneig om ouer te wees (beide moeder en kind), het voedsel wat uitgedeel is as bron van kos gehad, bottelvoeding 24 uur voor die opname gekry (kinders <24 maande oud), maar was minder geneig om vloeistofinname tydens diaree episodes te verhoog. Die kinders was ook meer geneig om manlik te wees.

Gevolgtrekking: Die dubbele las van wanvoeding was in hierdie arm gemeenskappe, huishoudings en individuele kinders sigbaar. Behalwe vir die effek van moederlike opvoeding op die risiko vir ondergewig, was die belangrikste faktore wat geassosieerd was met groeibelemmering en ondergewig 'n kind van manlike geslag en die feit dat die moeder dink haar kind groei goed. Aan die anderkant is oorgewig geassosieerd met moederlike BMI en huishoudings met 'n gereelde bron van inkomste.

Sleutelwoorde: Kinderwanvoeding; voedingstatus; Suid-Afrika; landelik; risiko faktore; belemmerde groei; ondergewig; oorgewig.

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ACRONYMS AND ABBREVIATIONS

AIDS	Acquired immunodeficiency syndrome
BMI	Body Mass Index
CVD	Cardiovascular disease
DALY	Disability-adjusted-life years
DoH	Department of Health
EC	Eastern Cape
GI	Gastrointestinal
HIV	Human immunodeficiency virus
INP	Integrated nutrition program
KZN	KwaZulu-Natal
MRC	Medical Research Council
NCDs	Non communicable diseases
NFCS	National food consumption survey
NFCS:FB-I	National food consumption survey, fortification baseline
NCHS	National Centre for Health Statistics
NGO	Non-governmental organisation
NIRU	Nutrition interventional research unit
SA	South Africa
SAJCN	South African journal of clinical nutrition
SAVACG	South African Vitamin A consultative group
SCOWT	Stunted child with living in overweight mother
SD	Standard deviation
SSA	Sub-Saharan Africa
TB	Tuberculosis
UNICEF	United Nations children fund
USA	United States of America
WHO	World Health Organisation
UN	United Nations

CHAPTER 1: INTRODUCTION

1.1 PROBLEM STATEMENT AND MOTIVATION

Malnutrition, a deviation from the norm in a child's growth and development, can manifest as under or overnutrition. Undernutrition can present itself as underweight (low weight-for-age), wasting (low weight-for-height) and stunting (low height-for-age), while overnutrition may manifest as overweight and obesity (high weight-for-height). Malnutrition is known to have detrimental effects on the child as well as the household and nation at large. Undernutrition is reported to be the underlying cause of up to 50% of the under-five mortality rate worldwide (UNICEF, 2008). Other detrimental effects of undernutrition include susceptibility to acute morbidity (Nannan *et al.*, 2007; Bejon *et al.*, 2008); decreased cognitive development (Grantham-McGregor *et al.*, 2007; Liu *et al.*, 2003); decreased economic productivity (Alderman *et al.*, 2006; Victora *et al.*, 2008) and susceptibility to chronic illnesses later in life (Barker *et al.*, 2002; Painter *et al.*, 2006).

Undernutrition, as a public health problem affects mostly children in developing countries. Between 2000 and 2006 more than a quarter of children younger than five years in developing countries were reported to be moderately or severely underweight or stunted (UNICEF, 2008). In South Africa (SA) undernutrition is reported to be a public health problem with stunting as the most prevalent anthropometric outcome. Among all age groups, children aged 1-3 years are reported to be most affected (Steyn *et al.*, 2005). Data from the South African Vitamin A Consultative Group (SAVACG) study that was done in 1994 showed a prevalence of 9.3% underweight, 22.9% stunting and 2.6% wasting in 6-71 months old children (SAVACG, 1996). The National Food Consumption Survey (NFCS) five years later reported similar results with 8.8% underweight, 19.3% stunting, and 3.3% wasting in 1-9 year-old children (Labadarios *et al.*, 2005). A more recent national survey, NFCS fortification baseline (NFCS:FB-I), that was done in 2005 reported 18% stunting in 1-9 year-old children (Labadarios *et al.*, 2008). Although the studies differed in their study designs these results suggest that the nutritional status of South African children has not changed much over the past 15 years.

South Africa (SA) is believed to be in nutrition transition as evidenced by co-existence of under and overnutrition (Jinabhai *et al.*, 2005; SAHDS, 2003). Secondary analysis of the 1999 NFCS data reported a prevalence of 17.1% combined overweight and obesity in children aged 1-9 years. Children living in formal urban areas were found to be most affected (Steyn *et al.*, 2005). The NFCS:FB-I reported a prevalence of 10% overweight and 4% obesity in children aged 1-9 years (Labadarios *et al.*, 2008). These results show that overweight/obesity is the second most prevalent adverse anthropometric outcome, after stunting, in South African children. This calls for concerted efforts, addressing both forms of malnutrition simultaneously in line with recommendations by international bodies like United Nations Standing Committee on Nutrition and World Bank (Uauy & Solomons, 2006; World Bank, 2006).

Development of childhood malnutrition is believed to be multi-factorial. According to the United Nations Children's Fund (UNICEF) conceptual framework for development of child malnutrition, an interplay of basic (societal issues like cultural, political, economic and societal systems), underlying (household issues like household food security, maternal and child care practices, water and sanitation) and immediate (dietary intake and disease state) factors determine the child's nutritional outcome (UNICEF, 1990). This framework is generally accepted among scientists but with recognition that the effect of each of these factors will differ from region to region.

