

Potential contribution of African leafy vegetables to the nutritional status of children

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ABSTRACT

Background: Children in South Africa are still affected by micronutrient deficiencies and children living in farm communities are especially vulnerable. African Leafy Vegetables (ALVs) are well endowed with micronutrients such as iron, zinc and vitamin A and might contribute to the nutritional status of children. However, these vegetables have been perceived as “poor people’s food” and over the years knowledge of and use of ALVs has decreased.

Aim: This study assessed the potential contribution of ALVs to the nutritional status of children in a semi-rural farm community.

Method: In this cross-sectional study, anthropometric indices, serum iron, zinc and retinol concentrations were determined in school children aged 5–13 years (n=155). Dietary intake of iron, zinc and vitamin A was evaluated by three 24-hour diet recalls of children (n=154). The iron, zinc and β -carotene content of selected ALVs was determined. Knowledge of and use of ALVs by primary caregivers was established using focus group discussions (FGDs). Descriptive statistics, independent t-tests, the Pearson Chi-Square Test and Mann-Whitney U Test were used. Anthropometric data were analysed using the World Health Organization Reference 2007 data. Dietary data were analysed using FoodFinder (version 3). Qualitative data from FGDs were translated, transcribed and color-coded to generate emerging themes.

Results: Stunting (11%) was the most prevalent anthropometric indicator of malnutrition. This was supported by the low socio-economic status of households. Deficiency prevalence in iron (serum ferritin <15 $\mu\text{g/L}$; 15.5%) and vitamin A (serum retinol <20 $\mu\text{g/dL}$; 3.2%) was low. Zinc deficiency was the most prevalent (serum zinc <65 $\mu\text{g/dL}$; 74.8%) deficiency. Median dietary intake of iron, zinc and vitamin A was generally above the Estimated Average Requirement. ALVs were potentially good sources of iron, zinc and β -carotene and could contribute substantially to the Recommended Dietary Allowance for these nutrients in children, without taking into account inhibiting factors that might affect the bioavailability. Iron content of the ALVs studied ranged from 1.4–3.2 mg/100 g edible portion. *Amaranthus cruentus* was the best source of iron. Zinc content of the ALVs ranged from 0.7–1.4 mg/100g edible portions, with *Cleome gynandra* having the highest zinc composition. The β -carotene content of the ALVs ranged from 182–314 $\mu\text{g RAE/100 g}$ edible portion, with both *Amaranthus cruentus* and *Cleome gynandra* being the best sources. Knowledge of ALVs

and their use was indigenous and was transferred between generations. Caregivers had positive attitudes towards the use of ALVs.

Conclusion: Although the prevalence of deficiencies was not severe (with exception of zinc deficiency), micronutrient deficiencies exist in the rural farm community studied. ALVs are potentially good sources of iron, zinc and β -carotene and might contribute to the nutritional status of school children. Knowledge of ALVs and the positive attitude and perceptions regarding their use by primary caregivers implied a potentially positive future response to interventions promoting consumption of ALVs in order to contribute to the alleviation of micronutrient deficiencies.

Key words: African Leafy Vegetables; nutritional status; semi-rural farm community; micronutrient deficiencies; iron; zinc; vitamin A

OPSOMMING

Agtergrond: Kinders in Suid-Afrika is steeds geaffekteer deur mikronutriënttekorte en kinders wat in plaasgemeenskappe leef, is veral kwesbaar. Afrika blaargroentes (ABGs) is ryk aan mikronutriënte soos yster, sink en vitamien A en mag tot die voedingstatus van kinders bydra. Hierdie groentes word egter beskou as armmense se voedsel en oor die jare het die kennis en gebruik van ABGs afgeneem.

Doel: Hierdie studie het die potensiële bydrae van ABGs tot die voedingstatus van kinders in 'n semi-plattelandse plaasgemeenskap ondersoek.

Metode: In hierdie dwarsnitstudie is antropometriese indekse, serumyster-, -sink- en –retinol-konsentrasies bepaal van skoolkinders 5-13 jaar oud ($n=155$). Dieetinnames van yster, sink en vitamien A is bepaal met drie 24-uurherroepe van kinders ($n=154$). Die yster-, sink- en β -karoteeninhoud van geselekteerde ABGs is bepaal. Kennis van en gebruik van ABGs deur primêre versorgers is vasgestel deur gebruik te maak van fokusgroepbesprekings (FGBs). Beskrywende statistiek, onafhanklike t-toetse, Pearson Chi-kwadraattoets en Mann-Whitney U- toets was gebruik. Antropometriese data is geanaliseer deur gebruik te maak van die *World Health Organization Reference 2007* data. Dieetdata is geanaliseer met *FoodFinder* (version 3). Kwalitatiewe data van FGBs is vertaal, getranskribeer en kleurkodeer om temas wat te voorskyn tree, te genereer.

Resultate: Groei-inkorting (11%) was die mees algemene antropometriese indikator van wanvoeding. Dit is ondersteun deur 'n lae sosio-ekonomiese status van huishoudings. Die voorkoms van tekorte in yster (serumferritien $<15 \mu\text{g/L}$; 15.5%) en vitamien A ($<20 \mu\text{g/L}$; 3.2%) was laag. Sinktekort was die mees algemene tekort (serumsink $<65 \mu\text{g/L}$; 74.8%). Mediaan dieetinnames van yster, sink en vitamien A was oor die algemeen bo die Geskatte Gemiddelde Vereiste (GGV; *EAR*). ABGs was potensieel goeie bronne van yster, sink en β -karoteen en kon aansienlik bydra tot die Aanbevole Dieettoelaes (ADTs; *RDA*) vir hierdie nutriënte in kinders, sonder om die inhiberende faktore wat die biobeskikbaarheid mag beïnvloed, in ag te neem. Ysterinhoud van bestudeerde ABGs het gestrek van 1.4-3.2 mg/100g eetbare porsie. *Amaranthus cruentus* was die beste bron van yster. Sinkinhoud van die ABGs het gestrek van 0.7-1.4 mg/100g eetbare porsie, met *Cleome gynandra* wat die hoogste sinkinhoud gehad het. β -karoteeninhoud van die ABGs het gestrek van 182-314

µgRAE/100g eetbare porsie, met beide *Amaranthus cruentus* en *Cleome gynandra* as die beste bronne. Kennis van ABGs en hulle gebruik was inheems en deur geslagte oorgedra.

Gevolgtrekking: Hoewel die voorkoms van tekorte nie ernstig was nie (met die uitsondering van sinktekort), is daar mikronutriënttekorte in die plattelandse plaasgemeenskap wat bestudeer is. ABGs is potensieel goeie bronne van yster, sink en β-karoteen en mag bydra tot die voedingstatus van skoolkinders. Kennis van ABGs en die positiewe houding en persepsies teenoor die gebruik daarvan deur primêre versorgers het 'n potensiele positiewe toekomstige respons geïmpliseer tot intervensies wat die verbruik van ABGs promoveer ten einde die mikronutriënttekorte te verlig.

