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THE ANTHROPOMETRIC NUTRITIONAL STATUS OF CHILDREN 0-18 YEARS OLD IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA: A SYSTEMATIC REVIEW

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SUBMITTED: JULY 2011

University of Cape Town

A mini-dissertation submitted to the Health Sciences Faculty, University of Cape Town, in partial fulfilment of the requirements for the degree of Master in Public Health

Cape Town, 2011

DECLARATION

I Solange Durão, student No. DRXSOL001, declare that work that I have submitted is my own and where the work of others has been used (whether quoted verbatim, paraphrased or referred to) it has been attributed and acknowledged.

Signature _____

Date _____

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PART A: PROTOCOL

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I. PROTOCOL EXECUTIVE SUMMARY

"Maternal and child undernutrition is the underlying cause of 3.5 million deaths, 35% of the disease burden in children younger than 5 years and 11% of total global Disability Adjusted Life Years (DALYs) lost"[1]. In South Africa, both under and overnutrition contribute to the health burden significantly [2-4].

Malnutrition is associated with serious short- and long-term consequences for children's health and development, as well as for their and the country's economic well-being and welfare [1, 5, 6]. Therefore, it is paramount to ensure the good nutritional status of all individuals within a country. In order to achieve this, an assessment of the situation is necessary.

Variability of the nutritional status of children across the different provinces affects prioritization and allocation of resources[7]. The Western Cape Department of Health, Directorate: Nutrition thus commissioned a study from the Department of Dietetics at the University of the Western Cape to use existing data to assess the nutritional status of infants, children, and adolescents residing in the Western Cape Province. Since a number of surveys and studies have already been done, a systematic review of published and unpublished studies that have measured nutritional status is appropriate. This will enable the determination of the prevalence of stunting, wasting, underweight, overweight, and obesity in 0-18 year olds residing in the Western Cape.

The systematic literature search will be conducted for articles published between January 1997 and May 2010, with primary data on the anthropometry of healthy children 0-18 years of age in the Western Cape province of South Africa. The search will be conducted through EbscoHost on MEDLINE, HealthSource (academic edition), CINAHL, and Academic Health File databases. An additional search of the Sabinet database will be done. Initially, studies will be screened on the basis of title, where after abstracts and full-texts will be sought. Articles meeting inclusion and exclusion criteria will be included in the review. In addition, reference lists of included articles will be hand-searched for other relevant articles. The quality of each study will be assessed using predetermined criteria. Individual researchers and academic and governmental institutions will be contacted in order to identify any unpublished studies with relevant anthropometry information.

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This review will employ systematic methods for study selection and quality assessment, which decrease the probability of bias[8]. The integration of data from individual studies also increases the precision of the results[9]. Thus, the review will aim to produce valid and reliable evidence for health-care decision-making and policy planning aimed at improving the nutritional status of children in the province.

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II. INTRODUCTION

1. Problem Statement

Malnutrition

"Maternal and child undernutrition is the underlying cause of 3.5 million deaths, 35% of the disease burden in children younger than 5 years and 11% of total global Disability Adjusted Life Years (DALYs)"[1].

In South Africa the situation hasn't improved significantly over the last decade, and for some indicators it has actually worsened. The 1994 study by the South African Vitamin A consultancy Group (SAVACG) showed a prevalence of stunting of 11.6% and 22.9% at the national level and in the Western Cape respectively; that of underweight was 9.3% and 7%, and that of wasting was 2.6% and 1.3%. The National Food Consumption Survey (NFCS) was a nationwide survey aimed at determining the nutritional status of children in South Africa, as well as its determinants, and it was performed in 1999 and 2005. The 1999 data were adjusted for oversampling of high-risk areas. According to these surveys[2, 3] the national prevalence of stunting in children 1-9 years of age improved slightly from 19.3% in 1999 to 18% in 2005. On the other hand the prevalence of underweight and wasting increased respectively from 8.8% and 3.3% in 1999 to 9.3% and 4.5% in 2005. Worse prevalences are described for rural areas in both the 1999 and 2005 NFCS's. According to the 2005 NFCS, the prevalence of wasting in the Western Cape Province has increased dramatically since 1999, from 1% to 11.5%.

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In adolescents (13-19 year olds), the 2002 Youth Risk Behaviour Survey (YRBS)[4] indicated that nationally the prevalence of stunting and underweight was 11% and 9%, respectively. The prevalence of stunting (9.5%) and underweight (6%) in adolescents in the Western Cape was lower than the national average.

With regards to overnutrition, the 1999 NFCS showed that 19% of children 1-9 years old were overweight or obese[2], and the figure in the 2005 National Food Consumption Survey-Fortification Baseline showed a decrease to 14%[3] based on the BMI-age cut-off points. According to the 2002 YRBS[4] the prevalence of overweight teenagers in the Western Cape (21.5%) was greater than the national average.

Undernutrition is associated with serious short- and long-term consequences for children's health and development as well as for theirs and the country's economic well-being and welfare[1, 5, 10]. Malnutrition weakens the immune system, enhancing the susceptibility to and the severity of illness, especially of infections, thereby greatly increasing mortality risk. In 2000, underweight accounted for 12.3% of all deaths in children younger than 5 years old in South Africa, and 38.3% of deaths were attributed directly to malnutrition[10]. In addition, children under the age of two may suffer irreversible physical and cognitive damage which adversely affects not only their future health, but also their economic welfare[1, 5]. Long term consequences of stunting include lower adult educational attainment, lower adult income, and lower stature in adults, affecting productivity and therefore earnings of those working in manual labour[6]. Furthermore, the risk of developing chronic diseases increases when stunting, severe wasting and intrauterine growth restriction (IUGR) are followed by rapid weight gain in the 3-5 year age range[11-13]. This phenomenon is observed in countries undergoing the nutrition transition, such as South Africa.

Given these consequences of malnutrition it is obvious that the goal of improving the nutritional status of individuals within a country is paramount. In order to achieve this, an assessment of the situation is necessary. The nutritional status of children in South Africa has been shown to vary significantly between the provinces as well as within each province, which affects prioritization and resource allocation[7]. Even though national studies have measured the prevalence of malnutrition in South Africa, they have not included sufficient numbers of participants from each province. The Western Cape Department of Health in South Africa thus commissioned a study from the Department of Dietetics at the University of the Western Cape to use existing data to assess the nutritional status of children 0-18 years old residing in the Western Cape Province. This will provide evidence to aid planning and evaluation of implementation of nutritional interventions in communities and primary health care clinics, at the provincial level.

In order to accomplish this, a systematic review of published and unpublished literature will be conducted. Relevant databases will be used to search for all articles with anthropometric data on children 0-18 years of age from the Western Cape Province published from January 1997 to May 2010. Inclusion and exclusion criteria will determine which studies will be included in the review. The quality of each study included will be determined through pre-specified methodological criteria such as participant selection and measurement of outcomes, among others. These systematic methods for locating studies and extracting and synthesising data are important because they

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decrease the probability of selection and measurements bias, while the pooling of data from individual studies also increases the precision of the estimates obtained[8]. Thus, valid and reliable evidence may be derived for making health-care related decisions.

Systematic reviews also allow the use of statistical methods to summarize the results from independent studies, which ensures that decisions are based on the entirety of the evidence available at a particular point in time[9]. However, it is not always feasible to do this. It depends on whether the studies are sufficiently homogeneous in their methods, participant selection, and outcomes analysed. A meta-analysis will be performed if the data allows. Similar meta-analytical methods can be used in a systematic review for the orderly sorting of data[8].

2. Rationale for the study

The nutritional status of children in South Africa varies significantly between the provinces as well as within each province, which affects resource prioritization and allocation[7]. Although the national surveys provide a picture of the nutritional status of children and adolescents in the country they might not be sufficiently representative of each province owing to the small number of participants per province.

Therefore research is needed to provide a clearer picture of the anthropometric nutritional status of infants, children and adolescents in the Western Cape Province. Since a number of surveys and studies have already been done, a systematic review of published and unpublished studies that have measured nutritional status in this particular population is appropriate.

3. Aim

To review published and unpublished literature to determine the prevalence of underweight, stunting, wasting, overweight and obesity in infants, children and adolescents (0-18 years old) in the Western Cape Province.

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I. METHODS

1. Study design

A systematic review of studies measuring the nutritional status of children in the Western Cape Province will be carried out. Meta-analysis, i.e. pooling of estimates, will be performed if appropriate.

2. Search strategy

A systematic literature search will be conducted for articles published between January 1997 and May 2010 with primary data on the anthropometry of healthy infants, children and adolescents (0-18 years of age) in the Western Cape Province. Vorster et al. conducted a review of the literature published from 1975-1996 to determine the nutritional status of South Africans, which is the reason this review will be using articles published from 1997 onwards.

The search will be conducted through EbscoHost on the following databases: MEDLINE, HealthSource (academic edition), CINAHL, and Academic Health File. An additional search of the Sabinet database will be done.

Initially, studies will be screened on the basis of title, whereafter, abstracts and full-texts will be sought. Articles meeting inclusion and exclusion criteria will be included in the review. In addition, reference lists of included articles will be hand-searched for other relevant articles.

If any articles are found that are not in English, an attempt will be made to translate them and include them in the review.

For data extraction, full text articles are preferred; however, articles with abstracts containing sufficient information will also be included. A table detailing which studies were excluded as well as the reason for exclusion will be compiled.

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Keywords to be used include:
(malnutrition OR undernutrition OR overnutrition OR underweight OR overweight OR obese OR stunted OR stunting OR wasting OR wasted OR "nutritional status" OR anthropometry)
AND (children OR adolescents OR infants) AND ("South Africa" OR "Western Cape")

Individual researchers and academic and governmental institutions will be contacted in order to identify any unpublished studies/datasets with relevant anthropometric information. Authors or institutions will be contacted for details of study design and method in case these are unclear.

3. Inclusion and exclusion criteria

The following inclusion and exclusion criteria will be used to identify relevant studies. Broad inclusion criteria with regards to study design will be used to ensure that all possible studies are included in the review.

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Inclusion criteria

- Any study with anthropometric data from the Western Cape Province will be included. All study designs will be included; baseline data from intervention or cohort studies will be used.
- Study population comprising infants, children or adolescents (0-18 years old).
- Studies published from January 1997 to May 2010.
- Studies with primary data on weight and height, or secondary analysis of anthropometric data.
- Anthropometric indices evaluated according to weight-for-age, weight-for-height, height-for-age, or BMI-for-age percentiles or z-scores using the National Centre for Health Statistics/ World Health Organization (NCHS/WHO) reference population. This growth reference has been adopted by WHO for international use[14]. More recent international growth references exist; however, since this review will include articles published since 1997 it is more likely that they have made use of the previous NCHS/WHO growth reference. Therefore, using this growth reference will ensure continuity of the reference population used for comparison of anthropometric indicators.
- Studies that have used the International Obesity Task Force[15] classification for BMI-for-age will also be included.

Exclusion criteria

- Study population older than 18 years of age.
- Studies that assess nutritional status only through biochemical, clinical and dietary measurements.
- Studies using a reference population other than the NCHS/WHO's for the evaluation of the anthropometric indicators.
- Studies assessing the nutritional status of children with a particular disease.

4. Data extraction

Following the identification of all studies eligible for inclusion, the relevant information will be summarized in table format. An Excel spreadsheet will be used to capture qualitative and quantitative data about the methods, participants, and outcomes of each study; this information will be used to describe the studies and to rate their quality (Appendix A).

Another reviewer will assess each study to check whether it meets the inclusion criteria, and will also extract the pertinent data and perform a quality assessment of each study. Both reviewers will discuss any discrepancies in article selection, data extracted or quality rating, and attempt to reach a consensus.

Anthropometric data to be extracted will be either in the form of means and standard deviations or of proportion of participants below and/or above a cut-off point for each anthropometric index i.e. weight-for-age, height-for-age, weight-for-height, and BMI-for-age (Table 1). This will be determined by the reporting format of choice of the included articles.

Published and unpublished data will be entered in same format. However, it is probable that there will be more missing information from unpublished studies; in this case the authors will be contacted to clarify any methods issue that is unclear.

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5. List and definition of variables

This study will measure only the anthropometric nutritional status. Although anthropometry alone does not provide a complete picture of the nutritional status situation it is still useful because it reflects inadequate or excessive food intake, growth of children, and overall health and welfare[16]. It is also the single most portable, universally applicable, inexpensive and non-invasive method to obtain information on nutritional status, often used to evaluate the outcome of policies and nutrition intervention programs, or to select individuals whom should be targeted for such programs[14].

The anthropometric indices weight-for-age (W-a), weight-for-height (W-h), height-for-age (H-a), and BMI-for-age will be used to assess anthropometric nutritional status. Table 1 summarizes the characteristics of the outcome variables, including the anthropometric indicators.

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TABLE 1: Summary of variables

Variables	Type	Unit	Definition
Age	Continuous		
Gender	Categorical		Male/female
Weight	Continuous	Kg	
Height	Continuous	Cm	
BMI-for-age	Ordinal	z-score cut-off or Percentile cut-off	<-3SD: severe wasting <-2SD: wasting -2SD>BMI-a<2SD: Normal >2SD/>95th p: overweight >3SD: obese
W-a z-score (WAZ)	Ordinal	Z-score cut-off	<-3SD: severely underweight <-2SD: underweight -2SD<WAZ<1SD: Normal weight >2SD*****
W-a percentile (WAP)	Ordinal	Percentile cut-off	<3rd percentile: underweight 3rd>WAP<95th p: normal w-a >95th percentile: overweight
H-a z-score (HAZ)	Ordinal	Z-score cut-off	<-3SD: severe stunting <-2SD: stunting -2SD<HAZ<2SD: Normal h-a >2SD******
H-a percentile (HAP)	Nominal	Percentile cut-off	<3rd p: stunting
W-h z-score (WHZ)	Ordinal	Z-score cut-off	<-2SD: wasted <-3 SD: severely wasted -2SD < WHZ < 2SD: Normal >2 SD: overweight >3 SD: obese
W-h percentile (WHP)	Ordinal	Percentile cut-off	<3rd p: wasting 3rd p<WH<95th p: normal >95th p: overweight

*WAZ>1 SD may indicate growth problems. However, this is better assessed through BMI-for-age or Weight-for-Height/Length. **HAZ>2SD indicates that a child is very tall. Tallness is only problematic if it is associated with an endocrine disorder. This is beyond the scope of this study.

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6. Validity and Reliability: Quality Assessment

A quality assessment of the included studies will be performed. The studies will be rated according to the number of quality criteria met. These are based on criteria established for identifying good observational studies according to the quality of their reporting on methods and results[17, 18]. They are as follows:

I. Has the study specified its target population and setting (geographical area, gender, age, ethnicity), with appropriate eligibility (inclusion and exclusion) criteria?
II. Have adequate sampling methods been used? Random sampling is considered the best, followed by cluster random sampling, if the methodology has been appropriately described and cluster effect taken into account. Convenience sampling is considered as not being representative of the general population.
III. Have the authors explained how the sample size was calculated and is the actual sample size of the study adequate?
IV. If the study is a survey: Has there been an adequate response rate? A response rate of 66-75% is deemed acceptable for population surveys. A low response rate signifies selective participation by one group more than the other and therefore increases probability of selection bias.
V. Are the definitions for anthropometric variables/indicators valid and repeatable? The classification of anthropometric measurements according to W-a, W-H, H-a, and BMI-a need to be according to NCHS/WHO reference population and based on z-scores or percentiles.
VI. Have fieldworkers/staff been trained in the appropriate protocol for performing anthropometric measurements?
VII. Have anthropometric measurements been performed using appropriately calibrated and reliable equipment? This is important to avoid measurement bias.
VIII. Have the statistical methods for the calculation of the z-scores or percentiles been described in sufficient detail?
IX. Is the number of participants clearly reported throughout each step of the study?
X. Are the baseline and socio-demographic characteristics of the participants described?

Results from individual studies will be stratified according to study quality, as determined by the above criteria, in order to assess whether the results differ significantly according to study quality.

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IV. ANALYSIS

The results will be stratified according to quality, i.e. according to how many criteria they meet, as well as by socio-demographic characteristics, such as area of residence, age, gender, and ethnicity, if data allow.

Epi Info 2000 will be used to analyse raw anthropometric data, i.e. weight and heights. Measurements will be compared with the NCHS/WHO 1978 reference population and for each child a Z-score will be calculated for W-a, W-H, and H-a. These indicators will be classified according to definitions described in Table 1 above.

Statistical software STATA version 8.0 will be used for exploratory data analysis as well as for calculating summary statistical measures for all anthropometric indicators.

The prevalence across the various studies will be reported (Appendix B: dummy table for presentation of results). A pooled prevalence measure will be calculated if there is sufficient homogeneity across the studies with regards to target population, intervention, comparison group, and outcomes measured.

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V. ETHICS AND COMMUNICATION

1. Ethics

This protocol will be submitted for ethics approval to the Human Research Ethics Committee of the Faculty of Health Sciences, University of Cape Town.

It is important to ensure that the use of unpublished data has been authorized. Therefore, authorization to use datasets obtained from individual researchers and institutions will be requested formally in writing. Only data for which authorization has been granted will be used in the review.

The final report will provide information that the Department of Health can use for planning interventions aimed at improving the nutritional status of infants, children and adolescents in the Western Cape Province. Therefore, it could have a positive impact on the welfare of communities and individuals.

2. Stakeholders

The final report will be circulated to all stakeholders namely, UWC, UCT, and the Western Cape Department of Health. Copies will also be sent to all individuals and institutions that provided datasets for inclusion in this project.

3. Reporting and implementation

The final report will be written up for publication in a peer reviewed scientific journal, according to the instructions for authors by publishers. A fully detailed report will be written up for the Western Cape Department of Health who originally requested the study.

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VI. LOGISTICS

This research project will be carried out on a part-time basis.