Considering the high prevalence of poor anthropometric outcomes and their detrimental effects on health, targeted strategies are vital in order to attain optimal health for South African children. An Integrated Nutrition Program (INP) was developed in 1994 to coordinate an inter-sectoral approach to solving nutrition problems in SA (INP, 2004). One of its goals is to reduce the prevalence of malnutrition in children, therefore, ensuring optimal growth of infants and young children. To achieve this, the INP seeks to address underlying socio-economic, environmental, educational and health related causes of malnutrition. The Health Systems Trust (HST), a non-governmental organisation (NGO), embarked on the implementation of a project based on the INP principles in KwaZulu-Natal (KZN) and Eastern Cape (EC) Provinces. The Nutritional Interventional

Research Unit (NIRU) of the Medical Research Council (MRC) then carried out a baseline assessment of the socio-demographic and anthropometric profile of 0-71 month old children and their caregivers at the request of HST. The baseline assessment revealed that undernutrition was low in infancy but more or less doubled in the second year of life. On the contrary, childhood overweight was most prevalent in the first and second years of life. A high percentage of the female caregivers (EC 55%, KZN 45%) of the studied children were, however, overweight/obese (Smuts *et al.*, 2008).

The baseline study used Epi Info 2000 software package which is based on the National Centre for Health Statistics (NCHS)/World Health Organisation (WHO) child growth reference (Hamill *et al.*, 1979) to construct anthropometric indices. This reference, however, is reported to underestimate the prevalence of stunting when compared to the newer WHO child growth standards (De Onis *et al.*, 2006; Nuruddin *et al.*, 2009). The study on the development of the WHO child growth standards followed a prescriptive approach and it is based on healthy breastfed children (De Onis *et al.*, 2004). Re-assessing the anthropometric status of the children in the baseline survey using the newer WHO child growth standards would therefore be beneficial.

1.2 RESEARCH AIMS AND OBJECTIVES

1.2.1 Aim

To determine factors associated with poor nutritional status of 0-60 month old children living in the EC and KZN Provinces as measured anthropometrically.

1.2.2 Objectives

1. To reassess the anthropometric status using the new WHO child growth standards (WHO, 2006) and compare the results with those of the older WHO/NCHS child growth reference (Hamill *et al.*, 1979).
2. To investigate the association between the anthropometric status of the children and socio-economic status, perceived household food availability, maternal and child care practices, environmental factors and child morbidity.

3. To explore the prevalence of coexistence of a stunted child and an overweight mother in the same household and determine factors associated with this paradoxical phenomenon.

1.3 STRUCTURE OF MINI-DISSERTATION

This mini-dissertation is written in article format comprising of four chapters. Chapter one is the introductory chapter consisting of the problem statement, aims, objectives, an articulation on the structure of the mini-dissertation and authors' contributions to the research done. Chapter two is the literature review providing background information on current knowledge about child nutrition and risk factors of child malnutrition to guide interpretation of results. Chapter three is the article "Risk factors of poor anthropometric status in children under 5 years living in rural districts of the Eastern Cape and KwaZulu-Natal Provinces, South Africa". The article will be submitted to the South African Journal of Clinical Nutrition (SAJCN) to be considered for publication. Chapter four gives general conclusions and recommendations. References for each chapter are provided at the end of each chapter. References for chapter three are written in Vancouver style in line with authors instructions for the SAJCN, while all the other references are written according to the North-West University Harvard reference style.

1.4 CONTRIBUTIONS OF THE AUTHORS

This work is an outcome of contributions by a team of researchers whose contributions to the work is detailed in Table **1.1**.

Table 1.1 Qualifications and roles of the research team

NAME	ROLE IN STUDY
Maemo Lesiapeto (M. Sc student)	Responsible for all aspects of the study: Literature review, data analysis, interpretation and writing up the results
Prof C.M. Smuts (Biochemist)	Project leader; provided supervision of the whole project. He was also supervisor for Maemo Lesiapeto
Dr S.M. Hanekom (Dietician)	Overlooked the financial needs to the study. Also provided guidance in scientific writing and data interpretation
Dr M. Faber (Nutritionist)	Provided guidance on the design, data analysis and interpretation of results. She was also member of the team that collected the original data.

I declare that I have approved the above-mentioned study, that my role in the study is as indicated above is representative of my actual contribution and I hereby give my consent that it be published as part of M. Sc mini-dissertation of Maemo Lesiapeto.

Prof C.M. Smuts Dr S.M. Hanekom Dr M. Faber

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SAVACG **see** SOUTH AFRICAN VITAMIN A CONSULTATIVE GROUP.

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CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will summarize current literature on child growth, nutrition transition and malnutrition in South African children younger than five years. Socio-economic and demographic indicators of SA will also be discussed due to their relevance in child nutrition and health. The information was gathered from a variety of sources like books (to provide background knowledge), peer reviewed publications, communication with experts in the area as well as from websites of relevant organisations like the UNICEF, WHO, Department of Health (DoH) and Statistics South Africa (SSA). For the purpose of this literature review the following definitions will apply.

Malnutrition - A deviation from the norm in a child's growth and development. It can manifest as either under or overnutrition (WHO, 1995**a**). The term malnutrition, however, is often used interchangeably with undernutrition in literature but for the purpose of this review malnutrition will be used to refer to under and overnutrition collectively.

Undernutrition - Is an under-nourishing process in which the normal needs of energy and one/more nutrients are continually not met or lost at a greater rate than acquired. It is a cumulative process thus making its measurement difficult. In public health, child undernutrition is usually assessed by anthropometric measurements and it encompasses stunting, underweight and wasting. Micronutrient deficiencies are another form of undernutrition (WHO, 1995**a**).

Stunting - Failure to reach linear growth potential and is measured as height-for-age at least two standard deviations (SD) below the median of a reference population. It is a good indicator of long-term undernutrition among young children. For children <24 months recumbent length is used instead of height (WHO, 1995**a**).