Sleutelwoorde: Afrika blaargroentes; voedingstatus; semi-plattelandse plaasgemeenskap; mikronutriënttekorte; yster; sink; vitamien A

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LIST OF ABBREVIATIONS

AGP	Alpha-1 glycoprotein
ALVs	African Leafy Vegetables
ARC	Agricultural Research Council
BMAZ	Body Mass Index-for-age Z- scores
CI	Confidence interval
CRP	C-reactive protein
DRI	Dietary Reference Intakes
EAR	Estimated Average Requirement
EDTA	Ethylenediaminetetraacetic acid
FAO	Food and Agriculture Organization
FGDs	Focus group discussions
FLAGH	Farm Labour and General Health Programme
FPPB	Food portion photograph book
HAZ	Height-for-age Z-scores
Hb	Haemoglobin
ID	Iron deficiency
IDA	Iron deficiency anaemia
KZN	KwaZulu-Natal
MRC	Medical Research Council
NFCS	National Food Consumption Survey
NFSC-FB	Food-based National Food Consumption Survey
NHANES	National Health and Nutrition Examination Survey
NW	North West
NWU	North-West University
RAE	Retinol activity equivalents
RAE	Retinol Activity equivalents

RBC	Red blood cells
RDAs	Recommended Dietary Allowances
RE	Retinol equivalents
SA	South Africa
SAVACG	South African Vitamin A Consultative Group
sTfR	Serum transferrin receptor
TIBC	Total iron binding capacity
USA	United States of America
USDA	United States Department of Agriculture
VAD	Vitamin A deficiency
WAZ	Weight-for-age Z-scores
WHO	World Health Organization
ZPP	Zinc protoporphyrin

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CHAPTER 1: INTRODUCTION AND AIM

1.1. Background and justification

Malnutrition is a public health concern especially affecting the developing world. Although a great deal of progress has been made in this area over the years, in Africa alone it is estimated that about 32 million children have poor nutritional status. The prevalence of underweight and stunting in children in southern Africa has been reported to be 13.6% and 24.3% respectively (FAO, 2010; Oldewage-Theron *et al.*, 2006). This prevalence of malnutrition has been associated with the chronic food shortages, poor food quality and insufficient food intake which are known to exist in southern Africa (FAO, 2010; Misselhorn, 2005). Malnutrition increases morbidity and mortality and has immense impact on physical growth and development. Some of the effects of malnutrition are known to result from micronutrient deficiencies (Bhan *et al.*, 2001). Micronutrient malnutrition is an on-going problem affecting mostly children. School-aged children are often excluded from health and nutrition interventions, yet their nutritional status has a huge influence on their cognition and health, which consequently affects their performance in school (Best *et al.*, 2010).

In South Africa (SA), the 1999 National Food Consumption Survey (NFCS) and the 2005 food-based NFCS (NFCS-FB-I11) revealed that stunting and underweight were the most prominent nutrition disorders in children aged 1–9 years. Almost one in five children was stunted and almost one in 10 children was underweight (Labadarios *et al.*, 2008). The 1999 NFCS also reported that the energy and essential micronutrient intake of one out of two children was approximately less than half of what is recommended, especially in rural areas (Labadarios *et al.*, 2005). The micronutrients that were found to be consumed at less than 67% of the Recommended Dietary Allowances (RDAs) were calcium, vitamin A, iron and zinc. Moreover, two out of three children had poor vitamin A status; one out of seven children was iron deficient and 45.3% of children had inadequate zinc status. The same survey also documented the insufficient intake of vitamin C, thiamine, riboflavin, niacin, vitamin B6, vitamin B12, and folic acid among a large number of children (Labadarios *et al.*, 2005).

African leafy vegetables (ALVs) have been reported to be good sources of most of these above-mentioned micronutrients, in particular iron, zinc and vitamin A (β -carotene). The lack of these micronutrients has caused great concern. Diets in developing countries are also known to lack a wide range of micronutrients (Tontisirin *et al.*, 2002). The β -carotene and iron content of ALVs are known to range from 99–1970 μg RE and 0.2–12.8 mg per 100 g edible portions respectively (Uusiku *et al.*, 2010). Moreover, apart from being great sources of vitamin A and iron, dark green ALVs supply other nutrients such as folic acid, ascorbic acid, zinc, and phytonutrients (Tontisirin *et al.*, 2002). Muhanji *et al.* (2011) have noted that in sub-Saharan Africa alone there are about 1,000 edible leafy vegetables.

Despite all the established research on the nutritional and non-nutritional benefits of ALVs, their consumption by many communities has decreased over the years (Dweba & Mearns, 2011). Knowledge of ALVs and their use is crucial for the survival of many African communities because they can serve as affordable sources of micronutrients (Termote *et al.*, 2011; Voster *et al.*, 2007). Modernisation of South African rural communities has been blamed for reduced consumption and negative perceptions of the use of ALVs. Faber *et al.* (2010) reported that ALVs in KwaZulu-Natal (KZN) were often regarded as a poor person's food. Labels like "backward knowledge" are linked to traditional vegetables and associated knowledge, thus discouraging the youth from learning about them (Vorster *et al.*, 2007). In SA it was reported that at the national level, one out of two households (51.6%) experienced hunger, and the households that were most at risk of food insecurity were those living in informal settlements and those that had the lowest monthly income (Chopra *et al.*, 2009). Farm communities in SA often have informal settlements and those living in them are said to be the least privileged of the population of SA. Farm communities form 45.8% of the rural population in the country and have been labelled the most vulnerable population in terms of income, health status, education and household nutrition security (Chopra *et al.*, 2009; Kruger *et al.*, 2006), making them an appropriate population for nutrition interventions.

Uusiku *et al.* (2010) and other authors studied the nutritional value of many ALVs and established that their use can potentially contribute to the reduction of micronutrient malnutrition and further improve human health. However, no studies have been carried out on how these vegetables can potentially make a contribution to the nutritional status of children in semi-rural farm communities, particularly in the North West (NW) Province of SA. There is therefore a research gap in public health nutrition on the potential contribution of ALVs to food intake in semi-rural farm communities within SA. More research on ALVs is needed in order to establish a solid foundation for promoting the use and conservation of

these vegetables in addressing micronutrient malnutrition using food-based approaches, and to contribute to the strategies currently being employed. Matenge (2012) found that *Cleome gynandra* (spiderplant), *Cucurbita maxima* (pumpkin), *Amaranthus cruentus* (amaranth) and *Vigna unguiculata* (cowpeas) were the ALVs most commonly consumed by the Setswana population in the NW Province of SA. Consequently, these four ALVs were included in this study and examined for their nutrient composition. The purpose of this study was to establish the potential contribution of ALVs to the nutritional status of children in a semi-rural farm community in the NW Province, SA.

1.2. The contribution of the study

This study is embedded in a larger research project entitled “Effect of African Leafy Vegetables on the alleviation of micronutrient deficiencies in school children residing in the NW Province of South Africa”. This latter study is partly linked to the infrastructure of the Farm Labour and General Health Programme (FLAGH). FLAGH is a transdisciplinary research, intervention and development programme, aimed at creating jobs and alleviating poverty among farm dwellers, identified as a vulnerable group. This programme targets farming communities around the Potchefstroom district. Therefore, results of this study will generate necessary data that will verify the need for intervention studies geared towards the consumption of ALVs in order to contribute to the eradication of micronutrient malnutrition in semi-rural farm communities in SA.

1.3. Research aim

To assess the potential contribution of ALVs to the nutritional status of children in a semi-rural farm community.

1.4. Specific research objectives

1. To establish a situational analysis of the semi-rural farm community by:
 - i. Assessing the socio-demographic and socio-economic parameters of households.
 - ii. Assessing the nutritional status of children, based on anthropometric measurements and dietary intake.
 - iii. Assessing the baseline blood of children from grade R to grade four for iron, zinc and vitamin A status.
2. To evaluate the nutritional composition of four selected ALVs.
3. To assess the extent of the knowledge and the use of ALVs by the semi-rural farm community.
4. To integrate the three above-mentioned objectives, in order to assess the potential contribution of ALVs to the nutritional status of children in the semi-rural farm community.

1.5. Research Team

The following people contributed to this dissertation:

Name	Affiliation	Role in the study
Prof. C.M. Smuts	Centre of Excellence for Nutrition, North-West University, Potchefstroom Campus	Supervisor of MSc. dissertation, guidance with protocol writing and interpretation of results.
Mrs M. van der Hoeven	Centre of Excellence for Nutrition and Africa Unit for Transdisciplinary Health Research, North-West University, Potchefstroom Campus	Co-supervisor of MSc. dissertation, guidance with protocol writing, data collection, analysis and interpretation of results.
Prof. M. Faber	Medical Research Council, Cape Town	Assisted with the analysis of dietary data.
Prof. M. Greeff	Africa Unit for Transdisciplinary Health Research, North-West University, Potchefstroom Campus	Content and construct validity of data collection tool for focus group discussions
Miss. J Osei	Centre of Excellence for Nutrition, North-West University, Potchefstroom Campus	Full-time MSc. student, protocol writing, data collection, analysis and interpretation of results, and write-up of MSc. dissertation.