Internet access as well as to journal articles and other literature is made possible through the University of Cape Town and the University of the Western Cape libraries.

1. Timeline

TABLE 2
Timeline

	2010 week	May 1	2	3	4	June 1	2	3	4	July 1	2	3	4	August 1	2	3	4	September 1	2	3	4	October 1	2	3	4	November 1	2	3	4	December 1	2	3	4
ACTIVITY	Proposal Development	x	x	x	x	x	x	x	x	x	x	x	x																				
	Ethical Approval													x	x	x	x																
	Writing Literature review																	x	x	x	x	x	x	x	x								
	Literature review & Data search																					x	x	x	x	x	x	x	x				
	Analysis																															x	x

	2011 week	January 1	2	3	4	February 1	2	3	4	March 1	2	3	4	April 1	2	3	4	May 1	2	3	4	June 1	2	3	4
ACTIVITY	Analysis	H	H	x	x																				
	Writing Results and Discussion					x	x	x	x	x	x	x	x	x	x	x	x								
	Writing Journal article																	x	x	x	x				
	Editing and submission																					x	x	x	x

H: Holiday

2. Budget

Item	Total Cost
UCT MPH fees	ZAR 14,610.00
Stationery	ZAR 300.00
Printing	ZAR 200.00
Binding	ZAR 30.00
Total	**ZAR 15,140.00**

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VII. STRUCTURE OF DISSERTATION

The mini-dissertation will be comprised of the following parts:

- Part A: Protocol.
- Part B: General literature review. This section will serve to describe the current nutrition situation in South Africa and in the Western Cape, as well as the causes and consequences of malnutrition. Issues related to the validity and reliability of anthropometric measurements will also be reviewed.
- Part C: Systematic review. This is the research paper *per se*. It will include a description of the systematic review process as well as the presentation and discussion of the findings. It will be written according to the instructions for authors for publication.
- Part D: Appendices.

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IX. PROTOCOL APPENDICES

APPENDIX A

Dummy table: Data Collection Form										
Study ID	Reference	Study design	Participants and setting	Sampling methods	Response rate	Anthropometric measurements			Statistical methods	Reporting no. of participants
						Definitions and reference popn.	Training of fieldworkers	Measuring equipment		

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(cont. From above)

Dummy table: Data Collection Form													
Reporting of participants		Outcome measures: either mean±SD or no./proportion below/above cut-off point											
Numbers	Characteristics	W-a (Underweight)						H-a (stunting)					
		<-3SD	<-2SD	>2SD	>3SD	<3rd p	>95th p	<-3SD	<-2SD	>2SD	>3SD	<3rd p	>95th p

(cont. From above)

Dummy table: Data Collection Form										
Outcome measures: either mean±SD or nr/proportion below/above cut-off point										
W-H (wasting)						BMI-a				
<-3SD	<-2SD	>2SD	>3SD	<3rd p	>95th p	<-3SD	<-2SD	>2SD	>3SD	>95th p

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APPENDIX B

Dummy table: Summary of studies reviewed							
Study Ref	**Study Design**	**Location**	**Participant characteristics**	**Anthropometric indices used**	**Outcome measures**	**Quality Rating**	**Comments**

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PART B: GENERAL LITERATURE REVIEW

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I. INTRODUCTION

Malnutrition and hunger affect large sections of the population worldwide. "Maternal and child undernutrition is the underlying cause of 3.5 million deaths, 35% of the disease burden in children younger than 5 years and 11% of total global Disability Adjusted Life Years lost"[1]. It is associated with serious short- and long-term consequences for children's health and physical and mental development as well as for their and the country's economic well-being and welfare[1, 2].

Therefore, in order for a society to prosper it is essential to ensure the optimal nutritional status of its inhabitants from an early age. In fact, reduction of poverty, hunger and undernutrition is the first of the Millennium Development Goals[3].

To do so it is necessary to evaluate the situation in order to enable targeting of programmes and definition of priorities. In this light, the Western Cape Department of Health, Directorate Nutrition, requested that a systematic review of published and unpublished literature be performed in order to assess the nutritional status of the children in the Western Cape Province.

This general literature review precedes the systematic review, which follows in the next chapter (Section C). It is structured according to the following objectives:

- Exploration of issues related to the measurement of malnutrition through anthropometry;
- Provision of an overview of the malnutrition situation globally and regionally;
- Understanding of the causes of malnutrition at the different levels of influence;
- Understanding of the short- and long-term consequences of malnutrition;
- Exploration of the use of systematic reviews in studying the nutritional status of populations.

The literature search for this literature review was conducted on online databases such as MEDLINE, Health Source Academic/Nursing edition through EbscoHost, as well as on Google scholar. Keywords related to the various topics were used to retrieve the relevant articles.

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II. MEASURING MALNUTRITION

Nutritional status is measured through an assessment of anthropometric, biochemical, clinical and dietary factors. For the purpose of the systematic review to follow, nutritional status will be described using only anthropometric indicators, which are used to assess body size, proportions and composition.

Anthropometry alone does not provide a complete picture of nutritional status. However, it is useful because it reflects inadequate or excessive food intake, growth of children, and overall health and welfare[4]. It is considered the single most portable, universally applicable, inexpensive and non-invasive method to obtain information on nutritional status[5]. Furthermore, it is often used to evaluate the outcome of policies and nutrition intervention programs, or to select individuals whom should be targeted by such programs[5], objectives that are pertinent to the study that follows.

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1) Anthropometric indicators

Anthropometric indices are combinations of measurements that allow for their interpretation. The most commonly used are weight-for-age (W-a), weight-for-height (W-h) and height-for-age (H-a).

These indices can be expressed as z-scores, percentiles, or percentage of median. The z-score system expresses the anthropometric measurements as a number of standard deviations below or above a reference mean or median value[6]. It is considered the preferable system as it adheres to a reference distribution, it has a linear scale that allows for summary statistics to be calculated, it has uniform criteria across all indices and it is useful for detecting changes at extremes of the distribution[4, 7]. Also, because Z-scores are likely to be normally distributed, analytical procedures that assume normality can be performed, such as *t*-tests and regression methods[7].

Although these are body size and composition indices, they are affected by nutrition and health, making them valid nutrition and health indicators. In some instances, as will be described below, these indices are also used as indirect indicators of socioeconomic status and/or inequities[4].

Weight-for-age (W-a) is the most commonly used anthropometric indicator as it is easy to measure, inexpensive to obtain, suitable for screening and it alters quickly in situations of food shortages, drought, food price variations, changes in food availability and changing health conditions[8]. It is therefore highly associated with morbidity and mortality. In fact, changes in W-a have been associated with changes in child mortality independently of socio-economic and other health-related changes[9, 10]. Interpreting a low W-a is complex, however, because it is influenced by both weight and height. It does not distinguish between the different physiological processes that underlie the underweight[6, 7]. In populations with a low wasting prevalence W-a reflects long-term nutrition and health conditions[6].

Low height-for-age (H-a) reflects failure to attain potential linear growth due to long-term inappropriate nutrition and/or health[6]. A high prevalence of low H-a is frequently associated with poor overall economic conditions and/or repeated and early exposure to adverse social and environmental conditions, such as illness and inadequate feeding practices[6, 7]. The opposite is true for low prevalences. Because of this, height-for-age can be used as an indicator to assess the effectiveness of population programmes that aim at improving environmental and socio-economic conditions[7].

A low weight-for-height (W-h) reflects short-term nutritional or health problems such as acute starvation and/or severe disease. Therefore, it is usually prevalent in emergency situations, such as famine or war[7]. However, it may also be associated with chronic diseases[6]. High W-h is an acceptable indicator of overweight and obesity at the population level[6].

Height-for-age and weight-for-height are therefore the preferred indices, as they distinguish between the causes of malnutrition. This in turn allows the implementation of the most appropriate interventions.

When studying populations, anthropometric indices can be used as a screening tool to determine the prevalence of a particular nutritional problem. This can be done by determining the number of children who fall below a specific cut-off point or by calculating the summary statistics for a particular study population. The latter provides a more accurate estimate of poor anthropometric status than the observed prevalence as differences in means provide greater statistical power[4]. Comparison of the whole population distribution with the reference population distribution is

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sometimes indicated; such as, for example, when studying populations where nutritional problems are present in a significant number of children[4]. This will enable the identification of those at risk of morbidity and mortality and therefore in need of further evaluation or intervention[7].

2) Reference populations

Once anthropometric indices are determined for an individual child or a group of children they need to be classified. This is achieved by comparing the measurements with those of a standard reference population, which will determine "relative status"[4, 6, 7].

The first reference population adopted by WHO for international use was the National Centre for Health Statistics (NCHS) reference curves from 1978, which were developed from the growth patterns of well fed, healthy preschool children from diverse ethnic backgrounds in the United States of America[5, 7]. The basic assumption was that genetic differences contributed insignificantly to differences in growth patterns across most populations, and that the growth patterns of well-fed, healthy children from diverse ethnic backgrounds were very similar[4, 5].

However, there are technical limitations to this NCHS/WHO growth reference. Data for children under 36 months of age were collected longitudinally by the Fels Research Institute from studies on white, middle-class populations, whereas those for children aged 2-18 years were collected from a combination of cross-sectional health surveys representative of the United States population performed by the NCHS. Furthermore, these two datasets differ in the method used to assess linear growth. Fels data were from recumbent length measurements whereas NCHS data refer to standing height. Recumbent length is, on average, greater than standing height; thus, there is a marked discrepancy in height status immediately before and after 24 months of age[5, 7]. At the population level this means that when evaluating anthropometry data of different age groups it is difficult to determine which differences seen are due to the disjunction in the reference curves, and which are the result of the physiological changes that normally occur around this age. Since these differences are often used in order to determine resource prioritization, it is important to identify the correct age group at the greatest physiological risk[7].

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The NCHS/WHO reference has other limitations. It has height and weight limits beyond which the calculation of the 3 indices is not possible[7]. The distributions of weight-for-age and weight-for-height are markedly skewed toward the higher end, which reflects a substantial level of childhood obesity and could, therefore, result in a misclassification of overweight children as "normal". Finally, there is a concern that these curves are inappropriate for healthy, breast-fed infants[5]. Healthy breast-fed infants living under conditions that favour achievement of genetic growth potential were found to grow less rapidly than the NCHS/WHO reference, which included children who were mostly bottle-fed[5].

These limitations have led many researchers over the years to develop other growth reference curves that are more specific for a particular country or that have better international representativeness. Examples of these include the international reference adopted by the International Obesity Task Force[11] for defining overweight and obesity in children, as well as the WHO Growth Standards developed in 2007[12]. Other countries have also developed classification systems based on their own national datasets. Conde and Monteiro's age-adjusted BMI classification system for overweight and obesity in children is one example[13]. Some of these systems will be discussed below.

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3) Agreement across different BMI classification systems

The Body Mass Index (BMI) is considered useful for evaluating the nutritional status of children and adolescents due to its ease of calculation and of obtaining the required measurements[11, 13-16]. However, the problem is defining the cut-off points to use when classifying the population according to BMI.

Since BMI changes constantly throughout childhood and adolescence, it makes sense to have age-dependant cut-off points rather than one cut-off point for all, as occurs in adults[11].

There are two age-dependant classifications of BMI that have used similar methodologies based on using adult BMI cut-offs and adapting them to children and adolescents. These are Cole et al.'s (2000) classification, which the International Obesity Task Force (IOTF) has approved for international use, and the Brazilian reference developed by Conde and Monteiro (2006).

It is important to know the agreement across the methods in order to appreciate how it affects comparisons between populations evaluated according to different classification systems. Although differences are expected due to the use of different populations and methodologies in their development[15] they may still have good agreement and may, therefore, be comparable.

All studies found in this literature review that assessed the agreement across different systems for classifying overweight and obesity in children were conducted in Brazil. In Rio de Janeiro, the nutritional status of school children was evaluated according to 3 references: Cole et al. (2000), Conde and Monteiro (2006) and Centers for Disease Control (CDC) (2000)[14]. Although the prevalence of overweight was higher using Conde and Monteiro than Cole et al., this difference was not significant. According to the Bland and Altman method, neither classification exceeded the limits of agreement of ±2SD, except for CDC vs. Conde and Monteiro. Another study in Curitiba, Brazil, also evaluated the nutritional status of schoolchildren attending public schools using the same classification systems of the previous study[15]. However, the authors used a different method to determine agreement between the systems, namely the Kappa statistic. Although there were differences in the prevalences depending on the classification used, excellent agreement (81-100%) was found between the 3 references overall and across gender groups. A similar study was conducted in Rio Grande do Sul, Brazil, among 7-17 years old schoolchildren[16]. The difference was that in this study the third classification system was that of the WHO (2007). Boys and girls had greater prevalence of overweight according to the Conde and Monteiro classification and for boys the prevalence of obesity was greater with WHO's criteria. Cole et al.'s and Conde and Monteiro's classifications showed good to excellent agreement across all age groups and gender, with a Kappa statistic ranging from 65% to 100%.

In light of the evidence presented above it can be concluded that there is good to excellent agreement across Conde and Monteiro's and Cole et al' criteria for classifying overweight and obesity in children and adolescents according to their BMI. They are therefore comparable.

Only one of these studies assessed the agreement of the classification of underweight according to these two classification systems. The prevalence of underweight was significantly lower for both sexes using Conde and Monteiro's system when compared with both Cole et al. and the CDC classification systems. This difference was attributed to the much lower cut-offs used by Conde and Monteiro[14]. No other study that compared the agreement between different systems when

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classifying underweight was found. Owing to this lack of data it is deemed unwise to compare prevalences of underweight determined according to these different systems.

III. EXTENT OF THE MALNUTRITION PROBLEM

1) Undernutrition

Among children younger than 5 years old in Southern Africa and in all developing countries 40.1% and 32% are stunted; 3.9% and 3.5% are severely wasted; and 21.9% and 20.2% are underweight, respectively[1].

In South Africa the situation hasn't improved significantly over the last decade, and for some indicators it has actually worsened. The 1994 study by the South African Vitamin A consultancy Group (SAVACG) was done on children aged 6-74 months and reported that, nationally, 11.6% of children were stunted, 9.3% were underweight and 2.6% were wasted[17]. The National Food Consumption Survey (NFCS), a nationwide survey to determine the nutritional status of children in South Africa, as well as its determinants, was performed in 1999 and in 2005. The 1999 data were adjusted for oversampling of high-risk areas. According to these surveys the national prevalence of stunting in children 1-9 years of age improved slightly from 19.3% in 1999 to 18% in 2005[18-20]. On the other hand the prevalence of underweight and wasting increased respectively from 8.8% and 3.3% in 1999 to 9.3% and 4.5% in 2005. Rural areas were reported to have higher prevalence of malnutrition than urban areas in both the 1999 and the 2005 surveys.

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In adolescents (13-19 year olds), the 2002 and 2008 Youth Risk Behaviour Surveys (YRBS)[21, 22] indicated a slight reduction in the national prevalence of underweight, from 9% in 2002 to 8.4% in 2008, whereas the prevalence of stunting and wasting increased, from 11.4% and 4% in 2002 to 13.1% and 4.4% in 2008, respectively.

In the Western Cape Province, the prevalence of stunting, underweight and wasting reported in the SAVACG study in 1994 were 22.9%, 7% and 1.3%, respectively[17]. Stunting was more prevalent in the Province than nationally. According to the 1999 NFCS[23] and 2005 NFCS-Fortification Baseline[20], the prevalence of stunting appears to have decreased over time from 14.5% in 1999 to 12% in 2005. The prevalence of underweight, however, has remained more or less the same, from

8.3% in 1999 to 8.2% in 2005. Wasting has become significantly more prevalent in the province, at 11.5% in 2005, which is worrisome.

2) Overnutrition

The 1999 NFCS[23] showed that nationally 5.2% of children 1-9 years old were overweight or obese (weight-for-height Z-score ≥ 2 SD). The figure in the NFCS-FB of 2005 showed a decrease to 4.8% according to the same indicator[20]. According to the 2002 YRBS[21] the prevalence of overweight and obese teenagers nationally was 17.2% and 4% respectively. Overweight and obesity in the Western Cape Province were more prevalent than nationally (21.5% and 7.1%, respectively). The 2008 YRBS[24] reported an increase in the national prevalence of overweight and obesity increased to 19.7% and 5.3%, respectively. The Western Cape Province, on the other hand, showed a decrease in these prevalences to 19.9% and 5.6%, respectively.

The information presented above is evidence that both under and overnutrition contribute to the burden of disease in South Africa. In order to understand more clearly the importance of good nutrition for individuals and society, as well as the possible preventative and remedial actions, we need to understand the causes and consequences of malnutrition. The following sections describe these.

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IV. CAUSES OF MALNUTRITION

The United Nations International Children's Fund's (UNICEF) conceptual framework recognizes the complexity of the determinants of malnutrition[25]. It identifies malnutrition causes at different levels of influence, providing the basis for analyzing the aetiology of malnutrition, as well as the possible approaches to remedial action. Its causal levels include: immediate, underlying and basic causes.

1) Immediate causes

The immediate causes of malnutrition include inadequate dietary intake, disease and psychosocial stress and trauma[25, 26]. The synergistic action between these two factors is thought to fuel a vicious cycle, often referred to as the "malnutrition-infection complex", which accounts for the high morbidity and mortality rates in children in developing countries[2]. Nutrient deficiencies are all probably associated with impaired immunity, and deficiencies in specific nutrients, such as zinc and vitamin A, are also associated with mucosal damage; these eventually result in increased incidence, severity and duration of illness. In its turn, disease is often accompanied by appetite loss, nutrient loss, malabsorption and altered metabolism, which all exacerbate the inadequacy of dietary intake. Although each factor can result in death on its own, the most common cause of death is a combination of both inadequate dietary intake and disease[2, 25].