Wasting - Refers to thinness and it is measured as weight-for-height at least 2SD below the median of a reference population. It describes a recent or current severe process leading to significant weight loss; usually a consequence of acute starvation or severe

disease. It is commonly used as an indicator of undernutrition among children in emergency situations such as famine, war displacements and natural disasters (WHO, 1995**a**).

Underweight - Is measured as weight-for-age at least 2SD below the median of a reference population. It may indicate wasting or stunting, but does not differentiate between them. It is the most commonly assessed form of undernutrition in developing countries (WHO, 1995**a**).

Obesity (or energy overnutrition) - Refers to accumulation of excess fat tissue relative to lean body mass. Since measurement of body fatness is difficult and complex, anthropometry is readily used as a proxy for body fatness. In children overweight is measured as body mass index (BMI) or weight-for-height at least 2SD above the median of a reference population, while obesity is at least 3SD above the median (WHO, 1995**a**).

2.2 SOCIO-ECONOMIC AND DEMOGRAPHIC INDICATORS OF SOUTH AFRICA

2.2.1 Geography and population

South Africa is in the southern region of Africa, according to the United Nations (UN) division of the world. This region is flogged by a number of social ills like poverty, political unrests, wars, infectious disease epidemics and famines. The country is divided into nine provinces with vast demographic and socio-economic differences. The SA population of 48.5 million is heterogeneous comprising mainly of Blacks/Africans (79%), whites (9.5%), coloured/mixed race (9%) and Indian/Asian race (2.6%). Sixty percent of the SA population live in urban areas. The EC and KZN provinces are located in the south-eastern and eastern side of the country respectively. The two provinces take up 21.6% (EC 13.9%; KZN 7.7%) of the SA land and are inhabited by 35% (EC 13.5%; KZN 21.2%) of the population. EC and KZN provinces house 15% and 22% of the SA children aged 0-4 years respectively (SSA, 2007).

2.2.2 Selected demographic and socioeconomic indicators

South Africa is an upper middle income country (WHO, 2009) and in 2007 the country had a gross national income (GNI) per capita (US $) of 5760 (UNICEF, 2009). In 2005, however, 26% of the South African population lived below the international poverty line of US$1.25/day (UNICEF, 2009). The SA constitution spells out adequate food and water as a human right for all South Africans (SA, 1994). The country has also ascribed to a number of international declarations with food, nutrition and health components like the Universal declaration of human rights (UN, 1948) and the convention on the rights of the child (UN, 1990**b**). Article 24 of the human rights declaration advocates for attainment of the highest standard of health and minimized malnutrition and other child health ills. The living conditions of South Africans are reported to have been improving since 1996 (time when the first community and household survey was carried out). About 80% have electricity in their homes while 88% have access to improved drinking water sources (SSA, 2007). Services and facilities, however, are generally better in urban than in rural areas (SSA, 2007; UNICEF, 2009). Housing, sanitation, access to electricity and access to improved drinking water were below the national average in EC and KZN provinces in 2007. Also, in these two provinces only 54% (EC) and 60% (KZN) of the people live in formal dwellings (SSA, 2007).

The population of SA grew at an annual rate of 1.7% between 1990 and 2007 with total fertility rate of 2.5 births per woman, crude birth rate of 21.7 per 1000 and crude death rate of 14.3 per 1000. In 2007 under-five mortality rate was reported to be 59 per 1000 live births (SSA, 2007; UNICEF, 2009). The percentage share of the population aged 0-14 years has been gradually declining while that of 15-64 years has been increasing since 1996 (SSA, 2007).

2.3 CHILD GROWTH

2.3.1 Infant and young child growth patterns

In human life, the foetal stage represents a period during which growth is at its highest rate followed by infancy. During infancy most children will double their birth weight by 5-6 months and triple it by one year, while they will increase their body length by 55% and head circumference by 40%. In the second year of life an average child grows by about 12 cm and gains about 3.5 kg. Following that, growth rate slows down to nearly a constant at the beginning of 4-5 years with average annual weight and height increments of about 2 kg and 6 cm respectively. The rate of growth will continue to be constant during middle childhood but some gender differences will begin to appear in height, while in weight only minimal differences will be observed. During adolescence, growth rate continues to be constant until at the onset of puberty where the growth spurt commences and secondary sexual characteristics appear. After this, growth rate decelerates until adulthood (Sun, 2006:19).

Nutritional demands during childhood, especially infancy, are high relative to those of adults. This is a consequence of children's relatively high growth rate, high proportion of metabolically active tissues (like the brain) and frequent occurrence of childhood illnesses. Attainment of these high nutritional needs can be hindered by physiological factors (like immaturity of the gastrointestinal and excretory systems), developmental stage (inability to search for food and eat), neurological impairment, psychological disorders and social and educational disadvantage. A notion that children are just small adults has long been dismissed with recognition that children are growing individuals and exhibit developmental changes at different stages of their lives. These include developmental changes in the gastrointestinal (GI) system to enhance the efficacy of nutrient absorption, while the kidneys and liver progressively increase ability to adapt to changes in under or over-supply of nutrients. More importantly is the children's neurological maturity from being completely dependent on adults in infancy to seeking out for food and later selecting food supply as they continue to grow and develop (Williams, 2005:378).