1.6. Structure of this mini-dissertation

This mini-dissertation is divided into six chapters. The first chapter is a general introduction to the project. Chapter two covers past and current literature, focusing on deficiencies in iron, zinc and vitamin A in children, and the potential contribution of ALVs to the nutritional status of children. Chapter three outlines the study design and methodology. Chapter four provides the study results. Chapter five presents the discussions and limitations of the results obtained and finally, chapter six presents the study conclusions and recommendations. The references and addenda follow thereafter.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter will discuss micronutrient malnutrition as a public health concern. The focus will be on deficiencies in iron, zinc and vitamin A. An overview of the literature on the nutritional status of children in SA will also be presented. The potential contribution of ALVs in combating deficiencies of iron, zinc and vitamin A will be discussed as described in literature.

2.2. Micronutrient deficiencies

Micronutrients are vitamins and minerals that are needed by the human body in minuscule amounts to enable production of enzymes and hormones, and to stimulate growth and other bodily functions (Evans & Halliwell, 2001). Fruits and vegetables are known to be rich sources of various micronutrients. Micronutrient deficiencies occur when habitual diets become monotonous and lack diversity (Kennedy *et al.*, 2003). Micronutrient malnutrition is also termed “hidden hunger” as the consequences often go unnoticed (Faber & Wenhold, 2007:395). It is estimated that more than two billion people worldwide are affected by micronutrient deficiencies, with deficiencies primarily in vitamin A, iodine, zinc and iron causing greatest public health concern (Faber *et al.*, 2010; Kennedy *et al.*, 2003; Tulchinsky, 2010).

Table 2.1 below illustrates the worldwide prevalence of selected micronutrient deficiencies. In this literature overview attention will be given specifically to iron, zinc and vitamin A. ALVs, which are the main focus of this study, are said to be well endowed with these micronutrients. Deficiencies of iron, zinc and vitamin A are a major contributor to deaths in young children in sub-Saharan Africa and Asia, as illustrated by figure 2.1 below (Caulfield *et al.*, 2006).

Table 2.1: Worldwide prevalence of selected micronutrient deficiency conditions

<i>Micronutrient</i>	<i>Deficiency Prevalence</i>	<i>Major Deficiency Disorders</i>
Iron	2 billion people	Iron deficiency, anaemia, increased maternal and infant mortality, cognitive impairment
Zinc	Estimated to be high in developing countries	Impaired growth (stunting), genetic disorders, decreased resistance to infectious diseases
Iodine	2 billion people at risk	Goitre, hypothyroidism, birth defects, cognitive impairment
Vitamin A	254 million pre-school children	Night blindness, xerophthalmia, increased risk of mortality in children and pregnant women

Adapted from Tulchinsky (2010)

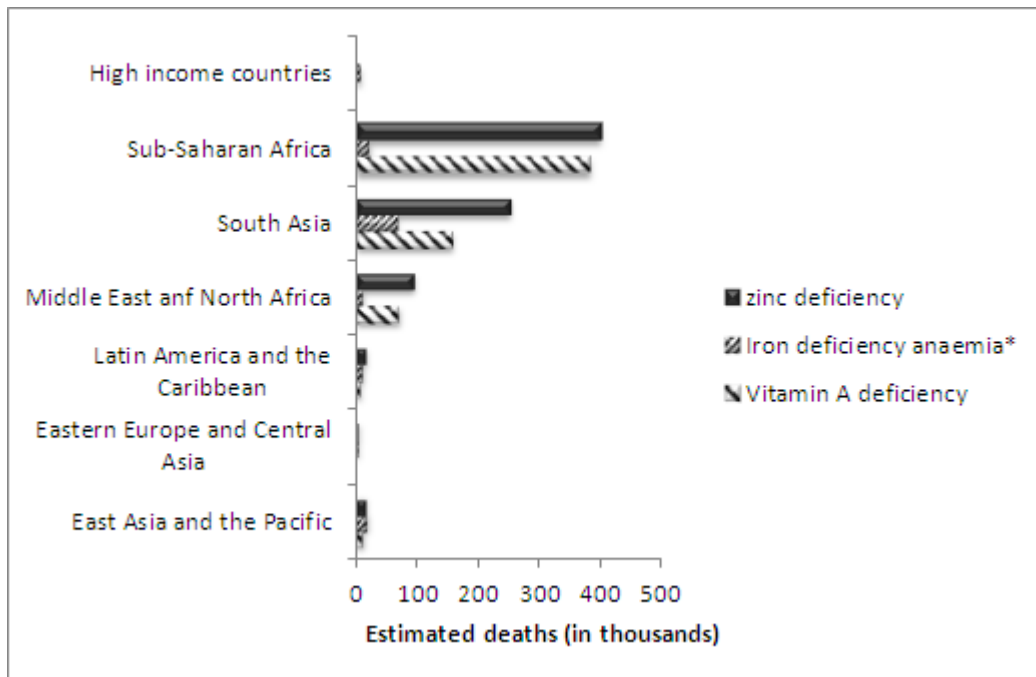


Figure 2.1: Estimated deaths of children (from birth to four years of age) attributable to selected nutritional deficiencies by region (*thousands*)

Note: This figure considers deaths only directly attributable to iron-deficiency anaemia in children.

*Excludes perinatal deaths attributable to maternal iron-deficiency anaemia.

(Adapted from Caulfield *et al.*, 2006)

2.2.1. Iron

Iron is required by human tissues, more particularly the brain, muscle and red blood cells (RBC), for basic cellular function. It is found primarily in haemoglobin (Hb) in the RBC and in myoglobin. Iron is used for the binding and transportation of oxygen and is also useful in regulating cell growth and differentiation (Caulfield *et al.*, 2006). Leafy vegetables can be a source of iron although meat sources may contain more iron, which is also more bioavailable. In order to have an adequate intake of iron, one would have to acquire a diet containing a combination of meat, eggs, fruits and vegetables (Pettit *et al.*, 2011). Dietary factors such as the type of iron (haem iron versus nonhaem iron), phytate, polyphenols, calcium and vitamin C, influence the bioavailability of iron. Haem iron is obtained from animal food sources whereas nonhaem iron is found in both plant and animal food sources (Faber & Wenhold, 2007). Vitamin C is the most potent enhancer of nonhaem iron absorption. However, animal food sources such as meat, fish and poultry contain a peptide

known as the MFP factor that also aids in the absorption of nonhaem iron if consumed with plant food sources at the same time (DeBruyne *et al.*, 2012). Phytate and polyphenols inhibit the absorption of nonhaem iron, whereas calcium inhibits the absorption of both haem and nonhaem iron (Faber & Wenhold, 2007).

2.2.1.1. Iron deficiency and iron-deficiency anaemia

Iron is present in many foods; therefore its intake is directly linked to energy intake. Deficiency is most likely to occur when iron requirements are greater than energy needs. This is what is often observed in infants, young children, adolescents and menstruating and pregnant women (Zimmermann & Hurrell, 2007). Deficiency of iron is usually defined as a ferritin level <15 µg/L in children aged five years and older (Nojilana *et al.*, 2007). A person is iron deficient when iron stores are depleted, regardless of the degree of iron depletion. The aetiology of iron deficiency can be described in three stages. In the first stage iron stores diminish. At this stage, serum ferritin measures are the most accurate to reflect iron stores and indicate iron status. The second stage of iron deficiency is characterised by a decrease in the transportation of iron within the body. The third stage occurs when the supply of transport iron diminishes to the point that it limits Hb production (WHO, 2011a).