Most incident stunting occurs during the first 2 years of life, when high nutrient demands meet diets that are limited in quantity and quality of micro and macronutrients[1]. At the same time, infectious diseases are particularly common in this age group and they contribute further to stunting, especially diarrhoeal disease, which has been to shown to increase the odds of stunting with increasing number of episodes. Protein-energy malnutrition, in turn, has been shown to increase the duration of diarrhoeal episodes[2].

2) Underlying causes

Underlying the immediate causes mentioned above are household food insecurity, inadequate maternal and child care practices, and poor access to health care and sanitary environments[25].

Hunger and food insecurity in South Africa are common. The 2005 NFCS-FB[23] found that 51% of households in South Africa experienced hunger and that 28% were at risk of hunger. The food poverty indicator measured whether the money spent on food by a household was sufficient to purchase a basic subsistence diet; it identified that 45% of households in SA are food insecure. The general household survey[27] reported that nationally there are more than 2.7 million children living in households that experience hunger; 17.4% of these children are in the Western Cape.

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A feeding practice deemed crucial for child health is breastfeeding[1, 2, 28]. Sub-optimal breastfeeding (partial or non-existent) increases the risk of morbidity and mortality in children under 2 years, more significantly so amongst those younger than 6 months[1]. In South Africa the exclusive breastfeeding rates were found to be very low, with only 12% of infants being exclusively breastfed[29]. The median duration of breastfeeding in the Western Cape was found to be the shortest (10 months) compared to other provinces. A study of 475 households in Accra, Ghana, with children aged 4-36 months investigated the association of the nutritional status of children and the care practices[2]. A scale of care practices was constructed, which included: breastfeeding patterns, timing of complementary feeding, food quality, and feeding practices. A significant association was found between the care practices score and stunting and underweight of the children. This association was not present among children of mothers with a secondary level of education or higher but it was highly significant among children of mothers with a primary level of education or less. Maternal educational levels might be associated with better knowledge and understanding of the appropriate care practices that ensure children's wellbeing.

Breastfeeding has also been associated with decreased risk of overweight and obesity. A study in Kenya observed that breastfeeding for longer than 24 months was significantly associated with 55% reduced odds of the child being overweight or obese in children even after adjusting for socio-economic and demographic factors[28].

Appropriate complementary feeding is essential in order to prevent deterioration of nutritional status during this stage when the infant is introduced to solid food and fluids other than breastmilk. In general it is accepted that complementary feeding is done poorly in many developing countries, which reflects a lack of information about what foods are appropriate, how much should be given, how they should be given, and their inadequacy in quantity and quality, among other problems[2].

Inadequate or improper education and information, particularly of women, may affect their ability to generate and use resources to ensure food security and appropriate nutrition[25]. It may also affect women's knowledge regarding adequate child care practices.

Poor sanitary conditions and a low birth weight were both found to be significantly associated with stunting and underweight in a cohort of children assessed at 2, 6 and 12 months of age in Ethiopia[30]. The same study showed that children living in urban areas were protected from stunting at 12 months of age, which the authors associated with increased exposure to knowledge of

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appropriate weaning food and practices and with better income, which increases purchasing power for adequate weaning foods.

The nutritional status of the mother may be an important proxy for the child's nutritional status. The nutritional status of the mother was significantly associated with moderate and severe stunting in a study using data from the Bangladesh Demographic Health Survey (DHS) of 1999-2000 on 5,333 children[31]. In another study in Kenya with data from the 2003 Kenya DHS, children with overweight and obese mothers had a greater likelihood of being overweight[28]. This association may be explained by the fact that mothers and their children share the same food environments that predispose them to either under or over nutrition.

The increasing prevalences of overweight and obesity in developing countries, of which South Africa is included, have been associated with changes in traditional dietary patterns to westernised ones, as well as with a decreased level of physical activity[20]. These are causes operating at the immediate and intermediate level. The 2008 National Youth Risk Behaviour Survey (YRBS)[22] described an increased consumption of energy dense foods in conjunction with a low level of physical activity by adolescents in South Africa. The 2005 NFCS-FB[20] reported that 47% of children 1-9 years old were consuming more than 100% of the RDA for energy across different age groups; this was especially true among those living in urban areas, which are also the areas with highest prevalence of overweight and obesity. Excessive intake of fat, especially saturated fat, as well as sugar and animal protein in urban areas compared to rural areas has been described in South Africa[32]. In the latter there was a higher intake of plant protein and lower intake of fat and sugar.

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3) Basic Causes

These are distal determinants that are socio-economic in nature. They affect nutritional status through the immediate and intermediate determinants in a variety of causal pathways[4]. They include socio-economic and political factors, such as access to and distribution of resources, which play a role in the causation of malnutrition. The lack of changes in the prevalence of underweight in South Africa since 1990 has been attributed to basic level causes such as poverty, hunger and poor household food security, especially in rural areas[9].

Education is one of the factors operating at this level. The 2005 NFCS-FB observed an inverse association between the level of maternal education and the prevalence of stunting, underweight, and wasting in children[20]. In Bangladesh, moderate and severe stunting were significantly associated with a low maternal and paternal educational levels[31].

Poverty is another fundamental cause of malnutrition, as well as an outcome[2]. An analysis of global data assessed the variability among nations in the prevalence of stunting and wasting and evaluated which national factors were associated with these anthropometric indicators[33]. National factors and geographic regions explained most variability in stunting and wasting. Factors associated with a lower prevalence of stunting were higher energy availability, female literacy and gross national product. The authors state that the variability among nations and provinces indicate that child malnutrition is determined by individual household circumstances as well as by factors operating at the national and provincial levels. As such, interventions need to be planned at all levels.

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V. CONSEQUENCES OF MALNUTRITION

Malnutrition weakens the immune system, enhancing the susceptibility to and the severity of illness, especially of infections, thereby greatly increasing mortality risk[1, 2, 9]. Both mild and moderate malnutrition have been associated with severe consequences for the health of children, in both the short- and long-term.

1) Short-term consequences

Short-term consequences of malnutrition include illness and death. Ten percent of the global disease burden may be attributed to maternal and child under nutrition[1]. It places a heavy burden on countries and families, especially low and middle-income countries, owing to its intergenerational nature and overall disease burden[10]. Stunting, severe wasting, and intrauterine growth restriction-low birth weight (LBW) are responsible for 21% of deaths of children younger than 5 years old globally, which is largely due to their synergistic relationship with infectious diseases; undernutrition also constitutes the largest percentage for any risk factor in this age group[1]. A review of 28 community-based surveys in sub-Saharan African countries estimated that 45 to 65%

of child deaths were due to severe, moderate and mild undernutrition[34]. A WHO analysis of 6 longitudinal studies found that 54% of deaths of children under 5 years in developing countries were associated with a low weight-for-age[4]. In South Africa underweight accounted for 12.3% of all deaths in children under 5 years old in 2000[9]. This was considered an underestimate by the authors, as the burden due to underweight on the child's intellectual and emotional development and the long-term effects on work capacity, as well as its effects on HIV/AIDS progression, were not accounted for in the study. The same study on the burden of disease from underweight ascribed 38.3% of deaths directly to malnutrition in children under 5 years old. Part of this was thought to be due to zinc, vitamin A and iron deficiencies that are associated with growth faltering.

Other serious consequences of undernutrition in children under the age of two years include irreversible physical and cognitive damage, which adversely affects their future health and economic well–being and welfare[1, 2]. A meta-analysis showed that low birth weight predicted a 6-point reduction in the IQ of school age children[2]. These data were mainly from developed countries and the authors suggest that in developing countries with poorer environments low birth weight would have a stronger impact on the IQ score. In a longitudinal study in Cebu, Philippines, children who were stunted between birth and 2 years of age had significantly lower cognitive ability when tested at age 8-11 years than non-stunted children[35]. This was strongly related to the fact that stunted children had reduced schooling owing to delayed enrolment, higher absenteeism and repetition of school years. The association between anthropometric indicators height-for-age and weight-for-age, fatty acids status, and iron, iodine and B-vitamin status on overall cognitive performance of 598 children aged 6-10 years old was studied in a cross-sectional study of Indian schoolchildren of poor socio-economic background[36]. After adjustment for age, sex, school, maternal education, and assessor of cognitive test, increases in height-for-age and weight-for-age Z-scores were associated with increases of the mental processing index (MPI) and all the cognitive domains, except for short-term memory and cognitive speed. As this was a cross-sectional study causal inference is limited. Also, the large number of comparisons made increased the probability of false positives. However, the authors did try to limit the number of comparisons by using composite scores for the cognitive tests. Finally, the overall model only explained 10-40% of the variation in cognitive parameters; other factors such as genetic variation and socio-emotional stimulation could account for the remaining variability.

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2) Long-term consequences

Long-term consequences of stunting arise from malnutrition's deleterious effects on cognitive and physical development. It is associated with lower adult educational attainment, lower adult income, and lower stature of adults, which affect productivity and therefore earnings of those working in manual labour[10].

As mentioned earlier, poverty is both a consequence and an outcome of undernutrition. Economic losses arise from foregone human productivity, foregone Gross Domestic Product, and losses in children's Disability Adjusted Life Years Lost (DALYs), which affects especially the poor[2]. Indeed, investment in nutrition is said to be one of the best options of a pro-poor sustainable economic growth strategy[2, 37].

For lower stature women the related implication is the increased likelihood that she will have a low birth weight baby, who is more likely to develop nutritional deficits later in life[4]. Therefore, under nutrition can result in an intergenerational vicious cycle[4, 10].

Childhood overweight can also have long-term consequences. Children who are overweight are at increased risk of becoming overweight adolescents and adults. This, in turn, increases their risk of developing chronic diseases or conditions such as ischemic heart disease, hypertension, diabetes and hypercholesterolemia, all of which can lead to significant morbidity and mortality[4]. The risk of developing these chronic diseases is also increased for undernourished children. When stunting, severe wasting and intrauterine growth restriction (IUGR) are followed by rapid weight gain in the 3 - 5 year age range there is a significant increase in the risk of chronic diseases later in life[1, 2, 38-40]. A review of epidemiologic studies concluded that there is evidence of an association between stunting and increased risk of obesity and chronic diseases later in life[41]. This is usually observed in countries undergoing the nutrition transition and experiencing the double burden of under and overnutrition, such as South Africa.

This double burden of under and overnutrition has economic and social implications as it usually occurs in developing countries that lack appropriate resources to treat chronic degenerative diseases[41].

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VI. SYSTEMATIC REVIEWS FOR DETERMINING NUTRITIONAL STATUS OF POPULATIONS

Systematic reviews are reviews of studies or a body of data that use clearly defined methods and criteria[42]. Therefore, features such as the literature search strategy, the inclusion and exclusion criteria and the quality assessment of each study, among others, have to be clearly specified.

By using these systematic methods for locating studies and extracting and synthesising data the probability of biases, such as selection and measurement bias, are reduced[43]. Thus they make it more likely that valid and precise evidence is used for drawing conclusions and making decisions related to health care[44]. Because such reviews allow for the systematic integration of qualitative and quantitative results from independent studies they provide a basis for planning and policy recommendations[42].

Well-defined strategies for overcoming publication and reviewer bias are necessary to ensure that the selected studies have been classified according to methods features such as study design, participant selection, and others.

As part of a systematic review a meta-analysis may be performed. This is the use of statistical methods to summarize and combine comparable results from independent studies, allowing for conclusions and decisions based on the entirety of the evidence available at a particular point in time[44]. Pooling the data allows an increase in statistical power and greater precision of estimates[42].

However, it is not always feasible to do a meta-analysis; it depends on whether the studies are sufficiently homogeneous in their methods, participant selection, and outcomes analysed.

The systematic review that follows the present literature review will draw on these benefits. It will integrate anthropometric data from different studies, providing, hopefully, a valid and precise summary of the anthropometric nutritional status of children living in the Western Cape.

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VII. CONCLUSION

Undernutrition constitutes a problem in the developing world. In fact, improved nutrition is important for achieving the millennium development goals[3, 37]. Furthermore, it has been shown that overnutrition also contributes to the burden of disease of developing countries, mostly owing to the nutrition transition.

This literature review has shown that both under and overnutrition have serious short- and long-term consequences for the health, physical and mental development of individuals as well as for the socio-economic welfare of societies.

As such, it is important to determine the nutritional status of individuals in a population. In this way targets and priorities for nutrition interventions can be determined.

It has also been shown that the assessment of nutritional status through anthropometric indicators is a reliable, valid and predictable way of doing this. The three main anthropometric indices used for this purpose are weight-for-age, weight-for-height and height-for-age. The interpretation of each differs and varies according to the socio-economic context, whether it is individuals or populations that are being evaluated and for what purpose the population's nutritional status is being evaluated.

When there are available anthropometric data from studies that have already been conducted, systematic reviews are a useful way of making use of these data. It enables the pooling of comparable results in a way that enhances precision and also provides valid evidence on the nutritional status of a population that can be used for making program and policy decisions.

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PART C: ARTICLE

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The Nutritional Status of children 0-18 years old in the Western Cape Province of South Africa: A Systematic Review

I. ARTICLE ABSTRACT

Objective: To determine the prevalence of stunting, wasting, underweight, overweight and obesity among children 0-18 years of age living in the Western Cape province, South Africa.
Design: Systematic review of published and unpublished studies.
Setting: Studies conducted in the Western Cape Province with anthropometric information.
Subjects: Studies with information on children 0-18 years old.
Results: A significant proportion of children in the Western Cape are undernourished. Stunting affects a higher proportion of children than underweight or wasting across all age and gender categories. All forms of undernutrition were more common among boys and the youngest children. Among children 0-5 years old 18·4% were stunted compared to 7·5% and 9·7% of children 6-10 and 11-18 years old, respectively. An unexpectedly high prevalence (5·1%) of wasting was observed among the youngest children. In addition, a high proportion of children are overweight; older children and girls being more affected. Among teenagers, 27·9% of girls were overweight compared to only 4·7% of the boys. Nutritional status improvements over the period between 1997 and 2009 were not observed.
Conclusions: The high proportions of malnourished children represent a serious public health problem given the short and long-term consequences for the health and socio-economic well being of individuals and society. Adequate interventions exist to address malnutrition and the lack of improvement suggests poor implementation. Strategies to improve implementation are necessary to increase the effectiveness of these interventions and guarantee better health and nutrition of the province's children.

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II. INTRODUCTION

Globally, maternal and child undernutrition is a significant underlying cause of death and disease burden in children younger than 5 years[1]. In South Africa undernutrition prevalence has not been declining[2-6] while, in addition, overweight is becoming increasingly common[4, 5].

Given the short and long-term consequences of malnutrition for individuals as well as societies[1, 7-12], ensuring adequate nutrition from the early years is a prerequisite for society's prosperity, and in fact the reduction of malnutrition constitutes the first Millennium Development Goal[13]. Thus, while it is important to prevent and control malnutrition, before this can be done it is important to assess the nutritional status situation.

The nutritional status of children in South Africa has been shown to vary significantly between provinces as well as within each province, which affects health system prioritization and resource allocation[14]. Even though national studies have measured the prevalence of malnutrition in South Africa, they have not included sufficient numbers of participants from each province to estimate precise provincial rates.

Given that studies on the subject have been published, the Western Cape Department of Health commissioned a study from the Department of Dietetics at the University of the Western Cape to use existing data to assess the nutritional status of children 0-18 years old residing in the Western Cape Province. The aim was to provide evidence to aid planning and evaluation of nutritional interventions in communities and primary health care clinics at the provincial level.

In order to provide this evidence, a systematic review of published and unpublished research with information on the anthropometry of children 0-18 years old in the Western Cape was conducted. Systematic reviews employ structured methods for locating studies and extracting and synthesising data so that the probability of bias is reduced[15]. Also, data from individual studies are integrated so as to increase the precision of estimates observed in smaller studies[16, 17].

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III. METHODS

1) Study design

A systematic review of published and unpublished studies was performed to determine the anthropometric nutritional status of children aged 0-18 years in the Western Cape.

2) Literature search strategy

A literature search was conducted through EbscoHost on the following databases: Academic Search Premier, CINAHL, HealthSource: Nursing/Academic Edition, and Medline. The keywords used were: (nutrition OR malnutrition OR undernutrition OR overnutrition OR underweight OR overweight OR obese OR obesity OR wasted OR wasting OR stunted OR stunting OR "nutritional status" OR anthropometry OR "anthropometric measurements") AND (children OR adolescents OR infants) AND ("south Africa" OR "western cape"). Another search was performed through the Sabinet database using the same keyword combination. The search was limited to articles published since 1997, as there had already been a review of studies published before 1997 by Vorster et al. (1997). A manual search of the reference lists of each included study was performed.

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Studies were included in the review if they met the following inclusion criteria:

i. Any study with anthropometric data from the Western Cape province of South Africa was included. All study designs were included. Baseline data from intervention or cohort studies were used.
ii. Study population comprising infants, children or adolescents (0-18 years old).
iii. Studies published from January 1997 to May 2010.
iv. Studies with primary data on weight and height, or secondary analysis of anthropometric data.
v. Nutritional status evaluated according to the anthropometric indices weight-for-age, weight-for-height and height-for-age or BMI-for-age percentiles or Z-scores using the National Centre for Health Statistics/ World Health Organization (NCHS/WHO) reference population. This growth reference has been adopted by WHO for international use[18]. More recent international growth references exist; however, since this review will include articles published since 1997 it is more likely that they have made use of the previous NCHS/WHO

growth reference. Therefore, using this growth reference will ensure consistency of the reference population used across the different studies.

vi. Studies that have used either of the age-dependant BMI classifications developed by Cole et al. (2000) and Conde and Monteiro (2006) for the classification of overweight and obesity in children and adolescents were included. The prevalences of overweight and obesity obtained by these two systems have been shown to have good to excellent agreement[19-21].