Child growth, however, follows a certain rhythm which can be disturbed by nutritional deficits, excesses or childhood illnesses. This highlights the importance of monitoring child growth and development (Williams, 2005:378). Anthropometric measurements are simple, cheap and cost-effective in assessing the nutritional status of children and those most commonly measured include weight, height and head circumference. Measurements like skin fold thickness, waist circumference and mid-upper arm circumference may, however, also be assessed. These anthropometric measurements can then be assessed against those of a reference population to identify growth deficits or excesses. To achieve this, the anthropometric measurements can be plotted against those of a reference population to observe graphically child growth patterns or they can be transformed into age-specific anthropometric indices like height-for-age, weight-for-age, weight-for-height and BMI (Sun, 2006:19; WHO, 1995**a**). Anthropometric indices can then be expressed as z-scores (SD-scores), percentiles or percent of median. Use of SD-scores (or z-scores) is the preferred method for reporting anthropometric data in public health nutrition since it allows for statistical calculations like mean values (WHO, 1995**a**).

2.3.2 The history of child growth references

Child growth references are used internationally in both public health and clinical practice. In public health they are often used as early warning signals where emergencies related to food and nutrition are predicted, in evaluation of child care practices and in nutrition screening to identify population groups at risk of malnutrition. In clinical settings child growth references are used for growth monitoring and promotion as well as identification of abnormal deviations of growth (WHO, 1995**a**). The first international child growth reference was developed by the NCHS of the United States of America (USA) (Hamill *et al.*, 1979). To develop this reference two distinct data sets which were collected at different time periods were combined; the Ohio Fels Research Institute Longitudinal Study (for children 0-24 months) and the United States (US) Health Examination Survey (for children over 24 months). The Fels Research Institute Longitudinal Study sample consisted of infants predominantly formula fed, of a homogenous genetic, geographic and socio-economic status. The US Health Examination Survey was a national cross-sectional survey. The studies followed a descriptive

approach (describing how the children grew) and the children were measured once every three months (Hamill *et al.*, 1979). The WHO endorsed the reference for international use which helped with identification of child malnutrition and also allowed for international comparisons.

Over time, however, the adequacy of the NCHS/WHO reference in assessing child growth was questioned due to observations that healthy breastfed infants living in environments supporting achievement of genetic growth potential grew less rapidly and deviated significantly from the reference. Weight-for-age and weight-for-height z-scores of breastfed infants were found to deviate from that of the reference population from two to three months of age (Agostoni *et al.*, 1999; Victora *et al*, 1998; WHO, 1995**b**). The limitations of the NCHS/WHO reference were attributed to the fact that infants were measured once every three months (thus failed to capture the rapid changing growth pattern of this age group), the sample population was small and homogenous, infants were predominantly formula fed and the analytical methods available at that time were inadequate for developing an international child growth reference. This deviation of the growth patterns of healthy breastfed children was considered to be sufficient to lead health workers to faulty decisions like premature introduction of complementary feeds or supplementation with other milks (Victora *et al.*, 1998; WHO, 1995**b**). In poverty-stricken communities where the burden of infectious diseases is high the consequences of such practices could be life threatening.

To address the limitations of the NCHS/WHO reference the World Health Assembly resolved that a new international child growth reference be developed. The new WHO child growth standards were then developed following a multi-country study which was specifically designed to develop child growth standards (De Onis *et al.*, 2004**a**; Garza & De Onis, 1999). The study followed a prescriptive approach where a large sample of breastfed children living in environments which did not hinder their genetic growth potential was studied. A longitudinal study design was employed for children younger than two years and a cross-sectional study design for children 18–71 months of age. In the longitudinal study children were measured every two weeks in the first two months of life and then monthly until 12 months old and thereafter every two months (De Onis *et*

al., 2004**a**; Garza, 2006). Studies comparing growth patterns of children based on the NCHS/WHO reference and the new WHO child growth standards found that healthy breastfed infants tracked along the WHO standards while appearing to falter on the NCHS/WHO reference. It was further observed that stunting and obesity increased for all age groups when assessed by the new WHO standards, while underweight reduced mainly in infancy (De Onis *et al.*, 2006; Nuruddin *et al.*, 2009).

2.3.3 Relevance of child growth in human health

Among all age groups children are especially vulnerable as demonstrated by the high number (11 million a year worldwide) of them dying in the first five years of life (Black *et al.*, 2008; UNICEF, 2008). As alluded to in Section 2.2.1, child growth can be disrupted by nutritional deficits/excesses and illnesses, making monitoring of child growth an important aspect of ensuring good health. Although growth attainment on its own is not sufficient to evaluate the health of an individual child adequately, it does provide a good indication of attainment of well-being (WHO, 1995**b**). Since children and infants are particularly vulnerable to ill-health and poverty, nutrition assessment of their growth provides a 'sentinel' indicator of the health and socio-economic development or status of the communities in which they live. An example of this is the use of child underweight as an indicator for attainment of the first Millennium Development Goal (MDG1) which is to reduce extreme poverty and hunger by half by 2015 (UN, 1990**a**). The prenatal period and early childhood are increasingly recognized as critical stages for development of undernutrition (Maleta *et al.*, 2003; Shrimpton *et al.*, 2001) and obesity (Chomtho *et al.*, 2008; Dietz, 1994). The World Bank highlights the 'window of opportunity' (period between prenatal through to two years of life) as a crucial period in which efforts to reduce child malnutrition are most likely to be effective (World Bank, 2006).