Severe depletion of iron stores results in a low haemoglobin concentration, which is the leading cause of anaemia, thus iron-deficiency anaemia (IDA) (Pettit *et al.*, 2011). On average about 50% of the global prevalence of anaemia is a result of iron deficiency (Stoltzfus, 2003). Anaemia is defined as Hb <11.5 µg/L. In children aged 5–13 years IDA is defined as Hb <11.5 or 12.0 µg/L and serum ferritin <15 µg/L (WHO, 2011a). Although iron deficiency is the leading cause of anaemia, there are other causes of anaemia which should not be overlooked, such as deficiencies in folate and vitamin B₁₂, reproductive blood losses and infections or parasites (Gibney *et al.*, 2004; Kennedy *et al.*, 2003).

Iron deficiency often proceeds harmfully without being noticed, making it very difficult to estimate its prevalence. As a result, anaemia is used as a proxy. The public health significance of anaemia in populations is classified by its prevalence estimated from blood levels of haemoglobin. A prevalence of 40% or higher is classified as severe, 20–39.9% is moderate, 5–19.9% is mild and <4.9% is normal (WHO, 2011a). Women of childbearing age, pregnant women, pre-school children and young children are most at risk of being iron deficient or anaemic. This is due to their increased requirements during the different life developmental stages (Kennedy *et al.*, 2003; Nojilana *et al.*, 2007; Tulchinsky, 2010). It is

estimated that about two billion people worldwide are affected by IDA. In 2001, estimations from WHO indicated that 39% of children younger than five years, 48% of children aged 5–18 years, 42% of all women, and 52% of pregnant women in developing countries were anaemic. More recently, the prevalence of IDA among pre-school children in developing countries has been estimated at 42% (WHO, 2008). Women who are deficient in iron during pregnancy have higher chances of dying during childbirth and giving birth to babies with low birth weight (Kennedy *et al.*, 2003). Inadequate dietary iron intake, poor bioavailability of dietary iron and increased iron requirements are the main causes of iron deficiency and IDA (Black, 2012). In addition, malabsorption caused by disorders like *Helicobacter pylori* infections in the upper small intestine can also cause iron deficiency (Lynch, 2007).

2.2.1.2. Indicators of iron status

Various biochemical and haematological tests can be used to determine the iron status of individuals and populations. Serum ferritin and Hb are the most commonly used indicators to diagnose iron deficiency and anaemia respectively (Bhaskaram *et al.*, 2003). The body's total iron stores are reflected by serum ferritin, making it the most important indicator of iron status. Serum ferritin levels can be affected by inflammation, infections and liver disease, causing its levels to elevate, thereby limiting it as a measure of iron stores. To solve this, parameters of acute and chronic infection are also measured together with serum ferritin. This identifies subjects with elevated ferritin concentration due to infection (Biesalski & Erhardt, 2007). Measurement of Hb to detect anaemia is inexpensive; however, it is not very sensitive or specific for iron deficiency. Hb synthesis is affected only at the third stage of iron deficiency, and other conditions and illnesses can influence the concentration of Hb, as mentioned above (Biesalski & Erhardt, 2007).

Other indicators to determine iron status include the use of zinc protoporphyrin (ZPP), total iron-binding capacity, transferrin saturation, and transferrin receptors. ZPP is the Hb precursor and it elevates during iron deficiency to indicate an insufficient supply of iron for haem synthesis. During the second stage of deficiency, before Hb levels drop below the cut-off levels, the iron in protoporphyrin is substituted by zinc and can be selectively measured by haematofluorometry. This makes ZPP a more sensitive parameter than Hb, because ZPP can give an indication of iron deficiency before it becomes severe (Biesalski & Erhardt, 2007; Gibney *et al.*, 2004). Iron is transported in the serum bound to a protein transporter known as transferrin. Supply of iron to tissues is indicated by the total iron-binding capacity (TIBC)

and transferrin saturation. During iron deficiency, transferrin saturation, which is a ratio of serum iron and TIBC, is decreased (Lutter, 2008). Transferrin saturation is expressed as a percentage. Serum transferrin receptor levels have been identified as the best tool for assessing ID. This is because it has been shown to be able to detect ID in the presence of chronic inflammatory conditions and infections (Bhaskaram *et al.*, 2003). In cases of iron deficiency, plasma transferrin receptors elevate, indicating an insufficient supply of iron to cells, or iron depletion in the body (Gibney *et al.*, 2004)

C-reactive protein (CRP), which is an acute-phase response factor, is also often measured during assessment of iron status in order to identify subjects with concurrent infections so as to control for this confounding factor during analysis of serum iron (Samuel *et al.*, 2010). Alpha-1 glycoprotein (AGP) is also used as a parameter to measure chronic infections during assessment of iron status (Biesalski & Erhardt, 2007). Table 2.2 shows the cut-off values of selected iron deficiency and IDA for various age and sex groups.

Table 2.2: Cut-off values of selected indicators for iron deficiency and IDA for various age and sex groups

Indicator	Age/ sex group	Cut-off values
Haemoglobin (g/dL)	Children 5–11years	11.5
	Children 12–13 years	12.0
Erythrocyte zinc protoporphyrin (ZPP) (µmol/mol haem)	Children 5 years or younger	>70
	Children older than 5 years	>80
	Children older than 5 years on washed red cells	>40
Transferrin saturation	All	<16%
Serum ferritin (SF) (µg/L)	Children 5 years or younger	<12
	Children older than 5 years	<15
	All age groups in the presence of infection	<30
Serum transferrin receptor (sTfR)	Varies with assay, and patient age and ethnic origin	Varies with assay, and patient age and ethnic origin

(Adapted from Zimmermann & Hurrell, 2007)

2.2.1.3. Consequences of iron deficiency and Iron-Deficiency Anaemia

The consequences of iron deficiency include retarded psychomotor development, delays in socio-emotional functioning and impaired cognitive function at all stages of life (Black, 2012; Palafox *et al.*, 2003). In a cross-sectional study, Halterman *et al.* (2001) demonstrated the relationship between iron deficiency and cognitive achievement among school children aged 6–16 years. Children with iron deficiency, with and without anaemia, had lower average math scores when compared with children with normal iron status (Halterman *et al.*, 2001). Baumgartner *et al.* (2012) in a 38-week randomised controlled trial also reported beneficial effects of iron supplementation on cognition in school children aged 6–11 years in SA. Children receiving iron supplementation recalled 0.90 more words (out of 12) at the second

trial when compared with placebo groups (Baumgartner *et al.*, 2012). In a double-blind, placebo-controlled study, Stoltzfus *et al.* (2001) reported that in anaemic pre-school children (6–59 months) in rural Zanzibar, iron supplementation improved language and motor development by 0.8 points on a 20-point scale. In iron-deficient populations, morbidity from infectious diseases is increased. Anaemia in iron deficiency causes RBC to become pale and small. As a result the RBC are unable to transport oxygen to the lungs and tissue, impairing energy metabolism. Symptoms of anaemia include fatigue, loss of appetite, loss of stamina, shortness of breath, weakness, pallor, dizziness and poor resistance to cold temperatures (Pettit *et al.*, 2011).

2.2.2. Zinc

Zinc is primarily an intercellular ion that works mostly in association with different enzymes. About two to three grams of zinc is present in the human body. The highest concentrations can be found in the liver, pancreas, kidney, bone and muscle (Mahan & Escott-Stump, 2004). Zinc has vital functions in the human body. It plays a role in the work of metalloenzymes, which are involved in a variety of metabolic processes, including the regulation of gene expression. Zinc functions in reactions that involve the synthesis and degradation of major metabolites such as carbohydrates, lipids, proteins and nucleic acids. It plays an important structural role as a component of various proteins and functions as an intracellular signal in brain cells (Mahan & Escott-Stump, 2004). It is essential in the production of the active form of vitamin A (retinol) in visual pigments and the retinol-binding protein that transports vitamin A (Whitney & Rolfes, 2008). Meat, particularly organ meat (liver), and shellfish are the best dietary sources of zinc. Milk and milk products, dry beans and nuts are also dietary sources. Green leafy vegetables can be reasonable sources, although in minute amounts (Kennedy *et al.*, 2003). Foods such as cereals and legumes contain phytates, which are known to inhibit the bioavailability of zinc, leading to further deficiency.