Exclusion criteria included: study population older than 19 years; assessment of nutritional status only through biochemical, clinical and dietary measurements; use of a reference population other than the NCHS for the evaluation of the anthropometric indicators for undernutrition, or the International Obesity Task Force's or Conde and Monteiro's for overnutrition indicators; and study population of children with a particular disease.

Well-known surveys conducted in South Africa include the South African Demographic and Health Survey (SADHS), conducted in 1998 and in 2003; the National Youth Risk Behaviour Survey (YRBS), conducted in 2002 and in 2008; and the National Food Consumption Survey (NFCS), conducted in 1999 and in 2005. The original reports of these surveys were included in this review and published papers with secondary analysis of data from these surveys were excluded.

Individual researchers as well as government departments and academic institutions were asked to contribute information regarding unpublished studies with anthropometric data on children in the Western Cape.

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3) Quality assessment of studies

The quality of each study included in the review was assessed according to pre-specified criteria adapted from studies that outlined criteria for good reporting of observational studies[22-24]. These criteria pertain to the reporting of methods and results of each study. They aim to describe whether study methods are valid and whether the results are applicable to this review. The individual criteria are described in Table 1. Each item in the quality assessment system represents a score of 1. The total quality score of a study was the sum of all criteria items that it has met. If a particular criterion was only partially met, it received a half (0.5) score.

TABLE 1
Quality Assessment System

N	Item	Score
I	Has the study specified its target population and setting?	1
II	Have adequate sampling methods been used?	
III	Have the authors explained how the sample size was calculated?	1
IV	Has there been an adequate response rate?	1
V	Do the authors report on the non-respondents, those that refuse to participate, and those that were absent?	1
VI	Are the definitions for anthropometric indicators valid and repeatable?	1
VII	Have fieldworkers/staff been trained in the appropriate protocol for performing anthropometric measurements	1
VIII	Have anthropometric measurements been performed using appropriately calibrated and reliable equipment?	1
IX	Have the statistical methods for the calculation of the z-scores or percentiles and prevalence been described in sufficient detail? What was the software and reference population used? How were anthropometric indicators classified?	1
X	Is the number of participants clearly reported throughout each step of the study?	1
XI	Are socio-demographic characteristics (age, gender and ethnicity) of the participants described?	1
XII	Are the study subjects and setting described similar to those of interest to this review?	1
TOTAL		**12**

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4) Data extraction

Two researchers independently assessed the quality of each included study and captured relevant data using a standardized Excel spreadsheet. Any discrepancies were discussed until a consensus was reached.

5) Ethical considerations

The study was approved by the University of Cape Town's Faculty of Health Sciences Research Ethics Committee on the 8th of October 2010 (HREC REF: 469/2010, Appendix B).

Unpublished data were only used if the individual researchers who provided them authorized it with written consent.

6) Statistical analysis

Epi Info version 3.3[25] was used to calculate weight-for-height, height-for-age, weight-for-age and BMI-for-age Z-scores for unpublished raw datasets. This was done using the 1978 NCHS/WHO reference population. Children with extreme Z-scores, i.e. -6 SD or below and +6 SD or above, were excluded from the analysis.

The weighted period prevalence of underweight, stunting, wasting, overweight and obesity were calculated on the basis of the total number of children analysed in the studies included. The studies were stratified according to age and gender, as well as socio-economic status when the data allowed. Calculations were done using MS Office Excel 2003 software. Graphical representations of the results were prepared using MS Office Powerpoint 2003.

Most published studies were done in known disadvantaged communities and were, therefore, classified as being representative of poor socio-economic status (SES). The nationally organized surveys are supposed to be representative of the province's SES distribution. The school entrants data were cross-sectional surveys done in primary schools from various suburbs in Cape Town. Therefore, the national surveys and the school entrants data were classified as representing a variety of socioeconomic backgrounds.

The Chi^2 test was performed to test for homogeneity between the proportions across strata for each anthropometric indicator. Fisher's exact test was performed if expected frequencies were not all ≥5. The 95% confidence intervals for each proportion were calculated. These analyses were performed in STATA version 8.0.

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IV. RESULTS

1) Literature search

The EbscoHost search resulted in a total of 672 articles. Scrutiny of titles and abstracts revealed 62 articles relevant for inclusion. The full text of these articles were sought to ascertain if they met all the inclusion criteria. Only 4 articles remained relevant for inclusion. The Sabinet search retrieved a total of 292 articles. Scrutiny of all the titles and publication dates revealed 30 articles that appeared to meet the inclusion criteria. After reviewing the full text versions of these, only 2 articles were found to meet the inclusion criteria and were included in the review. The detailed reasons for exclusion of studies can be seen in the search results diagram below (Figure 1).

The original reports of all national surveys were included, with the exception of the 1998 SA DHS. This survey used BMI adult cut-off points for the classification of underweight, overweight and obesity in children under 18 years old. For the purposes of this study this method was considered inappropriate.

In conclusion, a total of 11 published[3, 5, 6, 26-32] and 8 unpublished[31, 33-39] studies were included in the review. Their methods are summarized in Appendix table 1.

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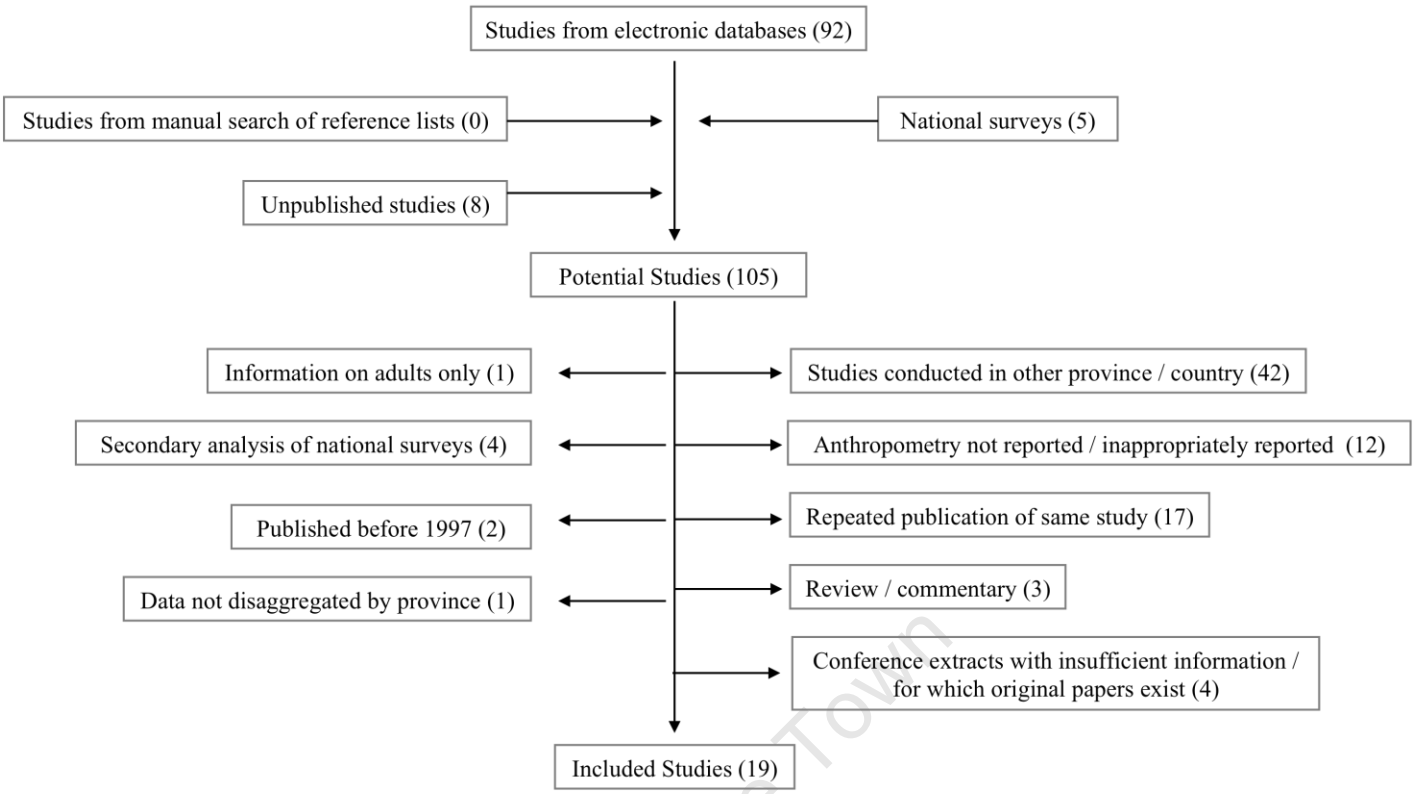

Figure 1. Flow diagram of the literature search

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2) Quality assessment

Most studies scored between 8·0 and 11·0. The lowest scores were 6·0[27] and 4·0[26] (Appendix table 2). Because of their low score, the uncertainty about the number of children analysed, and not reporting on children from a relevant setting these studies were excluded from all analysis, leaving 17 studies.

The most problematic quality items were the reporting of response rates and on non-respondents. Seven studies[26, 27, 35-37, 39, 40] did not report the response rates and five[3, 29, 33, 34, 41] had inadequate response rates (<66%). Only one study[31] reported on non-respondents.

Given that the studies did not differ significantly on the basis of the quality score the statistical analysis was based on the remaining 17 studies.

3) Description of data

The 17 included studies provided data on 17,098 children 0-18 years old living in the Western Cape Province, covering the period 1997 to 2009. Only 9 studies provided data stratified by gender, on a total of 4,468 boys and 4,983 girls. Data disaggregated by gender were only available for children 6-10 and 11-18 years old. Six studies provided information on approximately 9,061 children from all SES levels and 10 studies on approximately 8,276 children from a poor SES level.

The following sections present the findings with regards to the nutritional status of children 0-18 years old.

4) Nutritional status by age group

For all undernutrition indicators a similar pattern was observed (Figure 2). The prevalence of underweight was highest in the youngest age group, followed by the 11-18 years old and then the 6-10 years old age categories (8·9 vs. 4·8 vs. 6·3% p<0.001) (Appendix tables 3.1-3.3). The same pattern was observed for stunting (18·4 vs. 7·5 vs. 9·7% p<0·001) (Appendix tables 4.1-4.3) and wasting (5·1 vs. 1·4 vs. 3·4% p<0·001) (Appendix tables 5.1-5.3). These differences by age groups were observed across gender and SES categories.

With regards to overweight and obesity, a different pattern was observed. The oldest children had the highest prevalence of overweight followed by age groups 0-5 and then 6-10 years old (4·3 vs. 3·6 vs. 20·9% p<0·001) (Appendix tables 6.1-6.3). Similarly, with regards to obesity, children 11-18 years old had significantly higher prevalence of obesity than children 6-10 years old (Appendix tables 7.1-7.2).

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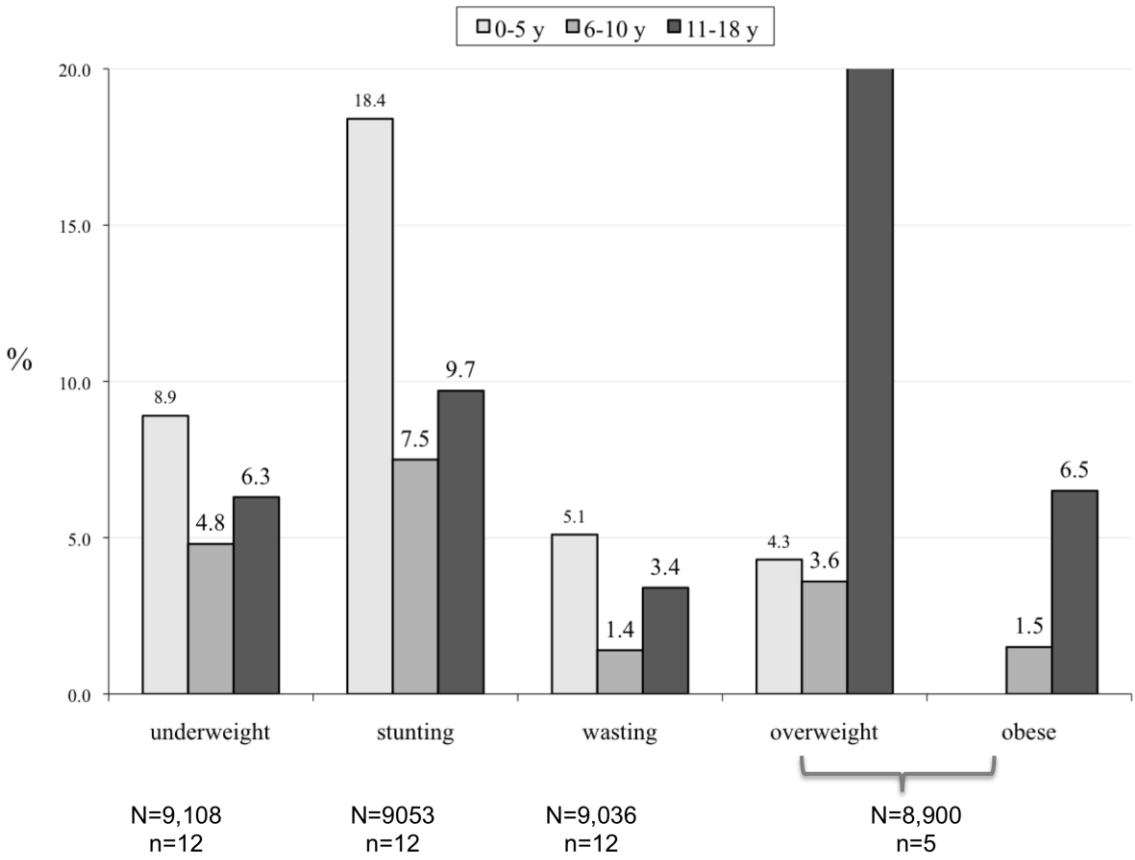

Figure 2. *Weighted period prevalence of underweight, stunting, wasting, overweight and obesity among 0-18 yr old* ***children*** *in the Western Cape (all SES), based on 12 studies for undernutrition indicators and 5 studies for overnutrition indicators, published between 1997 and 2009.*

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5) Nutritional Status by gender

Boys were more affected by undernutrition than girls (Figures 3 and 4). Boys had a higher prevalence of underweight than girls and the difference was significant among children 6-10 years (6·2 vs. 3·5% p<0·0001) and 11-18 years old (8·9 vs. 4·4% p<0·0001). With regards to stunting, boys 6-10 years old had a higher prevalence than girls of the same age (9·1 vs. 5·3% p<0·001) but among children 11-18 years old the prevalence of stunting was similar (9· 5 vs. 9· 8% p<0·82). Boys 11-18 years old had a higher prevalence of wasting than girls of the same age group (5·7 vs. 1·7% p<0·001) but the prevalence of wasting was similar for boys and girls 6-10 years old (1·34 vs. 1·35 p=0·99).

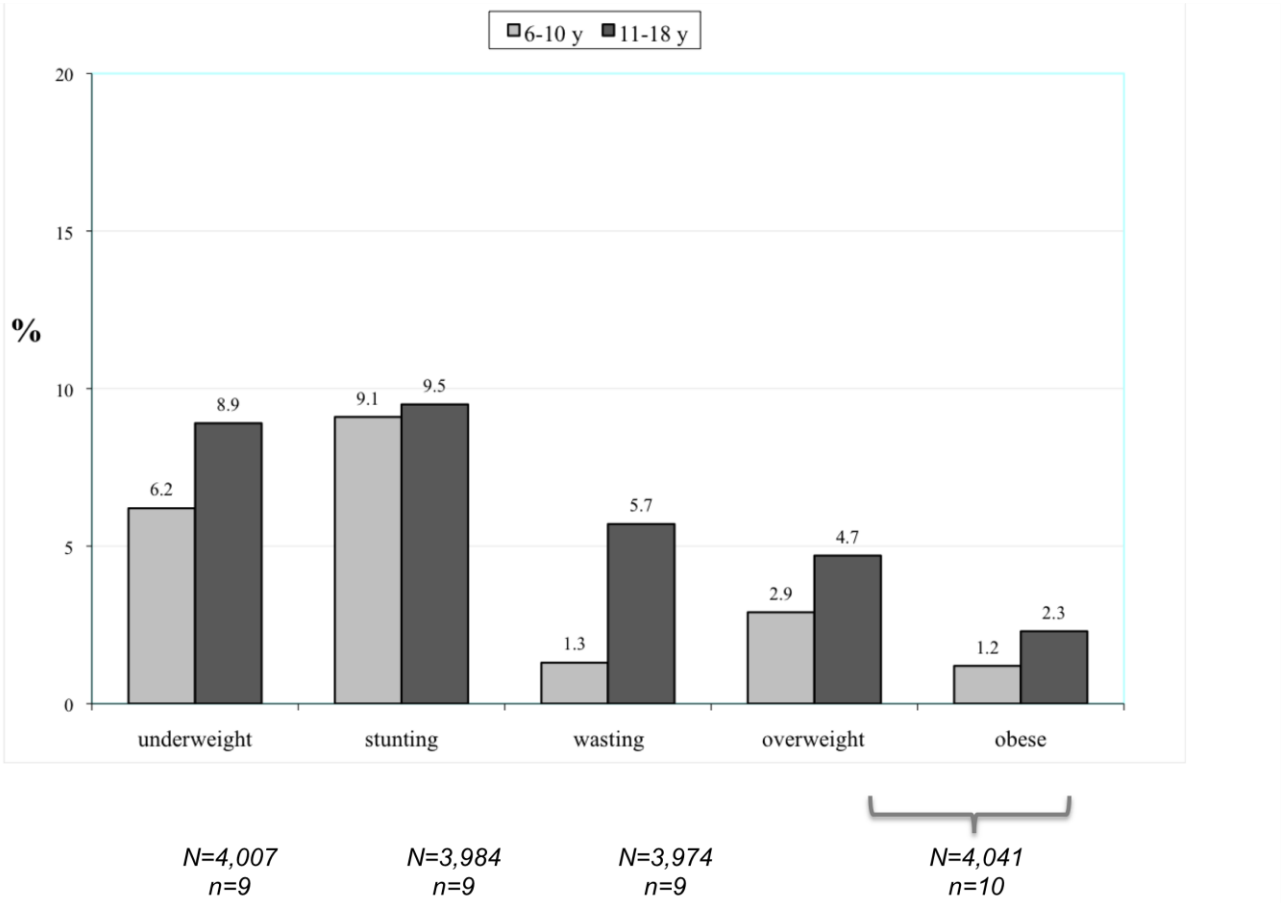

Figure 3. Weighted period prevalence of underweight, stunting, wasting, overweight and obesity among 6-18 yr old ***boys*** *in the Western Cape (all SES), based on 9 studies for undernutrition indicators and 10 studies for overnutrition indicators, published between 1997 and 2009.*

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The opposite was observed for overweight and obesity (Figures 3 and 4). Girls 6-10 years old and 11-18 years old had significantly higher prevalence of overweight than boys of the same age groups (2·3 vs. 4·3 p=0·005; 4·7 vs. 27·9% p<0·001, respectively). The same pattern was observed for obesity. This contrast was more apparent among teenagers.