2.4 THE NUTRITION TRANSITION

Nutrition transition refers to major changes in dietary composition and physical activity levels in societies resulting in changes in the nutritional profile (stature and body composition) of the human populations (Popkin, 2006). The nutrition transition is reported to follow two other important shifts, namely the demographic and the epidemiological transition. The demographic transition denotes a shift from a state of high birth and death-rates to a state where birth and death-rates are low (Omran, 2005). Epidemiological transition on the other hand refers to a shift from a pattern where diseases associated with undernutrition, poor sanitation, famines and unsafe environment are prevalent to one where noncommunicable diseases (NCDs) like obesity, cardiovascular diseases and diabetes mellitus are more prevalent (Olshansky & Ault, 1986). Factors associated with the nutrition transition include urbanization, economic growth, improved technology, population growth and acculturation. Popkin (2006) described the historical patterns of the nutrition transition as:-

Pattern 1	**Collecting food**; characterised by hunter-gatherer populations who ate diets high in carbohydrate and fibre but low in fat
Pattern 2	**Famine**; periods where acute hunger, starvation were prevalent with minimal variety in the diet
Pattern 3	**Receding famine**; characterised by increased consumption of fruits and vegetables and reduced dependency on staple foods
Pattern 4	**Degenerative diseases**; where there is increased availability of cheap foods which are high in fat and refined carbohydrates but low in fibre
Pattern 5	**Behavioural changes**; health awareness resulting in adoption of healthier eating patterns and physical activity leading to successful aging.

What is of concern, however, is the rapid shift from receding famine (Pattern 3) to a pattern characterized by degenerative diseases (Pattern 4) resulting in a state where obesity and NCDs become national public health problems while undernutrition-related infections remain at unacceptably high levels in developing countries (Popkin, 2002;

Popkin & Gordon-Larsen, 2004). These societies are said to suffer with the double burden of morbidity and mortality. In SA, this state of the double burden of morbidity and mortality is further worsened by the Human Immunodeficiency Virus/Acquired Immuno Deficiency Syndrome (HIV/AIDS) pandemic and related infections (Zwang *et al.*, 2007; Welz *et al.*, 2007). South Africans, especially those in urban areas, are found to be shifting from their traditional plant-based diets to more energy dense Western diets as well as adopting more sedentary lifestyles (Kruger *et al.*, 2005; Steyn *et al.*, 2006).

2.5 NUTRITIONAL STATUS OF PRESCHOOL CHILDREN

2.5.1 Introduction

This section will review literature on the global and national prevalence of anthropometric child malnutrition (wasting, underweight, stunting and overweight/obesity). Another form of child malnutrition of public health concern is hidden hunger, which refers to micronutrient deficiencies. Those of great public health concern include iron, vitamin A, iodine, folic acid, calcium and zinc deficiencies. Most undernourished children in developing countries, including SA, would suffer from a combination of micronutrient and macronutrient deficiencies (Black *et al.*, 2008; Sanghvi *et al.*, 2007). For the purposes of this literature review hidden hunger will not be discussed further.

2.5.2 Prevalence of childhood malnutrition

2.5.2.1 *Global Prevalence*

Globally, undernutrition was known to affect mostly children in developing countries while overweight and obesity affected mostly children in developed countries. There has been a gradual decrease in childhood undernutrition (anthropometric) worldwide though this decrease was not consistent in all UN regions and sub-regions (De Onis *et al.*, 2000). It was estimated that 33% of children younger than five years in developing countries were stunted in 2000. This was a decrease by 40 million children from a prevalence of

47.1% in 1980 (De Onis *et al.*, 2000). Of all the developing regions Africa was estimated to have the highest prevalence of childhood stunting (35.2%) though there were some sub-regional variations with Western Africa having the highest (34.9%) and North Africa having the lowest (20.2%) prevalence (De Onis *et al.*, 2000). In terms of numbers, South Asia had the largest number of stunted children. In another study De Onis *et al.* (2004**b**) estimated that globally childhood underweight will reduce from 26.5% in 1990 to 17.6% in 2015, a reduction of 50.4 million children aged younger than five years. Childhood underweight was, however, estimated to increase in Africa from 24.0% to 26.8% by the year 2015. The prevalence of childhood underweight was estimated to be 0.9% and 19.3% in developed and developing countries respectively in 2015 reflecting a big gap between the developed and developing world (De Onis *et al.*, 2004**b**).

Establishment of the WHO global database on child growth and development as a method to estimate global trends in child malnutrition have facilitated tracking of the nutritional status of children (De Onis & Blössner, 2003; Svedberg, 2006). These two studies reported comparable changes in child stunting (from 34% to 24%) and underweight (from 27% to 21%) globally between 1990 and 2005 (De Onis *et al.*, 2004**b**; Svedberg, 2006). Table **2.1** shows recent estimates of child undernutrition based on the new WHO child growth standards in 2005. About 32% (178 million) of children younger than five years in developing countries were stunted (Black *et al.*, 2008). Though this estimate suggests an increase in stunting this may be an artefact of the change in the reference population used. Globally 36 countries accounted for 90% of all stunted children, SA included (Black *et al.*, 2008). In Sub-Saharan Africa male preschool children are found to be more likely to be stunted when compared with their female counterparts. This was found to be more pronounced in children of the lowest socio-economic status group (Wamani *et al.*, 2007).

Table **2.1** Global estimates of childhood undernutrition based on the World Health Organisation child growth standards (Adapted from Black *et al.*, 2008)