Protein-rich diets are known to promote the absorption of zinc, by forming zinc amino chelates, which transform zinc to a more absorbable form. The RDA of zinc for school going children, preadolescents and women is 8 g/day (Mahan & Escott-Stump, 2004). Zinc is excreted mostly through faeces of normal individuals. It is also lost from the body through urine, sloughed skin, nails and hair. However, quantitatively, losses of zinc through these routes are relatively small when compared with losses through gastrointestinal excretions.

Increased urinary zinc excretion has been reported in starving populations (Brown *et al.*, 2001).

2.2.2.1. Zinc deficiency

Zinc deficiency may occur as a result of inadequate dietary zinc intakes, malabsorption, starvation or increased losses (Mahan & Escott-Stump, 2004). The main transport vehicle for zinc in the blood is a protein known as albumin. However, zinc can also bind with transferrin, the main carrier of iron. In some cases zinc competes with iron for transferrin. Diets that contain more than twice as much iron as zinc limit the transferrin sites available for zinc. This results in low zinc absorption, potentially leading to deficiency (Whitney & Rolfes, 2008). Zinc deficiency can also result from high phytate content in diets (Samuel *et al.*, 2010). Phytic acid binds zinc and form poorly soluble complexes therefore reducing zinc absorption (Krebs, 2000; Lönnerdal, 2000; Uusiku *et al.*, 2010). Reduction of dietary phytate in cereals may be useful in improving zinc status amongst populations consuming cereal based-diets with increased physiological zinc requirements (Manary *et al.*, 2000). Current information on the prevalence of zinc deficiency is scarce. However, the fact that it is estimated to be quite high in developing countries has resulted in more attention being drawn to this deficiency (Tulchinsky, 2010). People with low socio-economic status, young children, pregnant women and the elderly are the most vulnerable to zinc deficiency (Whitney & Rolfes, 2008). People with low socio-economic status are vulnerable because of lack of access to safe and nutritious food; young children often have high zinc needs as a result of rapid growth, which requires the synthesis of zinc-containing proteins, and pregnant women and the elderly because of increased requirements during their particular life development stage.

2.2.2.2. Indicators of Zinc status

Potential biomarkers of zinc include serum zinc, hair zinc and urinary zinc. Serum zinc concentration is the only biochemical indicator of zinc status which has available and adequate reference data, and is also the most commonly used indicator of zinc status (Hotz *et al.*, 2003). Most of the zinc present in blood is concentrated in the erythrocytes and leukocytes. Plasma zinc fluctuates in response to dietary intake and injury or inflammation. In the acute-phase response to an injury, the concentration of zinc in plasma can drop by 50%. Serum zinc is most likely to decrease after a zinc-free meal. This is possibly because

the pancreas utilises zinc in the blood to produce and secrete zinc metalloenzymes, which are used for digestion and absorption in the gastrointestinal tract (Mahan & Escott-Stump, 2004).

Serum zinc is said to be more useful in identifying the zinc status of populations than of individuals. Because factors such as age, sex, health status and the time of day of blood collection are possible confounding factors in the determination of zinc status, they should be taken into account. A significant difference exists between the serum zinc concentrations of males and females, with higher concentrations occurring in males, especially after 10 years of age. Concentrations of serum zinc were found to be lowest in younger children, and constantly increased with age. Serum zinc concentrations tend to peak further in early adulthood (18–25 years) and gradually decrease during middle adulthood. During late adulthood (65–70 years) it drops again, indicating a significant association with age (Hotz *et al.*, 2003). Overnight and daytime fasting results in an increase of circulating zinc concentration; therefore, the best time to assess zinc status is after fasting. Infections lead to a reduction of serum zinc concentrations. Therefore, CRP is often measured during assessment of zinc status in order to identify subjects with concurrent infections so as to control for this confounding factor during analysis of serum zinc (Hotz *et al.*, 2003).

A population is at high risk for zinc deficiency if the zinc status of more than 20% of the population is below the cut-off. The criterion for identifying populations at risk of zinc deficiency is based on data from the USA National Health and Nutrition Examination Survey (NHANES II). Hotz *et al.* (2003) developed appropriate cut-offs for the assessment of zinc deficiency, taking into account age, sex and time/fasting status. Table 2.3 below illustrates this.

Table 2.3: Suggested cut-offs (2.5th percentile) for the assessment of serum zinc concentration in populations

	Serum zinc (µg/dl)			
Age	<10 years	≥10 years		
	Children	Females		Males
		Non-pregnant	Pregnant	
Morning fasting	N/A	70	1 st trimester: 56 2 nd & 3 rd trimester: 50	74
Morning fasting- other	65	66		70
Afternoon fasting	57	59		61

Source: Hotz *et al.* (2003)

2.2.2.3. Consequences of zinc deficiency

Zinc deficiency can be very detrimental because it has the tendency to hinder digestion and absorption, causing diarrhoea, which may worsen malnutrition for all nutrients. Therefore, zinc deficiency is also most likely present in persons with iron and vitamin A deficiency. A pooled analysis of nine randomised controlled trials showed that children who received zinc supplementation reported lower overall incidence of diarrhoea by 18% (95% confidence interval (CI), 17–28%) when compared with children who were not supplemented (Black, 2003). Gupta *et al.* (2003) also found that zinc supplementation reduced the incidence of diarrhoea in children aged 6–41 months. The proportion of children suffering diarrhoea during the supplementation period was significantly lower in zinc-supplemented groups (15.8% in daily and 16.5% in weekly) than in the placebo group (30.8%). Clinical signs such as short stature and hypogonadism are indicative of zinc deficiency. These signs were first observed in young boys in Iran and Egypt (Brown *et al.*, 2001). Zinc deficiency can lead to growth retardation, delayed sexual maturation, delayed wound healing and impaired appetite (Whitney & Rolfes, 2008). Behavioural disturbances and skin lesions can also manifest as a result of zinc deficiency. Zinc supplementation over a period of 90 days has been reported to significantly ($p < 0.03$) reduce episodes of pyoderma among zinc-supplemented infants (Walker & Black, 2004). Even the mildest form of zinc deficiency can lead to a reduction of immune function. (Mahan & Escott-Stump, 2004).

2.2.3. Vitamin A

Vitamin A, like other nutrients, is essential in the human body. The primary (>90%) store of vitamin A in the human body is the liver. Because vitamin A is a fat-soluble vitamin, it therefore requires fat for absorption. Vitamin A plays a vital role in maintaining normal cell differentiation, vision, gene expression, reproduction, embryonic development, growth and immune function (Nojilana *et al.*, 2007). It is derived from both animal and plant food sources. Plant sources contain vitamin A in the form of provitamin-A carotenoids, which is the primary source of vitamin A in most developing countries (Gibney *et al.*, 2004). Dark green leafy vegetables such as amaranth and spinach are sources of provitamin-A carotenoids. Provitamin-A carotenoids are not readily absorbed by the body in comparison with vitamin A in the form of retinol, which is found mostly in meat and meat products. However, the bioavailability of plant sources of vitamin A can be enhanced if they are regularly consumed with dietary sources of fat (Kennedy *et al.*, 2003). The RDA for vitamin A is 400 µgRAE/day and 600 µgRAE/day for children aged 5–8 years and 9–13 years respectively (Mahan & Escott-Stump, 2004).