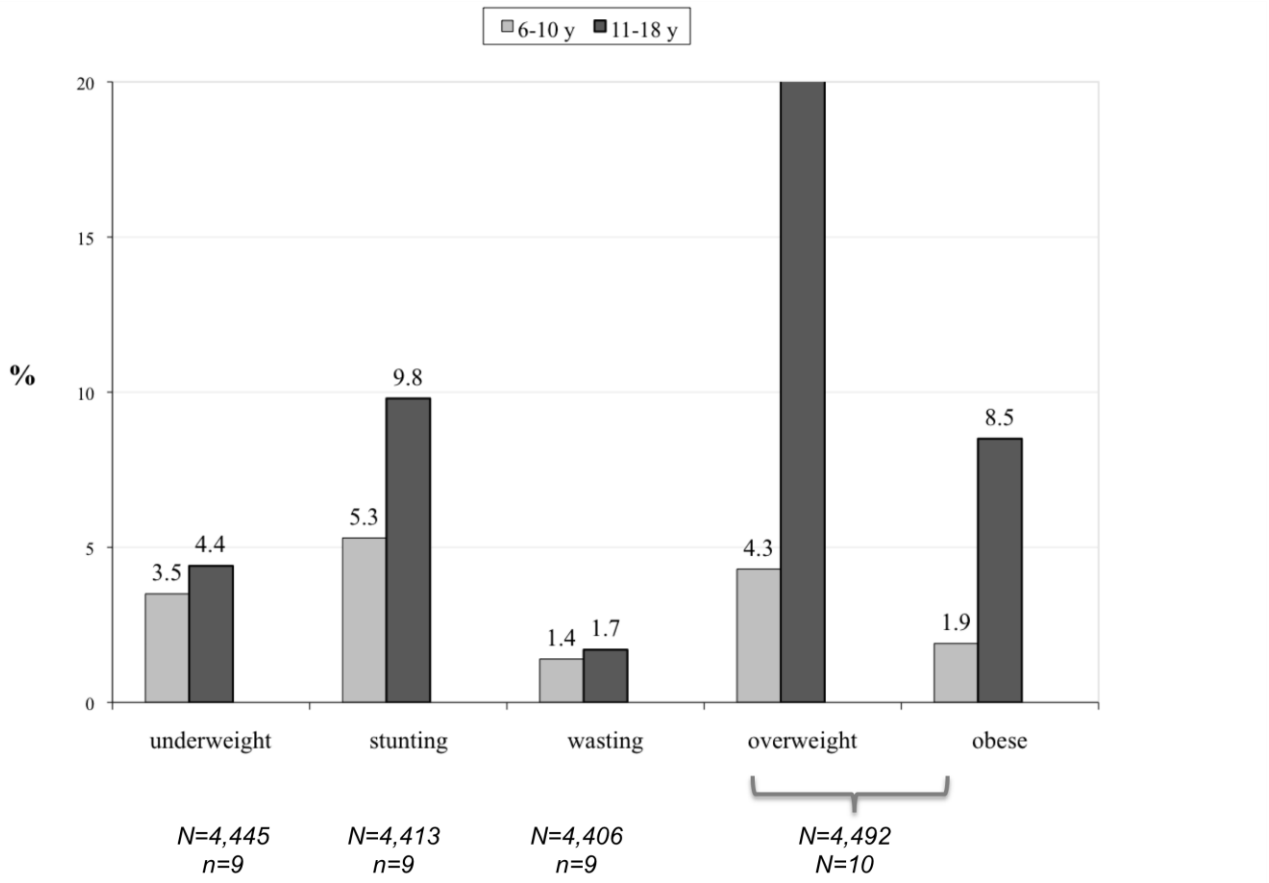

*Figure 4. Weighted period prevalence of underweight, stunting and wasting, overweight and obesity among 6-18 yr old **girls** in the Western Cape (all SES) based on 9 studies for undernutrition indicators and 10 studies for overnutrition indicators published between 1997 and 2009.*

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6) Nutritional Status by socio-economic status

It was not possible to do this analysis for all gender and age categories owing to lack of data.

Prevalence of undernutrition was not consistently associated with either SES category (not shown).

On the other hand, the prevalence of overweight/obesity was consistently lower among children from a poor SES. Among children 11-18 years old the prevalence of overweight was dramatically higher among those in the "all" SES category than those in the "poor" SES category. No obesity was observed among children from a poor SES.

7) Time trends in nutritional status

No obvious or consistent trend by years of study with regards to undernutrition indicators was observed.

One exception was the worrisome increase in the prevalence of wasting in the province from 0·9% in 1999 to 11·5% in 2005 among children 0-5 years old (not shown). Although these estimates show low precision (95% CI 0·9; 2·7 and 7·3; 17·01, respectively), the fact that the confidence intervals do not overlap indicates a statistically significant increase.

Dissimilar trends were observed for overweight and obesity in the different age and gender categories. A mainly decreasing trend in the prevalence of overweight and obesity was observed among teenagers (11-18 years old). The exception was an increase in the prevalence of overweight boys from 8·5% in 2002 to 12·0% in 2008. Among children aged 6-10 years old, the prevalence of overweight and obesity remained more or less the same between 1997 and 2002, but the 2009 estimates indicate an increase in the prevalence of overweight and obesity from 2002 to 2009 in this younger age category.

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V. DISCUSSION

This review has confirmed that a significant proportion of children in the Western Cape are undernourished. All forms of undernutrition are more common among boys than girls and in younger than older children. In addition, a high proportion of children are also overweight; older children and girls being more affected. Nutritional status improvements during the period between 1997 and 2009 were not observed. In fact, with regards to over-nutrition there is suggestion of recent increases in prevalence.

1) Limitations of the review

The fact that the socio-economic status (SES) categories were ill defined and that the “all SES” category contained wealthy and poor children make comparisons between these categories difficult and dilute the contrast expected between them.

The studies reviewed used different classification systems for each nutritional indicator. Therefore, the reported prevalences are often based on more than 1 classification system for the same indicators. Although previous studies have shown agreement between the systems used there is still the possibility of misclassification bias due to this.

Also, the National Centre for Health Statistics/World Health Organization (NCHS/WHO) 1978 classification system used may underestimate the prevalence of stunting and overweight in children of all ages, and of underweight and wasting in children 0-6 and 0-12 months, respectively, compared to the more recent international reference developed by WHO in 2006[42]. This is owing to it being based on data from mostly bottle-fed infants, whereas the WHO reference is based on breastfed infants only[42-44].

These limitations need to be kept in mind in the discussion below.

2) Classification of the magnitude of the undernutrition problem at the public health level

According to the WHO classification[45] for identifying "significance" at the public health level (Appendix table 8), the period prevalence of stunting from 1997 until 2009 in the Western Cape was "low". The prevalence of wasting was "moderate" for children 0-5 years old and boys 10-18 years old whereas among other children it was "low". The prevalence of underweight was "moderate" among children 0-5 years old whereas among all others it was "low".

Before we accept malnutrition as a problem of low public health significance, it is important to acknowledge the limitations of the WHO classification. While it is helpful in establishing the relative levels of public health importance of undernutrition and in summarizing prevalence data for prioritizing interventions, it is also arbitrary and only reflects convenient statistical grouping of prevalences observed worldwide[45, 46]. Therefore, "low" or "moderate" prevalences should be interpreted cautiously and not provide grounds for complacency.

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3) Main findings

A significant proportion of children were undernourished. The proportion of stunting was higher than that of underweight or wasting, a pattern that has been observed in other South African[2, 47-50] and international[1, 45, 46] studies.

All undernutrition indicators were more prevalent among younger children (0-5 years old) than older children. This is not a peculiar finding. This age group is commonly considered at high-risk for poor dietary practices, food insecurity and recurrent infections[1, 9, 47, 48, 51], all risk factors associated with poor socioeconomic conditions[8, 52-54].

Finding a moderate WHO prevalence of wasting (low weight for height), i.e. above 5%, was unexpected given that in the absence of food shortages wasting usually remains under 5%[45]. Other studies in South Africa[47] and developing countries[1] have reported lower levels of wasting.

All forms of undernutrition were more prevalent among boys than girls, whereas overnutrition was more prevalent among girls than boys. Similar gender patterns have been reported elsewhere[50, 55-62]. They also reflect the patterns observed among South African adults[63]. The greater vulnerability to under-nutrition among boys has been associated with their increased biological vulnerability and with differential treatment of boys and girls, but the evidence is inconclusive[62]. Higher prevalence of over-nutrition among girls has been attributed to differences in the time of onset of puberty, which is associated with increased muscularity among boys and adiposity among girls[56, 59], decreasing levels of physical activity in girls as they grow older[64], and urbanization and its associated diets high in calories[3, 5, 28].

The observation that children 6-10 years old were less affected by undernutrition than younger children is reasonable as they might be able to care for themselves better. However, their being less affected than teenagers is not easy to understand and requires further research.

Nutritional status improvements over the period between 1997 and 2009 were not observed. In fact, with regards to over-nutrition there is suggestion of recent increases in prevalence.

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4) How to explain these findings?

Undernutrition

Undernutrition reflects long-term poor dietary intake. Food security in South Africa appears to have worsened since 1999. Nationally, 52% of households reported experiencing hunger in the 1999 and 2005 NFCS's[3, 65]. The proportion of households at risk of hunger increased from 23% in 1999 to 28% in 2005. In 1999 25% of households were food secure whereas in 2005 this figure had decreased to 20%. In the Western Cape, the proportion of households at risk of hunger has increased from 29% in 1999 to 39% in 2005.

Poor dietary care practices are other underlying causes of undernutrition. One example is the absence of breastfeeding, particularly exclusive breastfeeding in the first 6 months of life, which is associated with reduced risk of infections, improved physical growth and motor development, and reduced risk of obesity[1, 9, 51, 66]. Breastfeeding practices in South Africa are poor; only 8% of infants younger than 6 months of age are exclusively breastfed according to the 2003 SADHS, showing no significant improvement from the figures in the 1998 survey[29]. Even though the Western Cape had the highest proportion of infants ever breastfed, the median duration was the shortest compared to other provinces (10 months)[29]. Premature introduction of complementary foods is another problematic practice. It increases the risk of infection, from contaminated liquids, reduces the amount of breast milk consumed and may increase risk of malnutrition due to inadequate nutrient and energy density[66-68]. In South Africa, foods and/or liquids other than breast milk are often introduced to infants younger than 4 months old[67].

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At the basic level, poor nutritional status and food insecurity are associated with a poor socio-economic status[67]. Despite being ranked one of the 50th wealthiest nations, this status is not reflected in the quality of life of individuals in the country owing to the high socio-economic inequality; South Africa is the 3rd most unequal country in the world[48, 67]. A high proportion of the population is still living in poverty and is unemployed, which influences access to food. These effects are further compounded by the rising food prices owing to rising fuel prices, biofuel production and trade restrictions, which affect mainly the urban poor as they spend a greater share of their household income on food[67, 69]. Since there is evidence that there is enough food available to feed the country's population, the food security problems are largely due to poor access to food[67, 69].

Overnutrition

Increasing levels of overweight and obesity in South Africa have been attributed to lifestyle and dietary changes consistent with the nutrition transition[70]. Traditional dietary patterns high in complex carbohydrates and low in sugar and fat are being substituted by diets high in fat, sugar and calories, much of it associated with urbanization. Among learners 13-18 years old in the Western Cape, 41% of boys and 39% of girls frequently consume fast foods and 56% of boys and girls consume cooldrinks regularly; proportions that are higher than the national average[28]. Among children 1-9 years old in the Western Cape province, 70-79% consume more than 100% of the recommended daily calorie intake, which is more common in urban areas[41].

Alongside this dietary shift there has been a decrease in physical activity levels. The Western Cape has one of the highest proportions of physical inactivity in South Africa[29]. Among teenagers, 45% of boys and 46% of girls were reported to participate in none or insufficient physical activity and 25% of boys and 29% of girls were reported to spend more than 3 hours per day watching television[28].

The trends presented above are consistent with the double burden from under and over-nutrition indentified in this review.

5) Implications of findings

The high proportions of under and over-nourished children identified in the province have serious negative consequences for individuals and society.

Malnourished children are at increased risk of morbidity and mortality from infectious diseases[46], they are at increased risk of becoming obese in adulthood, which is associated with increased morbidity and mortality due to non-communicable diseases [1, 71-73]. These consequences are already being felt in the province, where cardiovascular disease is a leading cause of death and non-communicable diseases account for a larger proportion of deaths than nationally (58% vs. 38%)[74].

Malnutrition also has direct costs in terms of health care resources for its prevention and treatment, and long-term indirect economic costs from diminished capacity for human capital formation [9, 74].

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Thus, it is no surprise that the first Millennium Development Goal (MDG) is to eliminate hunger and malnutrition[13]. Recent literature abounds with articles emphasizing the role of nutrition in alleviating poverty and improving socio-economic inequalities, particularly in the developing world. Because malnutrition perpetuates poverty and underdevelopment and thus affects a large proportion of the population, even mild to moderate forms of malnutrition are considered of great public health significance[14].

Accordingly, high priority should be given to improving the nutritional status of South African children. They represent future generations of workers contributing to the country's social and economic development. Their nutritional status should be carefully monitored, especially those younger than 5 years old who have higher susceptibility to malnutrition. This is particularly important with regards to stunting as preventive actions need to be implemented before the age of 2 years, i.e. before it becomes irreversible[1, 10]. Likewise, careful monitoring is warranted in order to better understand the wasting prevalence trend in the province.

Interventions and policies to address malnutrition developed by the Integrated Nutrition Programme (INP) are adequate in that they are evidence-based and reflect the need to address the causes of malnutrition at multiple levels of influence within a primary health care framework[14, 67, 75]. Despite this, high levels of malnutrition and lack of improvements over time are observed. This is most likely due to ineffective implementation of these programs, owing to barriers such as inadequate human and financial resources and information systems, among others[14].

Strengthening the implementation of the INP interventions addressing breastfeeding, infant and young child feeding, growth monitoring and promotion, strengthening collaboration between different public sectors as well as public-private partnerships are all needed to overcome these implementation bottlenecks.

In summary, in the Western Cape Province, malnutrition among children 0-18 years old is a serious health problem. Wasting and stunting are particularly worrisome, affecting the youngest children and boys more. Simultaneously, a high proportion is also overweight, mostly among teenage girls.

The findings confirm the view of a double-burden from under and over-nutrition in the province, which have serious short- and long-term consequences for the health and economic well being of the Western Cape population and the province's socio-economic development.