		Children <5 years in millions	Percentage stunted (95% CI)	Percentage severely wasted (95 % CI)	Percentage underweight (95 % CI)
Africa		141 914	40.1 (36.8-43.4)	3.9 (2.2-5.7)	21.9 (19.8-24.0)
	Eastern	48 807	50.0 (42.3-57.9)	3.6 (1.5-8.4)	28.0 (23.6-32.9)
	Middle	20 197	41.5 (38.3-44.8)	5.0 (2.0-12.0)	22.5 (19.2-26.1)
	Northern	22 171	24.5 (17.3-33.9)	3.3 (1.2-8.9)	6.8 (2.8-15.3)
	Southern	6 075	30.2 (25.4-35.6)	2.7 (1.0-6.8)	11.4 (8.0-15.7)
	Western	44 663	37.7 (33.5-42.1)	4.3 (1.8-9.6)	23.9 (21.0-26.9)
Asia		356 879	31.3 (27.5-35.1)	3.7 (1.2-6.2)	22.0 (18.5-25.6)
	Eastern	95 070	14.5 (13.5-15.5)	0.7 (0.3-1.6)	5.1 (4.8-5.4)
	South-central	181 481	40.7 (34.2-47.7)	5.7 (2.4-12.8)	33.1 (26.6-40.3)
	South-eastern	54 970	34.3 (26.5-43.5)	3.6 (1.4-8.8)	20.7 (17.2-24.6)
	Western	25 358	20.6 (10.0-38.8)	1.6 (0.4-5.8)	8.9 (2.8-24.2)
Latin America		56 936	16.1 (9.4-22.8)	0.6 (0.2-1.0)	4.8 (3.1-6.4)
Developing regions		555 729	32.0 (29.3-34.6)	3.5 (1.8-5.1)	20.2 (17.9-22.6)

CI: confidence interval

Variations in the definition of childhood obesity in epidemiological studies have led to difficulties in international comparisons (Ng & Lai, 2004; Lobstein *et al.*, 2004). Prior to 2006, two different international criteria were used to define child obesity and overweight; weight-for-height assessed against the NCHS/WHO reference and BMI for age assessed against the International Obesity Taskforce reference which was developed following concerns with the NCHS/WHO reference (Cole *et al.*, 2000). The new WHO child growth standards are also now available for use (WHO, 2006**a**).

Childhood obesity was originally known to be a problem of developed countries where children are continually reported to be above their expected weight-for-height (Dehghan *et al.*, 2005; Hedley *et al.*, 2004; Wang & Lobstein, 2006). Martorell and colleagues (2000) found overweight and obesity (defined as weight-for-height >1 SD and >2 SD respectively) in preschool children to be low in some developing countries in Asia and SSA. Childhood overweight and obesity were, however, found to be high in some

developing countries in Latin America, the Caribbean, Middle East and North Africa at levels comparable to those found in the USA. In another study De Onis and Blössner (2000) found childhood overweight (weight-for-height >2 SDs) to be 3.3% (17.5 million preschool children) in developing countries, while wasting was 2.5-3.5 times higher than overweight rates. In this study, however, obesity was found to be higher (6.5%) in Southern Africa compared to other studied African UN sub-regions, an observation attributed to the influence of higher child overweight rates in South African children (De Onis & Blössner, 2000).

The WHO (WHO, 2009**a**) estimated that in 2007 22 million children under the age of five years were overweight worldwide, of which more than 75% lived in low and middle-income countries. Another observation of concern is that in low and medium-income countries obesity is increasing at rates more rapid than it did in high-income countries (Dieu *et al.*, 2009; Popkin & Gordon-Larsen, 2004). In developed countries children of lower socio-economic status (Cecil *et al.*, 2005; Kleiser *et al.*, 2009) and certain ethnic groups like African-American and Hispanic children in the USA (Lobstein *et al.*, 2004; Ogden *et al.*, 2006) are reported to be most affected. In developing countries on the other hand, childhood obesity is most prevalent among the rich and in urban areas (Lobstein *et al.*, 2004; Sakamoto *et al.*, 2001). In older children girls are found to be at higher risk of childhood obesity than boys (Lobstein *et al.*, 2004; Irigoyen *et al.*, 2008), but results are inconsistent in preschoolers (Blomquist *et al.*, 2007; Jinabhai *et al.*, 2007).

2.5.2.2 Prevalence in South Africa

Table **2.2** shows the prevalence of child malnutrition in South African children. National data suggest that the anthropometric status of the children has changed minimally over the past 15 years. Though the studies differed in study design, stunting is reported as the most prevalent adverse anthropometric outcome followed by combined overweight and obesity in children younger than nine years (SAVACG, 1996; Labadarios *et al.*, 2005**a**; Labadarios *et al.*, 2008). Based on the WHO criteria for assessment of severity of undernutrition in a population (Gorstein *et al.*, 1994), the most recent report of 18% stunting, 9.3% underweight and 4.5% wasting implies that nationally undernutrition is of

low severity. There is currently no criterion for assessment of severity of childhood overweight or obesity in populations. National prevalence of child malnutrition, however, masks the variations in the nutritional status of the children by age group and area of residence. Children aged 1-3 years are consistently found to be most affected by both forms of malnutrition (Figure **2.1**). Children living in rural areas, especially rural formal areas, are most affected by undernutrition. Overweight and obesity are more prevalent in children living in urban areas (Labadarios *et al.*, 2008).

Table **2.2** Prevalence of child malnutrition in South African children over the past 15 years (SAVACG, 1996; Labadarios *et al.*, 2005**a**; Labadarios *et al.*, 2008)

ATHROPOMETRIC PARAMETER	SAVACG[γ] (1994)	NFCS † (1999)	NFCS:FB-I† (2005)
Height-for-age			
< -2 SDs	22.9 %	21.6%	18.0%
< -3 SDs	6.6%	6.5%	5.1%
Weight-for-age			
< -2 SDs	9.3%	10.3%	9.3%
< -3 SDs	1.4%	1.4%	1.0%
Weight-for-height			
< -2 SDs	2.6%	3.7%	4.5%
< -3 SDs	0.4%	0.8%	1.0%
Body mass index			
25-30 kg/m^2	Not reported	12.1%*[a]	10.0%#
≤ 30	Not reported	5.0%*[a]	4.0%#

SD: Standard deviation;
SAVACG: South African vitamin A consultative group
NFCS: National food consumption survey
NFCS: FB-I: National food consumption survey fortification baseline
[γ]Results for children aged 6-71 months
*Results for children aged 1-8 years
†Results for children aged 1-9 years
Results for children aged 12-71 months
#[a]Results from Steyn *et al.*, 2005