2.2.3.1 Vitamin A deficiency

It is believed that insufficient dietary intake of vitamin A and the bioavailability of provitamin A sources are the main causes of the deficiency in developing countries. However, these causes are not isolated. Increased nutritional requirements during the different life developmental stages and during infections may also potentially lead to the deficiency (Gibney *et al.*, 2004). VAD can also result from malabsorption caused by inadequate dietary fat, biliary or pancreatic insufficiency and impaired transport due to abetalipoproteinemia, liver disease, protein-energy malnutrition or zinc deficiency (Mahan & Escott-Stump, 2004).

The WHO has estimated that the health of more than 254 million pre-school children, particularly in developing countries, is affected by VAD (WHO, 1995). An update of this report showed that in 2005, 5.2 million children of pre-school age were affected by night blindness and 33.3% of pre-school children globally were at risk of VAD. The largest proportion (2.0%) of children affected by night blindness was from Africa (WHO, 2009). Reports in 2002 showed a worldwide prevalence of 21% among children aged 0–4 years old (Nojilana *et al.*, 2007). VAD among children in developing countries remains the leading cause of preventable severe visual impairment and blindness. It is also a significant

contributor to severe infections and death, particularly from diarrhoea and measles (Caulfield *et al.*, 2006).

2.2.3.2. Indicators of Vitamin A status

Vitamin A status can be determined through the measurement of serum retinol. This is useful in identifying populations that are vulnerable to VAD and also helps in identifying the severity of the problem (Kennedy *et al.*, 2003). It is also one of the most commonly used and widely accepted approaches for determining the vitamin A status of entire populations. Serum retinol concentration $<20 \mu\text{g/dl}$ or $\leq 0.70 \mu\text{mol/l}$ is an indication of an inadequate vitamin A status and $<0.35 \mu\text{mol/l}$ is severe VAD (WHO, 2011b). When more than 15% of a population has a serum retinol level below this amount, it is considered a significant public health problem (Nojilana *et al.*, 2007; van Jaarsveld *et al.*, 2005). The extent of VAD can be classified as mild, moderate or severe. Prevalences of 2–9%, 10–19% and 20% among children aged 6–71 months old are classified as mild, moderate and severe respectively (WHO, 2011b).

2.2.3.3. Consequences of vitamin A deficiency

One of the first signs of VAD is impaired vision due to loss of visual pigments. This manifests as night blindness which results from the inability of the retina to regenerate rhodopsin (Mahan & Escott-Stump, 2004). A deficiency in vitamin A causes loss of integrity of cells in the mucous membranes that line the respiratory tract, alimentary canal, urinary tract, skin and the epithelium of the eye. This predisposes the body to infections that further lead to increased morbidity and mortality. Clinically, these manifest as poor growth, blindness caused by xerophthalmia and corneal ulceration (Nojilana *et al.*, 2007). Xerophthalmia is known to occur at a later stage of deficiency. Childhood mortality resulting from measles and vitamin A deficiency can be substantially reduced in populations where xerophthalmia is rare, by improving the vitamin A status (Gibney *et al.*, 2004; Nojilana *et al.*, 2007). In a randomised, placebo-controlled, double-blinded trial of children aged 4–24 months from a low socio-economic background, Coutsooudis *et al.* (1991) reported that vitamin A supplementation reduced measles morbidity in children. VAD can also lead to impairments in certain aspects of cell-mediated immunity, ultimately increasing the risk of infection, more especially, respiratory infection (Mahan & Escott-Stump, 2004). A randomised double-blind placebo-controlled trial by Shankar *et al.* (1999) reported that in children aged 6–60 months,

vitamin A supplementation lowered the morbidity due to a parasite known as *Plasmodium falciparum*. The number of *P. falciparum* febrile episodes (temp. >37.5°C with a parasite count of at least 8000/μL) was 30% lower in the vitamin A-supplemented group than in the placebo group (178 versus 249 episodes; relative risk 0.70 [95% CI 0.57-0.87] *P*=0.0013).

2.2.3. Addressing deficiencies in iron, zinc and vitamin A

Deficiencies in iron, zinc and vitamin A can be addressed by employing strategies such as food fortification, supplementation and dietary diversification (van Jaarsveld *et al.*, 2005). These strategies should be integrated to complement each other because they all play important roles in addressing micronutrient deficiencies.

2.2.3.1. Food fortification

Enriching commonly eaten staple foods with micronutrients can make remarkable nutritional differences in the diets of all socio-economic classes that regularly purchase and consume commercially processed foods. Fortification is said to be a sustainable approach to addressing micronutrient deficiencies because it can be cost-effective and can easily be dovetailed into existing food production and distribution systems. The problem that is often encountered with fortification is that some target populations, particularly those located far from urban areas, lack access to centrally fortified foods (Tontisirin *et al.*, 2002).

2.2.3.2. Supplementation

Supplementing with iron, zinc and vitamin A in deficient populations can reduce deficiencies. Iron supplements are used for the rapid treatment of IDA in all gender and age groups. The absorption of iron is more efficient and increases during deficiency (Stoltzfus & Dreyfuss, 1998). Iron supplementation programmes are not always successful, often due to poor patient compliance and low coverage of the target population. However, if effectively carried out, these programmes can substantially improve the iron status of populations. Tee *et al.* (1999:1255) reported that a 22-week weekly supplementation of adolescent schoolgirls with iron and folate resulted in a significant improvement in their serum ferritin and Hb concentrations. As discussed earlier, zinc supplementation has been found to be efficient in reducing the incidence of diarrhoea and also effective in reducing episodes of pyoderma in infants, thus reducing morbidity and mortality in vulnerable populations (Gupta *et al.*, 2003;

Walker & Black, 2004:259). Massive intermittent dosing with large doses of vitamin A is widely practised in developing countries. Single-dose treatments of 600 000 RAE of vitamin A have reduced child mortality by 35–70% in developing countries. However, these treatments have proved to be costly and are only effective if they are sustained and if the coverage rate exceeds 85% (Mahan & Escott-Stump, 2004).

2.2.3.3. Dietary diversification

Dietary diversification can be encouraged in vulnerable communities. Ruel (2001), as quoted by Faber and Wenhold (2007), described dietary diversification as various approaches aimed at increasing the production, availability of, and access to, foods that are rich in micronutrients, the consumption of micronutrient-rich foods, and/or the bioavailability of micronutrients in diets. Dietary diversification can be achieved in various ways, and is not limited to horticultural approaches such as home gardens, behaviour change to improve consumption through communications, social marketing or nutrition education and improved methods of preparation, preservation and cooking that preserve the micronutrient content of food (Faber & Wenhold, 2007). Faber *et al.* (2002) found that encouraging households in rural Kwazulu-Natal to produce yellow and dark green leafy vegetables as part of an integrated home-gardening programme significantly improved the vitamin A status of children 2–5 years old. At the follow-up of the study, they observed that significantly more children in the experimental village ($P=0.001$) consumed *imifino* (the local ALV), when compared with the control village. At follow-up, the children from the experimental village had significantly ($P=0.0050$) higher serum retinol concentrations than those of the children from the control village (Faber *et al.*, 2002). The improvement in serum retinol levels in children was not solely attributable to the consumption of *imifino*, but also to the consumption of other fruits and vegetables rich in β -carotene. Therefore, these data must be interpreted with caution. This project also showed potential prospects for future sustainability. Twenty months after implementation of the home-gardening programme, about one third of all households in the experimental village continued to have a vegetable garden (Faber *et al.*, 2002).

In a community-based randomised trial, Kapur *et al.* (2003) suggested that nutrition education had a positive effect on iron status, possibly by improving the dietary iron intake of children (aged 9–36 months). Findings from the study showed that the percentage change in serum ferritin value at 16 weeks (post intervention) in the nutrition education group was 5.7%. This was significantly higher ($P<0.001$) than the control. Additionally, at 16 weeks,

children in the nutrition education group had significantly higher iron intakes ($P<0.001$) when compared with baseline intake. The adequacy of iron in the diet of the nutrition education group also increased significantly ($P<0.05$) when compared with the control group (Kapur *et al.*, 2003).