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PART D: APPENDICES

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APPENDIX A: TABLES

APPENDIX TABLE 1
Summary of studies with data on anthropometric nutritional status of children in the Western Cape

Study	Study design	Sampling	Subjects	sex	n	Anthropometric indicator	Cut-off	%
Van Stuijenberg et al (1997)	Pre and post-intervention study	?	6-12 year old primary school children in Worcester	Both	148 ?	HAZ WAZ	<-2 SD <-2 SD	17.2 16.6
Labadarios, D (2000) (NFCS 1999)	National cross-sectional survey	Multi-stage stratified random	1-9 year old children in the Western Cape (WC)	Both	324	HAZ WAZ WHZ WHZ	<-2 SD <-2 SD <-2 SD >2SD	14.5 8.3 0.9 5.2
Oelofse et al 2002	Cross-sectional	Random and non-random	Black and coloured children aged 6 months from Khayamandi and Cloetesville		120 ?	HAZ WAZ WHZ	<-2 SD <-2 SD <-2 SD	18 8 0
Reddy et al 2003 (NYRBS 2002)	Cross-sectional	Multi-stage stratified random	Learners in grade 8-11 aged 13-19 years old attending public schools in the WC (SA)	Both	1432	HAZ WAZ WHZ BMI** BMI**	<-2 SD <-2 SD <-2 SD >25kg/m² >30kg/m²	9.5 6 3 21.5 7.1
				M		HAZ WAZ WHZ BMI** BMI**	<-2 SD <-2 SD <-2 SD >25kg/m² >30kg/m²	9.5 9.6 5.5 8.2 2.4
				F		HAZ WAZ WHZ BMI** BMI**	<-2 SD <-2 SD <-2 SD >25kg/m² >30kg/m²	9.5 3.4 1.3 30.7 10.3
Sibeko et al (2004)	Cross-sectional	Convenience	Infants 1-6 months old attending a clinic in Langa.	Both	113	HAZ WHZ	<-2 SD >2 SD	1.8 35
Jooste and Joubert (2004)	Cross-sectional	Convenience? Random?	All grades 5 and 6 children attending primary school near Worcester	Both	66	HAZ WAZ	<-2 SD <-2 SD	33.3 19.7
				M	42	HAZ WAZ	<-2 SD <-2 SD	35.7 21.4
				F	24	HAZ WAZ	<-2 SD <-2 SD	29.2 16.7

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Study	Study design	Sampling	Subjects	sex	n	Anthropometric indicator	Cut-off	%
PUBLISHED								
DOH (2004) (SA DHS 2003)	Cross-sectional national survey	Multi-stage stratified random	Children under 5 in the WC	Both	149	HAZ	<-2 SD	34.7
						WAZ	<-2 SD	10.9
						WHZ	<-2 SD	6.2
			Adolescents 15-19 years old in the WC	Both	140	BMI*	<17.5kg/m²	7.1
						BMI*	>25kg/m²	7.14
						BMI*	>30kg/m²	9.29
				M	60	BMI*	<17.5kg/m²	6.8
						BMI*	>25kg/m²	2.3
						BMI*	>30kg/m²	2.3
				F	80	BMI*	<17.5kg/m²	6.9
						BMI*	>25kg/m²	11.7
						BMI*	>30kg/m²	14.7
NFCS-FB 2005	Cross-sectional national survey	Multi-stage stratified random	1-9 year old children in the Western Cape (WC)	Both	183	HAZ	<-2 SD	12
						WAZ	<-2 SD	8.2
						WHZ	<-2 SD	11.5
						WHZ	>2 SD	3.3
Somers et al (2006)	Cross-sectional survey	Proportionally stratified multi-stage random	African and coloured learners aged 10-16 years old attending public schools in Delft, Belhar and Mfuleni	Both	336	BMI**	≥25kg/m²	15.7
							≥30 kg/m²	5.95
				M	142	BMI**	≥25kg/m²	8.5
							≥30 kg/m²	3.5
				F	194	BMI**	≥25kg/m²	21
							≥30 kg/m²	7.7
Reddy et al (2010) (NYRBS 2008)	Cross-sectional	Stratified two-stage cluster sampling	Learners in grade 8-11 aged 13-19 years old attending public schools in the WC (SA)	Both	1196	HAZ	<-2 SD	9.7
						WAZ	<-2 SD	6.5
						WHZ	<-2 SD	3.7
						BMI**	≥25kg/m²	19.9
							≥30 kg/m²	5.6
				M		HAZ	<-2 SD	9.8
						WAZ	<-2 SD	8
						WHZ	<-2 SD	5.4
						BMI**	≥25kg/m²	11.7
							≥30 kg/m²	2
				F		HAZ	<-2 SD	9.6
						WAZ	<-2 SD	5.2
						WHZ	<-2 SD	2.2
						BMI**	≥25kg/m²	27.4
							≥30 kg/m²	8.9

*Conde and Monteiro's age-dependant BMI classification

** Cole et al's (2001) age-dependant BMI classification: age dependant BMI cut-off points that correspond to adults BMI classification of overweight and obesity, i.e. ≥25 kg/m² = overweight; ≥ 30kg/m² = obese.

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Study	Study design	Sampling	Subjects	sex	n	Anthropometric indicator	Cut-off	%
UNPUBLISHED								
Kamminga, F. 2007	Cross-sectional survey with retrospective cohort study	Convenience	Grade 1-5 learners at the Chrystel School of South Africa aged 5.8-12.7 years in 2002	Both	175	WAZ	<-2 SD	8
						WAZ	>2 SD	3.4
				M	72	WAZ	<-2 SD	8.3
						WAZ	>2 SD	2.8
				F	103	WAZ	<-2 SD	7.8
						WAZ	>2 SD	3.9
Swart, R. 2003	Unmatched case-control	Random selection with proportional representation	Grade 1 learners aged 6-7 years attending primary schools in Ceres	Both	116	HAZ	<-2 SD	8.7
						WAZ	<-2 SD	10.7
						WHZ	<-2 SD	1
Swart, R. 2004	Unmatched case-control	Random selection with proportional representation	Grade 1 learners aged 6-7 years attending primary schools in Ceres	Both	129	HAZ	<-2 SD	17.8
						WAZ	<-2 SD	8.1
						WHZ	<-2 SD	0
UWC, 2009 (Ikamva Labantu)	Cross-sectional survey	Convenience?	Learners from public schools in Gugulethu, Khayelitsha and Nyanga participating in the Hoops for Hope after school program aged 8-16 years old	Both	173	HAZ	<-2 SD	9.25
						WAZ	<-2 SD	2.9
						BMIZ	<-2 SD	1.2
						BMIZ	>2 SD	2.3
						BMIZ	>3 SD	0.0
				M	62	HAZ	<-2 SD	3.2
						WAZ	<-2 SD	1.6
						BMIZ	<-2 SD	0.0
						BMIZ	>2 SD	0.0
						BMIZ	>3 SD	0.0
				F	111	HAZ	<-2 SD	12.6
						WAZ	<-2 SD	3.6
						BMIZ	<-2 SD	1.8
						BMIZ	>2 SD	3.6
						BMIZ	>3 SD	0.0
Jooste and Lund 2004	Cross-sectional	Convenience?	All children under 5 years old attending the national measles and polio campaign in the Central Karoo District	Both	2299	WA p	<3rd p	16.4
						WA p	>97th p	2.2

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Summary of studies with data on anthropometric nutritional status of children in the Western Cape

Study	Study design	Sampling	Subjects	sex	n	Anthropometric indicator	Cut-off	%
UNPUBLISHED								
Jooste and Lund 2006	Cross-sectional	Convenience?	All children under 5 years old attending the national measles and polio campaign in the Central Karoo District	Both	4342	WA p WA p	<3rd p >97th p	16 2.1
UWC, 2006	Cross-sectional	?	Learners aged 5-17 years attending Khayamandi primary school	Both	987	HAZ WAZ BMIZ BMIZ	<-2 SD <-2 SD <-2 SD >2 SD	5.67 2.03 2.43 1.42
				M	516	BMIZ HAZ WAZ	>3 SD <-2 SD <-2 SD	0.0 7.56 3.1
				F	471	BMIZ BMIZ BMIZ	<-2 SD >2 SD >3 SD	3.1 0.97 0.0
						HAZ WAZ BMIZ BMIZ BMIZ	<-2 SD <-2 SD <-2 SD >2 SD >3 SD	3.61 0.85 1.7 1.91 0.0
School entrants, 1997	Cross-sectional	All?	Learners aged 6-9.6 years old attending public schools in cape town	Both	617	HAZ WAZ WHZ WHZ WHZ	<-2 SD <-2 SD <-2 SD >2 SD >3 SD	6.81 2.92 0.16 4.21 2.27
				M	324	HAZ WAZ WHZ WHZ WHZ	<-2 SD <-2 SD <-2 SD >2 SD >3 SD	6.48 3.4 0 1.85 1.23
				F	293	HAZ WAZ WHZ WHZ WHZ	<-2 SD <-2 SD <-2 SD >2 SD >3 SD	7.17 2.39 0.34 6.83 3.41

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Summary of studies with data on anthropometric nutritional status of children in the Western Cape

Study	Study design	Sampling	Subjects	sex	n	Anthropometric indicator	Cut-off	%
UNPUBLISHED								
School entrants, 1999	Cross-sectional	All?	Learners aged 5.2-9.7 years old attending public schools in cape town	Both	842	HAZ	<-2 SD	8.79
						WAZ	<-2 SD	5.34
						WHZ	<-2 SD	0.59
						WHZ	>2 SD	2.02
						WHZ	>3 SD	1.07
				M	394	HAZ	<-2 SD	10.91
						WAZ	<-2 SD	7.11
						WHZ	<-2 SD	0.51
						WHZ	>2 SD	2.03
						WHZ	>3 SD	1.02
				F	448	HAZ	<-2 SD	6.92
						WAZ	<-2 SD	3.79
						WHZ	<-2 SD	0.67
						WHZ	>2 SD	2.01
						WHZ	>3 SD	1.12
School entrants, 2000	Cross-sectional	All?	Learners aged 6.1-9.7 years old attending public schools in cape town	Both	444	HAZ	<-2 SD	6.31
						WAZ	<-2 SD	4.05
						WHZ	<-2 SD	2.03
						WHZ	>2 SD	2.03
						WHZ	>3 SD	0.68
				M	218	HAZ	<-2 SD	5.96
						WAZ	<-2 SD	6.42
						WHZ	<-2 SD	2.75
						WHZ	>2 SD	0.46
						WHZ	>3 SD	0.46
				F	226	HAZ	<-2 SD	6.19
						WAZ	<-2 SD	2.21
						WHZ	<-2 SD	1.33
						WHZ	>2 SD	3.54
						WHZ	>3 SD	0.88
School entrants, 2001	Cross-sectional	All?	Learners aged 4.7-10.5 years old attending public schools in cape town	Both	1559	HAZ	<-2 SD	6.35
						WAZ	<-2 SD	4.23
						WHZ	<-2 SD	1.8
						WHZ	>2 SD	4.23
						WHZ	>3 SD	1.73
				M	745	HAZ	<-2 SD	7.74
						WAZ	<-2 SD	5.28
						WHZ	<-2 SD	1.47
						WHZ	>2 SD	4.42
						WHZ	>3 SD	1.47
				F	814	HAZ	<-2 SD	4.83
						WAZ	<-2 SD	3.09
						WHZ	<-2 SD	2.15
						WHZ	>2 SD	4.03
						WHZ	>3 SD	2.01

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APPENDIX TABLE 1
Summary of studies with data on anthropometric nutritional status of children in the Western Cape

Study	Study design	Sampling	Subjects	sex	n	Anthropometric indicator	Cut-off	%
UNPUBLISHED								
School entrants, 2002	Cross-sectional	All?	Learners aged 5.7-14.9 years old attending public schools in cape town	Both	1210	HAZ	<-2 SD	10.91
						WAZ	<-2 SD	7.36
						WHZ	<-2 SD	1.82
						WHZ	>2 SD	3.06
						WHZ	>3 SD	1.32
				M	591	HAZ	<-2 SD	14.21
						WAZ	<-2 SD	9.81
						WHZ	<-2 SD	1.86
						WHZ	>2 SD	1.52
						WHZ	>3 SD	0.51
				F	619	HAZ	<-2 SD	7.75
						WAZ	<-2 SD	5.01
						WHZ	<-2 SD	1.78
						WHZ	>2 SD	4.52
						WHZ	>3 SD	2.1
School entrants, 2009	Cross-sectional	All?	Learners aged 5.2-8.7 years old attending public schools in cape town	Both	532	HAZ	<-2 SD	3.57
						WAZ	<-2 SD	3.01
						WHZ	<-2 SD	1.5
						WHZ	>2 SD	7.52
						WHZ	>3 SD	3.01
				M	262	HAZ	<-2 SD	4.96
						WAZ	<-2 SD	3.05
						WHZ	<-2 SD	1.53
						WHZ	>2 SD	7.25
						WHZ	>3 SD	3.44
				F	270	HAZ	<-2 SD	2.22
						WAZ	<-2 SD	2.96
						WHZ	<-2 SD	1.48
						WHZ	>2 SD	7.78
						WHZ	>3 SD	2.59

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APPENDIX TABLE 2

Quality Assessment of Studies

n		Study	Quality Criteria												
			I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Total**
1	PUBLISHED	van Stuijvenberg (1997)	Y	N	N	?	N	Y	?	N	YN	N	YN	Y	4
2		NFCS 1999	Y	Y	YN	N	N	Y	Y	Y	Y	Y	Y	Y	9
3		Oelofse et al (2002)	YN	YN	N	?	N	Y	Y	Y	Y	N	Y	N	6
4		NYRBS 2002	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	11
5		SADHS 2003	Y	Y	YN	N	N	Y	Y	Y	Y	Y	Y	Y	9.5
6		Sibeko et al (2004)	Y	Y	N	Y	YN	Y	YN	?	Y	Y	YN	Y	8.5
7		Jooste and Joubert (2004)	Y	Y	Y	Y	Y	Y	YN	YN	Y	Y	Y	Y	11
8		NFCS 2005	Y	Y	YN	N	N	Y	Y	Y	Y	Y	Y	Y	9.5
9		Somers et al (2006)	Y	Y	Y	Y	N	Y	Y	Y	Y	YN	Y	Y	10.5
10		NYRBS 2008	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	11
11	UNPUBLISHED	Swart (2003)	Y	Y	Y	N	?	Y	Y	Y	Y	Y	?	Y	9
12		Swart (2004)	Y	Y	Y	N	?	Y	Y	Y	Y	Y	?	Y	9
13		Jooste and Lund (2004)	Y	Y	Y	?	N	Y	YN	YN	YN	Y	Y	Y	8.5
14		UWC (2006)	Y	Y	Y	?	N	Y	Y	?	Y	Y	YN	Y	8.5
15		Jooste and Lund (2006)	Y	Y	Y	?	N	Y	YN	YN	YN	Y	Y	Y	8.5
16		Kamminga (2007)	Y	Y	N	Y	N	Y	?	?	Y	Y	Y	Y	8
17		UWC (2009)	Y	Y	Y	?	N	Y	Y	Y	Y	Y	Y	Y	10
18		School Entrants (1997-2002 and 2009)	Y	Y	Y	?	N	Y	Y	YN	Y	Y	YN	Y	9

KEY	
Y	Meets criterion
N	Does not meet criterion
YN	Partially meets criterion
?	Unknown/not reported
I	Target population/setting specified?
II	Sampling methods adequate?
III	Sample size explained?
IV	Response rate adequate?
V	Non-respondents reported?
VI	Anthropometric indicators valid and reliable?
VII	Fieldworkers trained?
VIII	Equipment calibrated and reliable?
IX	Statistical methods described?
X	Number participants reported throughout study?
XI	Socio-demographic characteristics of participants described?
XII	Subjects and setting relevant to this review?

APPENDIX TABLE 3.1 Prevalence of underweight among children 0-5 years old						
Sex	**Date**	**Age group (Years)**	**SES strata**	**Prevalence underweight**		
				N	**%**	**95% CI**
BOYS & GIRLS	1999[1]	1-9	All	27/324	8.3	5.6-11.9
	2003[2]	0-5		16/149	10.9	6.3-16.9
	2005[1]	1-9		15/183	8.2	4.7-13.2
			Subtotal	**58/656**	**8.86**	**6.8-11.3**
	2004[3]	0-5	Poor	377/2299	16.4	14.9-17.9
	2006[4]	0-5		695/4342	16.0	14.9-17.1
			Subtotal	**1072/6641**	**16.14**	**15.3-17.1**

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APPENDIX TABLE 3.2

Prevalence of underweight among children 6-10 years old

Sex	Date	Age group (Years)	SES strata	Prevalence Underweight		
				N	%	95% CI
	2002[5]	5.8-12.7	Poor	14/175	8	4.4-13.1
	2003[6]	6-7		12/116	10.7	5.5-17.4
	2004[7]	6-7		10/129	8.1	3.8-13.8
	2006[8]	5-9.9		7/653	1.07	0.4-2.2
			Subtotal	**44/1073**	**4.09**	**2.9-5.5**
BOYS & GIRLS	1997[9]	6-9.7	All	18/617	2.92	1.7-4.6
	1998[10]	5.2-8.7		43/895	4.8	3.5-6.4
	1999[11]	5.2-9.7		45/842	5.34	3.9-7.1
	2000[12]	6.1-9.7		18/444	4.05	2.4-6.3
	2001[13]	4.7-9.2		66/1559	4.23	3.3-5.4
	2002[14]	5.7-9.8		87/1201	7.24	5.8-8.9
	2009[15]	5.2-8.7		16/532	3.01	1.7-4.8
			Subtotal	**293/6090**	**4.81**	**4.3-5.4**
BOYS	2002[5]	5.8-12.7	Poor	6/72	8.3	3.1-17.3
	2006[8]	5-9.9		5/326	1.53	0.5-3.5
			Subtotal	**11/398**	**2.75**	**1.4-4.9**
	1997[9]	6-9.6	All	11/324	3.4	1.7-5.9
	1998[10]	5.2-8.7		28/447	6.26	4.2-8.9
	1999[11]	5.2-9.7		28/394	7.11	4.8-10.1
	2000[12]	6.1-9.7		14/218	6.42	3.6-10.5
	2001[13]	6.1-9.7		39/745	5.28	3.7-7.1
	2002[14]	5.9-9.8		56/584	9.59	7.3-12.3
	2009[15]	5.2-8.7		8/262	3.05	1.3-5.9
			Subtotal	**184/2974**	**6.2**	**5.4-7.1**
GIRLS	2002[5]	5.8-12.7	Poor	8/103	7.8	3.4-14.7
	2006[8]	5-9.9		2/327	0.61	0.07-2.2
			Subtotal	**10/430**	**2.33**	**1.12-4.24**
	1997[9]	6-9.6	All	7/293	2.39	0.9-4.9
	1998[10]	5.2-8.7		15/448	3.35	1.9-5.5
	1999[11]	5.2-9.7		17/448	3.79	2.2-6.01
	2000[12]	6.1-9.7		5/226	2.21	0.7-5.1
	2001[13]	6.1-9.7		25/814	3.09	1.9-4.5
	2002[14]	5.7-9.4		31/617	5.02	3.4-7.1
	2009[15]	5.2-8.7		8/270	2.96	1.3-5.8
			Subtotal	**108/3116**	**3.47**	**2.85-4.17**