Small scale studies in various parts of SA generally report results which are different from the national prevalence in both under and overnutrition. In a study of preschool children living in an informal settlement in Bloemfontein undernutrition was above the

national prevalence with stunting, underweight and wasting affecting 22-29%, 19-20% and 4-7% of the preschool children respectively (Dannhauser *et al.*, 2000). On following a cohort of Black infants in rural Limpopo Province, Mamabolo and researchers (2004) reported that 9.6%, 48.9% and 7.3% of the children were stunted, underweight and wasted respectively at birth. By three years of age 48%, 9%, 1%, 18% and 24% were stunted, underweight, wasted, overweight and obese respectively (Mamabolo *et al.*, 2005). Faber *et al.* (2001) observed results similar to national prevalence of undernutrition but not obesity in 2-5 year olds living in a rural area in KZN Province. In a large sample of preschool children of the poorest areas of KZN and EC Provinces, Smuts *et al.* (2008) found stunting to be of concern especially in children over 12 months while obesity was highest in infants.

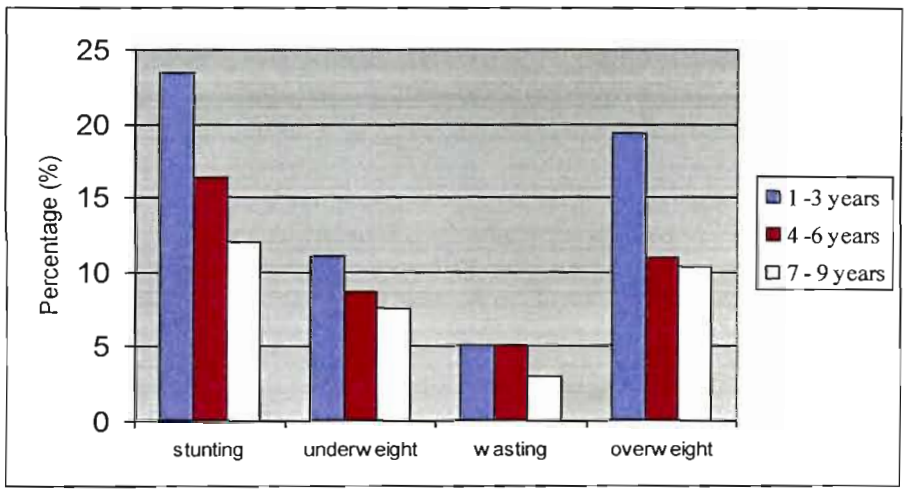

Figure **2.1** Anthropometric status of South African children aged 1-9 years by age group (Labadarios *et al.*, 2008)

This literature review highlights that undernutrition coexists with overnutrition in South African children. Jinabhai *et al.* (2005) reported similar observations in children aged 2-11 years residing in KZN province; an increase in overweight and obesity while stunting remained high over a period of five years. This observed state of coexistence of under and overnutrition is termed 'the double burden of malnutrition' or the nutrition paradox and it is believed to be one of the consequences of the nutrition transition. National data

from other middle and upper-low-income countries like China (Doak *et al.*, 2002), Brazil (Monterio *et al.*, 2004) and Pakistan (Jafar *et al.*, 2008) also reported this paradox.

Epidemiological studies globally also report observations of this double burden of malnutrition in the same household where any two members of the household (Doak *et al.*, 2002; Doak *et al.*, 2005) or mother-child-pairs (Barquera *et al.*, 2007; Garrett & Ruel 2005; Jehn & Brewis 2009) suffer with opposite forms of malnutrition. There is currently no national data on this occurrence in SA. Both forms of malnutrition can occur in the same child (Fernald & Neufeld, 2007; Mamabolo *et al.*, 2005) and stunted children are found to be especially at risk of obesity (Hoffman *et al.*, 2007; Kruger *et al.*, 2004). The mechanisms of why stunted children are at risk of overweight/obesity are still largely unknown, but early life metabolic programming and impaired fat oxidation are suggested (Hoffman *et al.*, 2000; Wells, 2007). What is of interest is that, globally, in poor countries the double burden affects mostly people in the upper quintile of the socio-economic status while in middle-income countries and high-income countries the poorest of those societies are most affected by the double burden of malnutrition (Monterio *et al.*, 2004; Armstrong & Reilly., 2003).

2.6 CONSEQUENCES OF CHILD MALNUTRITION

2.6.1 Introduction

The detrimental effects of child malnutrition include short-term consequences like increased risk of mortality and morbidity as well as more long-term consequences like reduced economic productivity and increased risk of NCDs later in life (Black *et al.*, 2008). Most research on the consequences of childhood undernutrition was done in developing populations while at the time of writing this review, research on childhood overweight and obesity was mostly done in developed countries.

2.6.2 Increased risk of morbidity

The relationship between nutrition and immunity has long been recognized and as research evolved both under and overnutrition are now reported to relate with immunity

in a vicious cycle (Keusch, 2003; Solomons, 2007). Undernutrition (anthropometric) may increase the incidence and severity of infections like diarrhoea, malaria, HIV and respiratory disease by impairing the immune function (Bejon *et al.*, 2008; Fillol *et al.*, 2009). Increased infections will in-turn worsen undernutrition by increasing nutritional needs and nutrient loss, and reducing nutrient intake (Garza, 2005). Black *et al.* (2008) estimated that percentage of disability-adjusted life-years (DALYs) lost in children younger than five years due to anthropometric undernutrition is 52.1% (18.7% underweight, 12.6% stunting, 14.8% wasting). Of the percentage of DALYs lost due to wasting 6% was due to severe wasting. In SA protein and energy malnutrition in children aged 0-4 years was estimated to contribute 44.7% of the total disease burden in 2000 (Nannan *et al.*, 2007).