2.3. Nutritional status of children in South Africa

The nutritional status of communities and individuals can be assessed by combining different standardised techniques of dietary, anthropometric, biochemical and clinical methods of measurement (Faber & Wenhold, 2007). Since the scope of this dissertation is the possible alleviation of micronutrient deficiencies in school children, the nutritional status of school going children in SA will be discussed by examining available information on their anthropometric status, dietary intake, specifically their micronutrient intake, and their eating habits.

Studies available to give an indication of the national nutritional status of children in SA are: the 1994 South African Vitamin A Consultative Group (SAVACG) study, carried out on children aged 6–71 months by SAVACG (1995), the 1999 National Food Consumption Survey (NFCS) carried out on children aged 1–9 years by Labadarios *et al.* (2000) and the National Food Consumption Survey-Fortification Baseline (NFCS-FB) study conducted in 2005 on children aged 1–9 years (Labadarios *et al.*, 2008). Although these studies used different methodologies and sampling frames, their results were similar, making them reliable sources of representative data (Bourne *et al.*, 2007). At the national level, children in SA are undernourished. Chronic malnutrition characterised by a high prevalence of stunting is said to be more profound than acute malnutrition (Faber & Wenhold, 2007; Labadarios *et al.*, 2005). Deficiencies in iron, vitamin A and zinc are matters of public health concern in the country (Bourne *et al.*, 2007). In 2000, 1.8 million children were said to be deficient in vitamin A (Nojilana *et al.*, 2007) and 5.1% of children had IDA (Nojilana *et al.*, 2007). Samuel *et al.* (2010) reported a risk of zinc deficiency in a poor peri-urban informal settlement in SA. Almost half (46%) of children aged 7–11 years had a serum zinc level below the 70 µg/dl cut-off.

2.3.1. Anthropometric status of children

Available data on the anthropometric status of children aged 1–9 years in SA from the 1999 NFCS as reported by Labadarios *et al.* (2005) showed that, at the national level, one in every five children was stunted (height-for-age, -2SD), making it the dominant nutritional disorder at the time. Stunting was worse in farm communities, affecting nearly one in every three children. The prevalence of underweight (weight-for-age, -2SD) showed that one in 10 children were underweight, with less than 1.5% of children severely underweight (weight-for-age, -3SD) nationwide. Again, children living in farm communities were an exception, with a prevalence of 5%. Nationwide, wasting (weight-for-height, -2SD) was the least prevalent disorder, affecting one in every 20 children, including those living on farms (Labadarios *et al.*, 2005). The 2005 NFCS-FB study, which is the most recent nationwide survey, revealed that the stunting rate of children aged 1–9 years decreased by 3.6% between 1999 and 2005 (Kruger *et al.*, 2007). The best improvement was observed in rural areas (26.5–20.3%). Prevalence of underweight in children increased in those living in urban areas and decreased in children living in the rural areas, although this improvement was greatest in children living in formal rural areas. The nationwide prevalence of severe stunting (height-for-age, -3SD), wasting and underweight remained almost unchanged between 1999 and 2005 (Kruger *et al.*, 2007). Figure 2.2 illustrates the nationwide prevalence of stunting and underweight observed in children aged 1–9 years in 2005.

In other single studies, Mamabolo *et al.* (2005) reported that almost half (48%) of three-year-old black children residing in the central region of Limpopo Province were stunted and <10% were underweight. Oldewage-Theron & Egal (2010) also found stunting to be prevalent in primary school children in rural QwaQwa in the Free State. Out of a total of 142 children, 11.3% and 2.8% were stunted and severely stunted respectively. This shows that even after results reported from the 1999 NFCS and the 2005 NFCS-FB, underweight and stunting continue to be a public health concern in children in SA. Stunting in childhood has been associated with impaired cognitive development and poor performance in school. However this association takes into account other complex environmental and social factors that affect both physical and mental development (Chang *et al.*, 2002; Mendez & Adair, 1999). Childhood stunting may also lead to reduced adult size and reduced work capacity. Chang *et al.*, (2002) confirmed that stunted children had lower ($p < 0.001$) arithmetic, spelling and word reading comprehension when compared with non-stunted children. Mendez and Adair (1999) also reported that severe chronic under nutrition in early life may affect cognitive development in later childhood.

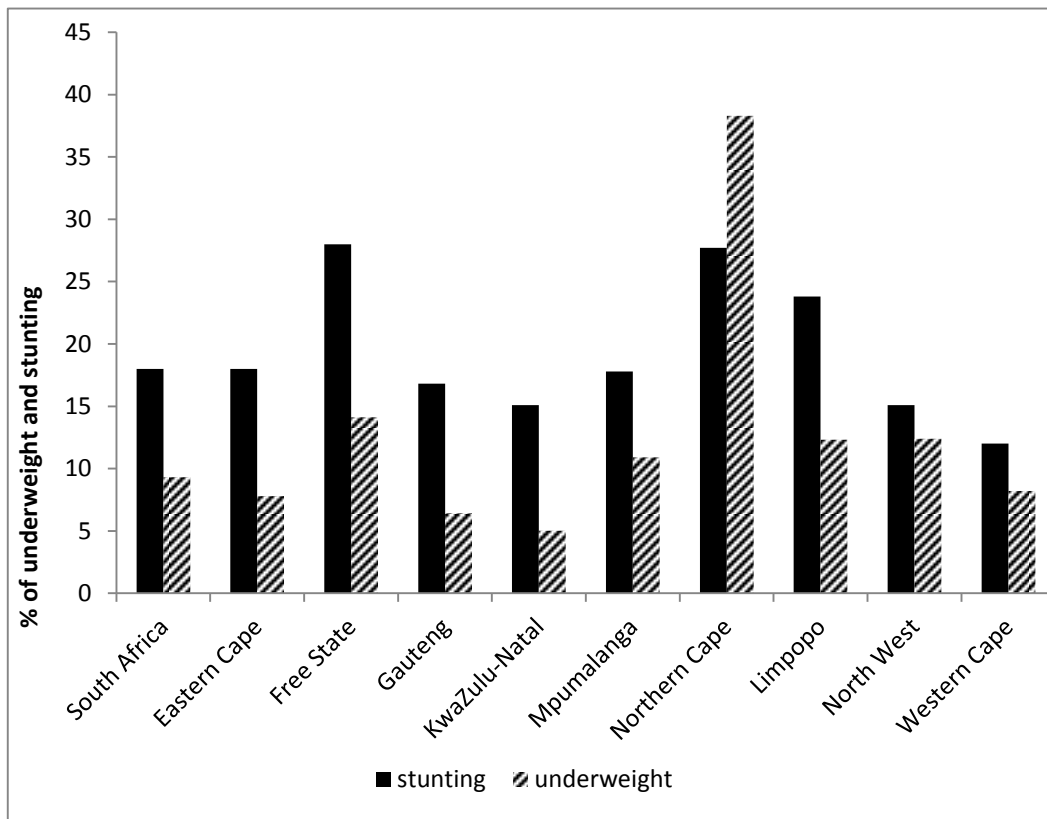


Figure 2.2: Nationwide prevalence of stunting and underweight in children aged 1–9 years
(Source: Kruger *et al.*, 2007)

2.3.2. Dietary intake of children in South Africa

Labadarios *et al.* (2005), in the 1999 NFCS, reported that the micronutrient intake of children in SA was remarkably low and failed to meet even two thirds of the RDA. The authors also observed significant differences of intake between children who resided in rural areas and those in urban areas, with rural children being least privileged. For the purpose of this study, only the national intakes of iron, vitamin A and zinc were reported, because of their potential suitability for dietary interventions with regard to ALVs. According to the 1999 NFCS, at the national level 50% of children in all age groups and all provinces except the Western Cape, did not meet at least two thirds of the RDA for vitamin A (Labadarios *et al.*, 2005). At the national level 25–35% of children could not meet up to 50% of the RDA for iron and 36–57% had an iron intake of less than 67% of the RDA (Labadarios *et al.*, 2005), implying low intakes and a high risk of deficiency. Zinc intake was also reported to be inadequate in all age groups and provinces, with 32–53% of children having an intake of less than half of the

RDA and 50–73% of children having an intake of less than two thirds of the RDA (Labadarios *et al.*, 2005). This implies yet again, a high risk of deficiency nationally. The most recent national report on the micronutrient status of children in SA was revealed in the 2005 NFSC-FB. According to this study, the most prominent micronutrient deficiencies in children aged 1–9 years were in vitamin A and zinc (Labadarios *et al.*, 2008). Figure 2.3 illustrates the micronutrient status of children as reported by the 2005 NFCS-FB study.