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APPENDIX TABLE 3.3 Prevalence of underweight among children 11-18 years old						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Underweight**		
				N	**%**	**95% CI**
BOYS & GIRLS	2002[16]	13-18	All	77/1264	6.1	4.84-7.56
	2008[17]	13-18		71/1098	6.5	5.08-8.09
			Subtotal	**148/2362**	**6.29**	**5.32-7.32**
	2004[18]	11.4-14	Poor	13/66	19.7	10.9-31.3
	2006[19]	10-17		13/334	3.89	2.1-6.6
	2009[20]	10-16		5/162	3.09	1.01-7.1
			Subtotal	**31/562**	**5.52**	**3.78-7.74**
BOYS	2002[16]	13-18	All	54/556	9.7	7.38-12.5
	2008[17]	13-18		38/477	7.9	5.67-10.8
			Subtotal	**92/1033**	**8.87**	**7.24-10.81**
	2004[18]	11.4-14	Poor	9/42	21.4	10.3-36.8
	2006[19]	10-17		11/190	5.79	2.9-10.1
	2009[20]	10-16		1/60	1.67	0.04-8.9
			Subtotal	**21/292**	**7.19**	**4.5-10.8**
GIRLS	2002[16]	13-18	All	25/708	3.6	2.29-5.17
	2008[17]	13-18		34/621	5.4	3.82-7.57
			Subtotal	**59/1329**	**4.44**	**3.39-5.69**
	2004[18]	11.4-14	Poor	4/24	16.4	4.7-37.4
	2006[19]	10-17		2/144	1.39	0.2-4.9
	2009[20]	10-16		4/102	3.92	1.1-9.7
			Subtotal	**10/270**	**3.68**	**1.79-6.71**

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APPENDIX TABLE 4.1 Prevalence of stunting among children 0-5 years old						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Stunting**		
				N	**%**	**95% CI**
BOYS & GIRLS	1999[1]	1-9	All	47/324	14.5	10.9-18.8
	2003[2]	0-5		52/149	34.7	27.3-43.1
	2005[1]	1-9		22/183	12	7.7-17.6
			Total	**121/656**	**18.4**	**15.5-21.6**

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APPENDIX TABLE 4.2 Prevalence of stunting among 6-10 year old children						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Stunting**		
				N	**%**	**95% CI**
BOYS & GIRLS	1997[9]	6-9.9		42/617	6.81	4.9-9.1
	1998[10]	5.2-8.7		64/895	7.15	5.6-9.04
	1999[11]	5.2-9.7		74/842	8.79	6.9-10.9
	2000[12]	6.1-9.7	All	28/444	6.31	4.2-8.9
	2001[13]	6.1-9.7		99/1559	6.35	5.2-7.7
	2002[14]	5.7-9.8		128/1201	10.66	8.9-12.5
	2009[15]	5.2-8.7		19/532	3.57	2.2-5.5
			Subtotal	**454/6090**	**7.46**	**6.8-8.1**
	2003[6]	6-7		10/116	8.7	4.2-15.3
	2004[7]	6-7	Poor	23/129	17.8	11.7-25.5
	2006[8]	5-9.9		14/653	2.14	1.2-3.6
			Subtotal	**47/898**	**5.24**	**3.9-6.9**
BOYS	1997[9]	6-9.6		21/324	6.48	4.1-9.7
	1998[10]	5.2-8.7		42/447	9.4	6.9-12.5
	1999[11]	5.2-9.7		43/394	10.91	8.01-14.4
	2000[12]	6.1-9.7	All	13/218	5.96	3.2-9.98
	2001[13]	6.1-9.7		58/745	7.74	5.96-9.95
	2002[14]	5.7-9.8		80/584	13.7	11.01-16.76
	2009[15]	5.2-8.7		13/262	4.96	2.67-8.34
			Total	**270/2974**	**9.07**	**8.07-10.2**
GIRLS	1997[9]	6-9.6		21/293	7.17	4.49-10.75
	1998[10]	5.2-8.7		22/448	4.91	3.1-7.34
	1999[11]	5.2-9.7		31/448	6.92	4.75-9.68
	2000[12]	6.1-9.7	All	14/226	6.19	3.43-10.2
	2001[13]	6.1-9.7		39/814	4.83	3.43-6.49
	2002[14]	5.7-9.4		48/617	7.78	5.79-10.2
	2009[15]	5.2-8.7		6/270	2.22	0.82-4.77
			Total	**181/3116**	**5.27**	**5.01-6.69**

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APPENDIX TABLE 4.3

Prevalence of stunting among children 11-18 years old

Sex	Date	Age group (years)	SES strata	Prevalence Stunting		
				N	%	95% CI
BOYS & GIRLS	2004[18]	11.4-14	Poor	22/66	33.3	22.2-46.01
	2006[19]	10-17		42/334	12.57	9.2-16.6
	2009[20]	10-16		16/162	9.9	5.8-15.5
			Subtotal	**80/562**	**14.23**	**11.5-17.4**
	2002[16]	13-18	All	117/1206	9.7	8.09-11.5
	2008[17]	13-18		106/1101	9.6	7.95-11.5
			Subtotal	**223/2307**	**9.65**	**8.5-10.9**
BOYS	2004[18]	11.4-14	Poor	15/42	35.7	21.55-51.97
	2006[19]	10-17		28/190	14.74	10.02-20.59
	2009[20]	10-16		2/60	3.33	0.41-11.53
			Subtotal	**45/292**	**15.41**	**11.47-20.07**
	2002[16]	13-18	All	51/530	9.6	7.25-12.5
	2008[17]	13-18		45/480	9.4	6.92-12.3
			Subtotal	**96/1010**	**9.5**	**7.77-11.5**
GIRLS	2004[18]	11.4-14	Poor	7/24	29.2	12.6-51.1
	2006[19]	10-17		14/144	9.72	5.42-15.77
	2009[20]	10-16		14/102	13.73	7.71-21.96
			Subtotal	**35/270**	**12.97**	**9.2-17.56**
	2002[16]	13-18	All	66/676	9.8	7.63-12.3
	2008[17]	13-18		61/621	9.8	7.59-12.4
			Subtotal	**127/1297**	**9.8**	**8.23-11.5**

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APPENDIX TABLE 5.1 Prevalence of wasting among 0-5 year old children						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Underweight**		
				N	**%**	**95% CI**
BOYS & GIRLS	1999[1]	1-9	All	3/324	0.9	0.19-2.68
	2003[2]	0-5		9/149	6.2	2.79-11.16
	2005[1]	1-9		21/183	11.5	7.25-17.01
			Total	**33/656**	**5.06**	**3.49-6.99**

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APPENDIX TABLE 5.2

Prevalence of wasting among children 6-10 years old

Sex	Date	Age group (years)	SES strata	Prevalence Wasting		
				N	%	95% CI
BOYS & GIRLS	1997[9]	6-9.6		1/617	0.16	0.004-0.89
	1998[10]	5.2-8.7		9/895	1.01	0.46-1.9
	1999[11]	5.2-9.7		5/842	0.59	0.19-1.38
	2000[12]	6.1-9.7	All	9/444	2.03	0.93-3.81
	2001[13]	6.1-9.7		28/1559	1.8	1.19-2.59
	2002[14]	5.7-9.8		22/1201	1.83	1.15-2.76
	2009[15]	5.2-8.7		8/532	1.5	0.65-2.94
			Subtotal	**82/6090**	**1.35**	**1.07-1.67**
	2003[6]	6-7		1/116	1	0.022-4.71
	2004[7]	6-7	Poor	0/129	0	0-2.82
	2006[8]	5-9.9		16/653	2.45	1.41-3.95
			Subtotal	**17/898**	**1.91**	**1.11-3.01**
BOYS	1997[9]	6-9.6		0/324	0	0-1.13
	1998[10]	5.2-8.7		6/447	1.34	0.49-2.89
	1999[11]	5.2-9.7		2/394	0.51	0.062-1.82
	2000[12]	6.1-9.7	All	6/218	2.75	1.02-5.89
	2001[13]	6.1-9.7		11/745	1.47	0.74-2.63
	2002[14]	5.7-9.8		11/584	1.88	0.94-3.35
	2009[15]	5.2-8.7		4/262	1.53	0.42-3.86
			Total	**40/2974**	**1.34**	**0.96-1.83**
GIRLS	1997[9]	6-9.6		1/293	0.34	0.009-1.89
	1998[10]	5.2-8.7		3/448	0.67	0.14-1.94
	1999[11]	5.2-9.7		3/448	0.67	0.14-1.94
	2000[12]	6.1-9.7	All	3/226	1.33	0.28-3.83
	2001[13]	6.1-9.7		18/814	2.15	1.32-3.47
	2002[14]	5.7-9.4		11/617	1.78	0.89-3.17
	2009[15]	5.2-8.7		4/270	1.48	0.41-3.75
			Total	**42/3116**	**1.35**	**0.97-1.82**

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APPENDIX TABLE 5.3 Prevalence of wasting among children 11-18 years old						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Wasting**		
				N	**%**	**95% CI**
BOYS & GIRLS	2002[16]	13-18	All	37/1206	3.1	2.17-4.2
	2008[17]	13-18		41/1084	3.8	2.73-5.09
			Subtotal	**79/2290**	**3.43**	**2.74-4.28**
	2006[19]	10-17	Poor	8/334	2.4	1.04-4.67
	2009[20]	10-16		2/162	1.23	0.15-4.39
			Subtotal	**10/496**	**2.02**	**0.97-3.68**
BOYS	2002[16]	13-18	All	31/530	5.8	4.01-8.19
	2008[17]	13-18		26/470	5.5	3.65-8.0
			Subtotal	**57/1000**	**5.66**	**4.35-7.32**
	2006[19]	10-17	Poor	8/190	4.21	1.84-8.13
	2009[20]	10-16		0/60	0	0-5.96
			Subtotal	**8/250**	**3.2**	**1.39-6.21**
GIRLS	2002[16]	13-18	All	9/676	1.3	0.61-2.51
	2008[17]	13-18		14/614	2.2	1.25-3.79
			Subtotal	**22/1290**	**1.73**	**1.07-2.57**
	2006[19]	10-17	Poor	0/144	0	0-2.53
	2009[20]	10-16		2/102	1.96	0.24-6.9
			Subtotal	**2/246**	**0.81**	**0.009-2.91**

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APPENDIX TABLE 6.1 Prevalence of overweight among children 0-5 years old						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Overweight**		
				N	**%**	**95% CI**
BOYS & GIRLS	1999	1-9	All	17/324	5.2	3.09-8.27
	2005	1-9		6/183	3.3	1.21-6.99
			Total	**22/507**	**4.34**	**2.74-6.49**

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APPENDIX TABLE 6.2

Prevalence of overweight among children 6-10 years old

Sex	Date	Age group (years)	SES strata	Prevalence Overweight		
				N	%	95% CI
BOYS & GIRLS	1997[9]	6-9.6		26/617	4.21	2.77-6.11
	1998[10]	5.2-8.7		28/895	3.13	2.09-4.49
	1999[11]	5.2-9.7		17/842	2.02	1.18-3.21
	2000[12]	6.1-9.7	All	9/444	2.03	0.93-3.81
	2001[13]	6.1-9.7		66/1559	4.23	3.29-5.36
	2002[14]	5.7-9.8		34/1201	2.83	1.97-3.93
	2009[15]	5.2-8.7		40/532	7.52	5.43-10.09
			Total	**220/6090**	**3.61**	**3.16-4.11**
BOYS	1997[9]	6-9.6		6/324	1.85	0.68-3.99
	1998[10]	5.2-8.7		12/447	2.68	1.39-4.64
	1999[11]	5.2-9.7		8/394	2.03	0.88-3.96
	2000[12]	6.1-9.7	All	1/218	0.46	0.012-2.53
	2001[13]	6.1-9.7		33/745	4.42	3.07-6.16
	2002[14]	5.7-9.8		8/584	1.37	0.59-2.68
	2009[15]	5.2-8.7		19/262	7.25	4.42-11.09
			Total	**87/2974**	**2.93**	**2.35-3.59**
GIRLS	1997[9]	6-9.6		20/293	6.83	4.22-10.35
	1998[10]	5.2-8.7		16/448	3.57	2.05-5.74
	1999[11]	5.2-9.7		9/448	2.01	0.92-3.78
	2000[12]	6.1-9.7	All	8/226	3.54	1.54-6.86
	2001[13]	6.1-9.7		33/814	4.03	2.81-5.65
	2002[14]	5.7-9.4		26/617	4.21	2.77-6.11
	2009[15]	5.2-8.7		21/270	7.78	4.88-11.64
			Total	**133/3116**	**4.27**	**3.59-5.04**

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APPENDIX TABLE 6.3

Prevalence of overweight among children 11-18 years old

Sex	Date	Age group (years)	SES strata	Prevalence Overweight		
				N	%	95% CI
BOYS & GIRLS	2002[16]	13-18	All	255/1209	21.1	18.8-23.5
	2008[17]	13-18		225/1094	20.6	18.2-23.1
			Subtotal	**480/2303**	**20.9**	**19.2-22.6**
	2006[19]	10-17	Poor	2/334	0.6	0.073-2.15
	2009[20]	10-16		2/162	1.23	0.15-4.39
			Subtotal	**4/496**	**0.81**	**0.22-2.05**
BOYS	2002[16]	13-18	All	45/531	8.5	6.25-11.2
	2003[2]	15-19		1/60	2.3	0.042-8.94
	2008[17]	13-18		59/476	12	9.57-15.7
			Subtotal	**106/1067**	**4.68**	**8.21-11.9**
	2006[19]	10-17	Poor	2/190	1.05	0.13-3.75
	2009[20]	10-16		0/60	0	0-5.96
			Subtotal	**2/250**	**0.8**	**0.09-2.86**
GIRLS	2002[16]	13-18	All	201/678	29.7	26.2-33.2
	2003[2]	15-19		9/80	11.7	5.28-20.28
	2008[17]	13-18		172/618	27.9	24.3-31.6
			Subtotal	**383/1376**	**27.85**	**25.5-30.3**
	2006[19]	10-17	Poor	0/144	0	0-2.53
	2009[20]	10-16		2/102	1.96	0.24-6.9
			Subtotal	**2/246**	**0.81**	**0.99-2.91**

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APPENDIX TABLE 7.1

Prevalence of obesity among children 5-10 years old

Sex	Date	Age group (years)	SES strata	Prevalence Obesity		
				N	%	95% CI
BOYS & GIRLS	1997[9]	6-9.6	All	14/617	2.27	1.25-3.78
	1998[10]	5.2-8.7		12/895	1.34	0.69-2.33
	1999[11]	5.2-9.7		9/842	1.07	0.49-2.02
	2000[12]	6.1-9.7		3/444	0.68	0.14-1.96
	2001[13]	6.1-9.7		27/1559	1.73	1.14-2.51
	2002[14]	5.7-9.8		13/1201	1.08	0.58-1.84
	2009[15]	5.2-8.7		16/532	3.01	1.73-4.84
			Total	**94/6090**	**1.54**	**1.24-1.89**
BOYS	1997[9]	6-9.6	All	4/324	1.23	0.34-3.13
	1998[10]	5.2-8.7		4/447	0.89	0.24-2.28
	1999[11]	5.2-9.7		4/394	1.02	0.28-2.58
	2000[12]	6.1-9.7		1/218	0.46	0.012-2.53
	2001[13]	6.1-9.7		11/745	1.47	0.74-2.63
	2002[14]	5.7-9.8		2/584	0.34	0.042-1.23
	2009[15]	5.2-8.7		9/262	3.44	1.58-6.42
			Total	**35/2974**	**1.18**	**0.82-1.63**
GIRLS	1997[9]	6-9.6	All	10/293	3.41	1.65-6.19
	1998[10]	5.2-8.7		8/448	1.79	0.77-3.49
	1999[11]	5.2-9.7		5/448	1.12	0.33-2.37
	2000[12]	6.1-9.7		2/226	0.88	0.11-3.16
	2001[13]	6.1-9.7		16/814	2.01	1.13-3.17
	2002[14]	5.7-9.4		11/617	1.78	0.89-3.17
	2009[15]	5.2-8.7		7/270	2.59	1.05-5.27
			Total	**59/3116**	**1.90**	**1.44-2.43**

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APPENDIX TABLE 7.2 Prevalence of obesity among children 11-18 years old						
Sex	**Date**	**Age group (years)**	**SES strata**	**Prevalence Obesity**		
				N	**%**	**95% CI**
BOYS & GIRLS	2002[16]	13-18	All	86/1209	7.1	5.73-8.71
	2008[17]	13-18		63/1094	5.8	4.45-7.31
			Subtotal	**149/2303**	**6.48**	**5.52-7.44**
	2006[8]	10-17	Poor	0/334	0	0-1.09
	2009[20]	10-16		0/162	0	0-2.25
			Subtotal	**0/496**	**0**	**0-0.74**
BOYS	2002[16]	13-18	All	13/531	2.4	1.31-4.15
	2003[2]	15-19		1/60	2.3	0.042-8.94
	2008[17]	13-18		10/476	2.1	1.01-3.83
			Subtotal	**24/1067**	**2.26**	**1.45-3.33**
	2006[8]	10-17	Poor	0/190	0	0-1.92
	2009[20]	10-16		0/60	0	0-5.96
			Subtotal	**0/250**	**0**	**0-1.47**
GIRLS	2002[16]	13-18	All	70/678	10.3	8.14-12.86
	2003[2]	15-19		12/80	14.7	7.99-24.74
	2008[17]	13-18		57/618	9.2	7.06-11.78
			Subtotal	**138/1376**	**8.54**	**8.49-11.74**
	2006[8]	10-17	Poor	0/144	0.00	0.00-2.53
	2009[20]	10-16		0/102	0.00	0.00-3.55
			Subtotal	**0/246**	**0.00**	**0.00-1.49**

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APPENDIX Table 8

WHO Classification of severity of undernutrition at the public health level[21]

	Prevalence (%)		
	Stunting (H-a < -2SD)	Underweight (W-a < -2 SD)	Wasting (W-h < -2 SD)
Low/Acceptable	<20	<10	<5
Medium/Poor	20-29	10-19	5-9
High/Serious	30-39	20-29	10-14
Very high/Critical	≥40	≥30	≥15

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APPENDIX B: ETHICS APPROVAL

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Faculty of Health Sciences Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: sumayah.ariefdien@uct.ac.za

08 October 2010

HREC REF: 469/2010

Ms S Durao
School of Public Health & Family Medicine
Falmouth Building
Faculty of Health Sciences

Dear Ms Durao

PROJECT TITLE: THE ANTHROPOMETRIC NUTRITIONAL STATUS OF CHILDREN 0-18 YEARS IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA: A SYSTEMATIC REVIEW

Thank you for submitting your study to the Health Science Faculty Research Ethics Committee for review

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 15 October 2011.