Though the complications of childhood obesity are anticipated to be more pronounced in later life there are observations of increased risk of hypertension, dyslipidaemia and hyperinsulinimia in obese children, in some as early as 3-5 years (Belfort *et al.*, 2007; Burke *et al.*, 2005**a**; Weiss *et al.*, 2004). There is an alarming increase in type 2 diabetes mellitus in children concurrent with increase in childhood obesity (Craig & Huang, 2009; Sinha *et al.*, 2002). Epidemiological studies reported an association between asthma and obesity in children though it has been difficult to determine the temporal order of the association (To *et al.*, 2004; Von Mutius *et al.*, 2001). Carroll *et al.* (2007) reported an increased risk of hospital admissions due to asthma exacerbations in obese children compared to those of normal weight. Another pulmonary complication of obesity is apnoea/disordered breathing (Redline *et al.*, 1999; Sulit *et al.*, 2005). Obese children are often reported to have poor quality of life and in a study of obese American children and adolescents the participants rated the quality of their lives to be low at levels comparable with that of children with cancer (Schwimmer *et al.*, 2003). Other complications of childhood obesity include glomerulosclerosis (Adelman *et al.*, 2001), Blount's disease (Parsons *et al.*, 2007) and gallstones (Friesen & Roberts, 1989).

2.6.3 Susceptibility to noncommunicable diseases later in adulthood

There is growing evidence that development of obesity and a number of NCDs start in early childhood. Over the past two to three decades research has reported that poor growth in utero and/or accelerated early childhood weight gain is associated with changes in metabolism resulting in increased risk of adult obesity (Chomtho *et al.*, 2008; Jones-Smith *et al.*, 2007; Sayer *et al.*, 2004), type 2 diabetes (Wang & Lobstein *et al.*, 2006; Yajnik, 2009), high blood pressure (Law *et al.*, 2002; Sesso *et al.*, 2004) and cardiovascular disease (CVD) (Burke *et al.*, 2005**a**; Painter *et al.*, 2006). This is known as early programming (Barker *et al.*, 1993). Childhood obesity is reported to track into adolescence and adulthood in some individuals (Burke *et al.*, 2005**a**; Whitaker *et al.*, 1997), while stunted children are especially at higher risk of obesity in later life (Popkin *et al.*, 1996; Sawaya *et al.*, 2004).

Research on how early life nutrition affects adult risk of NCDs is ongoing but some primary pathways have been suggested. The first one is that poor growth during foetal and infancy permanently constrain lean mass resulting in impairment in metabolic capacity to tolerate high energy/fat diets later in life. The second pathway is that rapid weight gain in early life may divert energy disproportionally to the adipose tissue preferably abdominal, resulting in increased metabolic load. Lastly an oversupply of nutrients in utero can impair appetite and energy metabolism in the child resulting in increased obesity and subsequent NCDs in later life (Wells, 2007).

2.6.4 Increased risk of mortality

Risks of mortality due to under- and overnutrition vary in terms of timing and cause of death. Since standardization of methodology estimating contribution of undernutrition to mortality by Pelletier *et al.* (1994), undernutrition is found to potentiate 50-60% of childhood deaths. These deaths are mostly due to mild-to-moderate undernutrition since these are the most numerous when compared to severe cases of undernutrition (Caulfield *et al.*, 2004; Garenne *et al.*, 2006). This contribution of undernutrition to child mortality was found by Bejon *et al.* (2008) to be similar with that seen caused by diseases like

gastroenteritis, HIV/AIDS, severe malaria and invasive bacterial disease. Black *et al.* (2008) estimated that child undernutrition (underweight, stunting and wasting) was responsible for five million (48.1%) childhood deaths in 2005 worldwide. Of the three adverse anthropometric outcomes underweight was found to be responsible for the largest disease burden. In SA Nannan *et al.* (2007) reported that just under 12 000 (12.3%) deaths in children aged below four years was attributable to underweight.

Childhood mortality due to the potentiating effect of obesity is not known. Overweight/obesity, however, contribute significantly to the increased adult mortality due to cardiovascular disease and other NCDs (Dietz, 1998; Gunnell *et al.*, 1998). Cardiovascular disease, a cluster of diseases, has always been a major killer in most developed countries but it is now found in unacceptably high levels in developing countries. In SA, NCDs were reported as prominent causes of death in middle-aged adults during the pre-HIV era (Tollman *et al.*, 2008). Despite the observed rise in mortality due to HIV/AIDS, tuberculosis (TB) and related infections, mortality from NCDs remain evident in SA adult population (Tollman *et al.*, 2008).

2.6.5 Decreased economic productivity

Child undernutrition can affect human capital in three main ways namely, by impairing cognitive development, reducing lean body mass and/or short stature and increasing costs due to health and social support services. About 200 million children in developing countries fail to attain their full development potential due to undernutrition (Grantham-McGregor *et al.*, 2007). Undernourished children are reported to either enrol late at school or not enrol at all (Beasley *et al.*, 2000; Brooker *et al.*, 1999), have a lower intelligence quotient (Emond *et al.*, 2007; Liu *et al.*, 2003) and attain lower academic grades for their age (Mendez & Adair, 1999; Themane *et al.*, 2003). Stunting between 1-3 years could result in lower school grade attainment in adulthood and reduced life time earnings (Victora *et al.*, 2008).

Poor anthropometric outcome, especially stunting, may result in reduced productivity in labour intense jobs resulting in reduced earnings later in adulthood (Haas, 2006; Victora