Please submit a Standard Study Closure form (FHS010) on completion of the study.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

pp **PROFESSOR M BLOCKMAN**
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

sAriefdien

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

APPENDIX C: *PUBLIC HEALTH NUTRITION* INSTRUCTIONS FOR AUTHORS

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The submission must include a statement reporting any conflicts of interest, all sources of funding and the contribution of each author to the manuscript. If there are no conflicts of interest this must be stated. If the work was funded, please state "This work was supported by (for example) The Medical Research Council [grant number xxx (if applicable)]". If the research was not funded by any specific project grant, state "This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors." On submission the author will be asked to submit this information during the submission process and should not include it as part of the manuscript. This enables double-blind reviewing. If accepted, the paragraph will then be published as part of the manuscript. This journal adheres to the Committee on Publication Ethics (COPE) guidelines on research and publications ethics http://www.publicationethics.org.uk/guidelines ."

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(e) *Results*: these should be given as concisely as possible, using figures or tables as appropriate.
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and monographs should include the town of publication and the number of the edition to which reference is made. Thus:

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1. Setchell KD, Faughnan MS, Avades T *et al*. (2003) Comparing the pharmacokinetics of daidzein and genistein with the use of 13C-labeled tracers in premenopausal women. *Am J Clin Nutr* **77**, 411–419.
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ed., pp. 481–514 [GA Bray and C Bouchard, editors]. New York: Marcel Dekker.
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15. Henderson L, Gregory J, Irving K *et al*. (2004) *National Diet and Nutrition Survey: Adults Aged 19 to 64 Years*. vol. 2: *Energy, Protein, Fat and Carbohydrate Intake*. London: The Stationery Office.
16. International Agency for Research on Cancer (2004) *Cruciferous Vegetables, Isothiocyanates and Indoles. IARC Handbooks of Cancer Prevention* no. 9 [H Vainio and F Bianchini, editors]. Lyon, France: IARC Press.
17. Linder MC (1996) Copper. In *Present Knowledge in Nutrition*, 7th ed., pp. 307–319 [EE Zeigler and LJ Filer Jr, editors]. Washington, DC: ILSI Press.
18. World Health Organization (2003) *Diet, Nutrition and the Prevention of Chronic Diseases*. *Joint WHO/FAO Expert*

Consultation.
WHO Technical Report Series no. 916. Geneva: WHO.
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References to material available on websites should include the full Internet address, and the date of the version cited. Thus:

20. Department of Health (1997) Committee on Toxicity of Chemicals in Food Consumer Products and the Environment. Statement on vitamin B6 (pyridoxine) toxicity. http://www.open.gov.uk/doh/hef/B6.htm
21. Kramer MS & Kakuma R (2002) *The Optimal Duration of Exclusive Breastfeeding: A Systematic Review*. Rome: WHO; available at http://www.who.int/nut/documents/optimal_duration_of_exc_bfeeding_review_eng.pd
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http://www.mrw.interscience.wiley.com/cochrane/clsysrev/articles/CD003177/frame.html
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Mathematical modelling of nutritional processes. Papers in which mathematical modelling of nutritional processes forms the principal element will be considered for publication provided: (a) they are based on sound biological and mathematical principles; (b) they advance nutritional concepts or identify new avenues likely to lead to such advances; (c) assumptions used in their construction are fully described and supported by appropriate argument; (d) they are described in such a way that the nutritional purpose is clearly apparent; (e) the contribution of the model to the design of future experimentation is clearly defined.

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For substances of known molecular mass (Da) or relative molecular mass, e.g. glucose, urea, Ca, Na, Fe, K, P, values should be expressed as mol/l; for substances of indeterminate molecular mass (Da) or relative molecular mass, e.g. phospholipids, proteins, and for trace elements, e.g. Cu, Zn, then g/l should be used.
Time. The 24 h clock should be used, e.g. 15.00 hours.
Units are: year, month, week, d, h, min, s, kg, g, mg, µg, litre, ml, µl, fl. To avoid misunderstandings, the word litre should be used in full, except in terms like g/l. Radioactivity should be given in becquerels (Bq or GBq) not in Ci. 1 MBq = 27·03 µCi (1Bq = 1 disintegration/s).

Statistical treatment of results. Data from individual replicates should not be given for large experiments, but may be given for small studies. The methods of statistical analysis used should be described, and references to statistical analysis packages included in the text, thus: Statistical Analysis Systems statistical software package version 6.11 (SAS Institute, Cary, NC, USA). Information such as analysis of variance tables should be given in the paper only if they are relevant to the discussion. A statement of the number of replicates, their average value and some appropriate measure of variability is usually sufficient.
Comparisons between means can be made by using either confidence intervals (CI) or significance tests. The most appropriate of such measures is usually the standard error of a difference between means (SED), or the standard errors of the means (SE or SEM) when these vary between means. The standard deviation (SD) is more useful only when there is specific interest in the variability of individual values. The degrees of freedom (df) associated with SED, SEM or SD should also be stated. The number of decimal places quoted should be sufficient but not excessive. Note that pH is an exponential number, as are the log(10) values often quoted for microbial numbers. Statistics should be carried out on the scalar rather than the exponential values.
If comparisons between means are made using CI, the format for presentation is, e.g. 'difference between means 0·73 (95 % CI 0·314, 1·36) g'. If significance tests are used, a statement that the difference between the means for two groups of values is (or is not) statistically significant should include the level of significance attained, preferably as an explicit *P* value (e.g. *P*=0·016 or *P*=0·32) rather than as a range (e.g. *P*<0·05 or *P*>0·05}. It should be stated whether the significance levels quoted are one-sided or two-sided. Where a multiple comparison procedure is used, a description or explicit reference should be given. Where appropriate, a superscript notation may be used in tables to denote levels of significance; similar superscripts should denote lack of a significant difference. Where the method of analysis is unusual, or if the experimental design is at all complex, further details (e.g. experimental plan, raw data, confirmation of assumptions, analysis of variance tables, etc.) should be included.

Figures. In curves presenting experimental results the determined points should be clearly shown, the symbols used being, in order of preference, ○, ●, △, ▲, □, ■, ×, +. Curves and symbols should not extend beyond the experimental points. Scale-marks on the axes should be on the inner side of each axis and should extend beyond the last experimental point. Ensure that lines and symbols used in graphs and shading used in histograms are large enough to be easily identified when the figure is reduced to fit the printed page. Figures and diagrams can be prepared using most applications but please do not use the following: cdx, chm, jnb or PDF. All figures should be numbered and legends should be provided. Each figure, with its legend, should be comprehensible without reference to the text and should include definitions of abbreviations. Latin names for unusual species should be included unless they have already been specified in the text. Each figure will be positioned near the point in the text at which it is first introduced unless

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Refer to a recent copy of the journal for examples of figures.

Plates. The size of photomicrographs may have to be altered in printing; in order to avoid mistakes the magnification should be shown by scale on the photograph itself. The scale with the appropriate unit together with any lettering should be drawn by the author, preferably using appropriate software.

Tables. Tables should carry headings describing their content and should be comprehensible without reference to the text. Tables should not be subdivided by ruled lines. The dimensions of the values, e.g. mg/kg, should be given at the top of each column. Separate columns should be used for measures of variance (SD, SE etc.), the ± sign should not be used. The number of decimal places used should be standardized; for whole numbers 1·0, 2·0 etc. should be used. Shortened forms of the words weight (wt) height (ht) and experiment (Expt) may be used to save space in tables, but only Expt (when referring to a specified experiment, e.g. Expt 1) is acceptable in the heading.
Footnotes are given in the following order: (1) abbreviations, (2) superscript letters, (3) symbols. Abbreviations are given in the format: RS, resistant starch. Abbreviations appear in the footnote in the order that they appear in the table (reading from left to right across the table, then down each column). Abbreviations in tables must be defined in footnotes. Symbols for footnotes should be used
in the sequence: *†‡§‖¶, then ** etc. (omit * or †, or both, from the sequence if they are used to indicate levels of significance).
For indicating statistical significance, superscript letters or symbols may be used. Superscript letters are useful where comparisons are within a row or column and the level of significance is uniform, e.g. '^{a,b,c}Mean values within a column with unlike superscript letters were significantly different (P<0·05)'. Symbols are useful for indicating significant differences between rows or columns, especially where different levels of significance are found, e.g. 'Mean values were significantly different from those of the control group: *P<0·05, **P<0·01, ***P<0·001'. The symbols used for P values in the tables must be consistent.
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Descriptions of solutions, compositions and concentrations. Solutions of common acids, bases and salts should be defined in terms of molarity (M), e.g. 0·1 M-NaH_2PO_4. Compositions expressed as mass per unit mass (w/w) should have values expressed as ng,
µg, mg or g per kg; similarly for concentrations expressed as mass per unit volume (w/v), the denominator being the litre. If concentrations or compositions are expressed as a percentage, the basis for the composition should be specified (e.g. % (w/w) or % (w/v) etc.). The common measurements used in nutritional studies, e.g. digestibility, biological value and net protein utilization, should be expressed as decimals rather than as percentages, so that amounts of available nutrients can be obtained from analytical results by direct multiplication. See *Metric Units, Conversion Factors and Nomenclature in Nutritional and Food Sciences*. London: The Royal Society, 1972 (para. 8).

Nomenclature of vitamins. Most of the names for vitamins and related compounds that are accepted by the Editors are those recommended by the IUNS Committee on Nomenclature. See *Nutrition Abstracts and Reviews* (1978) **48**A, 831–835.

Acceptable name	*Other names**
Vitamin A	
Retinol	Vitamin A_1
Retinaldehyde, retinal	Retinene
Retinoic acid (all-*trans* or 13-*cis*)	Vitamin A_1 acid
3-Dehydroretinol	Vitamin A_2
Vitamin D	
Ergocalciferol, ercalciol	Vitamin D_2 calciferol
Cholecalciferol, calciol	Vitamin D_3
Vitamin E	
α-, β- and γ-tocopherols plus tocotrienols	
Vitamin K	
Phylloquinone	Vitamin K_1
Menaquinone-n (MK-n)†	Vitamin K_2
Menadione	Vitamin K_3, menaquinone, menaphthone
Vitamin B_1	
Thiamin	Aneurin(e), thiamine
Vitamin B_2	

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Riboflavin Vitamin G, riboflavine,
lactoflavin
Niacin
Nicotinamide Vitamin PP
Nicotinic acid
Folic Acid
Pteroyl(mono)glutamic acid Folacin, vitamin B_c or M
Vitamin B_6
Pyridoxine Pyridoxol
Pyridoxal
Pyridoxamine
Vitamin B_{12}
Cyanocobalamin
Hydroxocobalamin Vitamin B_{12a} or B_{12b}
Aquocobalamin
Methylcobalamin
Adenosylcobalamin
Inositol
Myo-inositol *Meso*-inositol
Choline
Pantothenic acid
Biotin Vitamin H
Vitamin C
Ascorbic acid
Dehydroascorbic acid

*Including some names that are still in use elsewhere, but are not used by the *British Journal of Nutrition*.
†Details of the nomenclature for these and other naturally-occurring quinones should follow the Tentative Rules of the IUPAC-IUB Commission on Biochemical Nomenclature (see *European Journal of Biochemistry* (1975) **53**, 15–18).
Generic descriptors. The terms **vitamin A**, **vitamin C** and **vitamin D** may still be used where appropriate, for example in phrases such as 'vitamin A deficiency', 'vitamin D activity'.
Vitamin E. The term **vitamin E** should be used as the descriptor for all tocol and tocotrienol derivatives exhibiting qualitatively the biological activity of α-tocopherol. The term **tocopherols** should be used as the generic descriptor for all methyl tocols. Thus, the term **tocopherol** is not synonymous with the term **vitamin E**.
Vitamin K. The term **vitamin K** should be used as the generic descriptor for 2-methyl-1,4-naphthoquinone (menaphthone) and all derivatives exhibiting qualitatively the biological activity of phylloquinone (phytylmenaquinone).
Niacin. The term **niacin** should be used as the generic descriptor for pyridine 3-carboxylic acid and derivatives exhibiting qualitatively the biological activity of nicotinamide.
Vitamin B_6. The term **vitamin B_6** should be used as the generic descriptor for all 2-methylpyridine derivatives exhibiting qualitatively the biological activity of pyridoxine.
Folate. Due to the wide range of C-substituted, unsubstituted, oxidized, reduced and mono- or polyglutamyl side-chain derivatives of pteroylmonoglutamic acid that exist in nature, it is not possible to provide a complete list. Authors are encouraged to use either the generic name or the correct scientific name(s) of the derivative(s), as appropriate for each circumstance.
Vitamin B_{12}. The term **vitamin B_{12}** should be used as the generic descriptor for all corrinoids exhibiting qualitatively the biological activity of cyanocobalamin. The term **corrinoids** should be used as the generic descriptor for all compounds containing the corrin nucleus and thus chemically related to cyanocobalamin. The term **corrinoid** is not synonymous with the term **vitamin B_{12}**.
Vitamin C. The terms **ascorbic acid** and **dehydroascorbic acid** will normally be taken as referring to the naturally-occurring L- forms. If the subject matter includes other optical isomers, authors are encouraged to include the L- or D- prefixes, as appropriate. The same is true for all those vitamins which can exist in both natural and alternative isomeric forms.
Amounts of vitamins and summation. Weight units are acceptable for the amounts of vitamins in foods and diets. For concentrations in biological tissues, SI units should be used; however, the authors may, if they wish, also include other units, such as weights or international units, in parentheses.
See *Metric Units, Conversion Factors and Nomenclature in Nutritional and Food Sciences* (1972) paras 8 and 14–20. London: The Royal Society.

Nomenclature of fatty acids and lipids. In the description of results obtained for the analysis of fatty acids by conventional GLC, the shorthand designation proposed by Farquhar JW, Insull W, Rosen P, Stoffel W & Ahrens EH (*Nutrition Reviews* (1959), **17**, Suppl.) for individual fatty acids should be used in the text, tables and figures. Thus, 18 : 1 should be used to represent a fatty acid with eighteen carbon atoms and one double bond; if the position and configuration of the double bond is unknown. The shorthand designation should also be used in the abstract. If the positions and configurations of the double bonds are known, and these are important to the discussion, then a fatty acid such as linoleic acid may be referred to as *cis*-9,*cis*-12-18 : 2 (positions of double bonds related to the carboxyl carbon atom 1). However, to illustrate the metabolic relationship between different unsaturated fatty acid families, it is sometimes more helpful to number the double bonds in relation to the terminal methyl carbon atom, *n*. The preferred nomenclature is then: 18 : 3*n*-3 and 18 : 3*n*-6 for α-linolenic and γ-linolenic acids respectively; 18 : 2*n*-6 and 20 : 4*n*-6 for linoleic and arachidonic acids respectively and 18 : 1*n*-9 for oleic acid. Positional isomers such as α- and γ-linolenic acid should always be clearly distinguished. It is assumed that the double bonds are methylene-interrupted and are of the *cis*-configuration (see Holman RT in *Progress in the Chemistry of Fats and Other Lipids* (1966) vol. 9, part 1, p. 3. Oxford: Pergamon Press). Groups of fatty acids that have a common chain length but vary in their double bond content or double bond position should be referred to, for example, as C_{20}

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fatty acids or C_{20} PUFA. The modern nomenclature for glycerol esters should be used, i.e. triacylglycerol, diacylglycerol, monoacylglycerol *not* triglyceride, diglyceride, monoglyceride. The form of fatty acids used in diets should be clearly stated, i.e. whether ethyl esters, natural or refined fats or oils. The composition of the fatty acids in the dietary fat and tissue fats should be stated
clearly, expressed as mol/100 mol or g/100 g total fatty acids.

Nomenclature of micro-organisms. The correct name of the organism, conforming with international rules of nomenclature, should be used: if desired, synonyms may be added in parentheses when the name is first mentioned. Names of bacteria should conform to the current Bacteriological Code and the opinions issued by the International Committee on Systematic Bacteriology. Names of algae and fungi must conform to the current International Code of Botanical Nomenclature. Names of protozoa should conform to the current International Code of Zoological Nomenclature.

Nomenclature of plants. For plant species where a common name is used that may not be universally intelligible, the Latin name in italics should follow the first mention of the common name. The cultivar should be given where appropriate.

Ethics of human experimentation. The notice of contributors is drawn to the guidelines in the World Medical Association (2000) Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects, with notes of clarification of 2002 and 2004 http://www.wma.net/e/policy/b3.htm, the *Guidelines on the Practice of Ethics Committees Involved in Medical Research Involving Human Subjects* (3rd ed., 1996; London: The Royal College of Physicians) and the Guidelines for the Ethical Conduct of Medical Research Involving Children, revised in 2000 by the Royal College of Paediatrics and Child Health: Ethics Advisory Committee (*Arch Dis Child* (2000) **82**, 177–182). A paper describing any experimental work on human subjects should include a statement that ethical approval has been obtained.

Animal experimentation. The Editors will not accept papers reporting work carried out using inhumane procedures. Authors should indicate that their experiments have been approved by the appropriate local or national ethics committee for animal experiments.

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