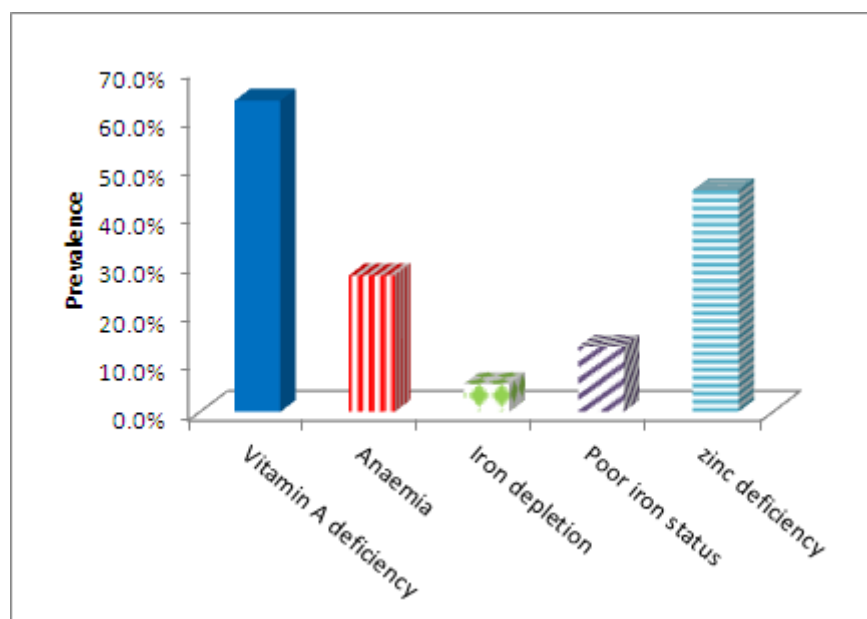


Figure 2.3: Micronutrient status of children 1–9 years in SA (2005 NFCS-FB)

When compared with other developing countries, the diet of South African children is said to lack variety of foods (Steyn *et al.*, 2006b). A monotonous diet in many households within the country has contributed to malnutrition; with micronutrient-rich fruits and vegetables being most neglected (Labadarios *et al.*, 2011).

Faber *et al.* (1999) reported that primary school children in rural KZN often preferred rice and listed it as their favourite food, either eaten alone or in combination with mainly meat, chicken or beans. The most disliked food by children in this same rural population was their traditional maize meal stiff porridge (phutu), which was eaten alone or with cabbage, dark leafy vegetables (imifino) or beans and other vegetables. This implied that children in this population preferred foods that were not micronutrient-dense and were more likely to consume them. It was further revealed that in rural KZN, school going children often had two main meals in a day (mainly lunch and supper). The foods that were frequently (at least 4

days a week) consumed by children included bread, potatoes, potato chips “Nik naks”, sweets/chocolates and phutu (Faber *et al.*, 1999). Samuel *et al.* (2010) also reported that school going children aged 7–11 years, living in a peri-urban settlement in the Vaal region, had a diet that consisted primarily of stiff maize meal and tea. Their mean daily intake of these foods was 404 g and 203 g of stiff maize meal and tea respectively (Samuel *et al.*, 2010). This diet was monotonous, and Labadarios *et al.* (2011) has associated such monotonous diets with food insecurity. Taking all these studies into account, it is obvious that the diets of children in SA lack variety and are often not micronutrient-dense.

As regards the NW province, the focus of this current study, there is evidence that interventions to address micronutrient deficiencies in the province are required. The 2005 NFCS-FB revealed that the major deficiencies in children aged 1–9 years in the province were in vitamin A (49.6%) and zinc (41.1%). Among the same age group, 5.8% were said to have severe vitamin A deficiency, 28.1% were anaemic, 6.9% had depleted iron stores and 5.2% had iron deficiency (Dhansay *et al.*, 2007; Labadarios *et al.*, 2007; Labadarios & Louw, 2007). According the 1999 NFCS, almost one in five children in the NW Province ate two main meals daily, with in-between meals. At the national level, the meal pattern for children was observed to be three main meals daily, with or without in-between meals (Labadarios *et al.*, 2005). Therefore, when compared with the meal pattern at the national level, children in the NW Province seemed to have fewer meals. The 2005 NFCS-FB further reported that hunger was experienced by 52.2% of households within this province, which was higher than the nationwide prevalence of 51.6% (Gericke & Labadarios, 2007).

2.3.2.1. Fruit and vegetable intake of children in South Africa

There are various guidelines available regarding the consumption of fruits and vegetables, and the quantities that are recommended are usually similar. The 2004 WHO Comparative Quantification of Health Risks stated that the theoretical-minimum-risk distribution (required adequate intake to prevent disease) for fruit and vegetable intake was estimated to be 480 grams in children aged 5–14 years (Lock *et al.*, 2004). The United States of America Department of Agriculture (USDA) designed the MyPyramid guidelines. These guidelines were designed to meet the RDA or Adequate Intake (AI) levels with the intent of meeting the nutritional requirements of almost every person (USDA, 2012). These guidelines were also found to be similar to what was recommended by the WHO. The USDA MyPyramid guidelines recommended a daily intake of 240 grams of vegetables in children aged 4–8

years. The USDA MyPyramid guideline does not have a recommendation for daily vegetable intake for children older than eight years. Therefore, for the purpose for this present study, the same requirement (240 g/day) was assumed for older children (9–13 years).

Results from the 1999 NFCS revealed that most South African children aged 1–9 years consumed fruit and/ or vegetables, with a larger number of children consuming more vegetables than fruit (Labadarios *et al.*, 2005). Green leafy vegetables were the 16th most frequently consumed item by children aged 1–9 years (Labadarios *et al.*, 2000). The average fruit and vegetable intake in children was reported to be 110–205 grams per capita nationwide (Labadarios *et al.*, 2005). This intake was below what was recommended by the USDA MyPyramid guidelines and poor intake was observed in all the provinces within the country. It was also observed that, as children grew older, they tended to consume more fruits and vegetables, although the intake still remained under the recommended levels (Labadarios *et al.*, 2005; Naude, 2007).

2.4. Farm communities in South Africa

Farm communities in the country are known to be most vulnerable in terms of nutritional status (Vorster *et al.*, 2000). This is also evident in the 1999 NFCS. Kruger *et al.* (2006) also reported that children living on farms were often more likely to be stunted and severely malnourished (underweight) when compared with other children. In their study they reported the prevalence of stunting, underweight and wasting to be 24.5%, 19.1% and 6.7 % respectively in farm children in the NW Province (Kruger *et al.*, 2006).

South African farm workers are known to be the least privileged and most vulnerable in the country's workforce. They are often exposed to the least favourable working environment, one which exposes them to health and environmental hazards while earning the lowest wages (Lemke, 2005). Racial inequality in the country as a result of its history has been blamed for the current situation of people working and living on farms. Employment opportunities are limited for farm dwellers, especially women (Kruger *et al.*, 2006). Their terms of employment frequently do not offer security. Often, when farm workers retire, they may lose their rights to stay on the farm and therefore have no accommodation thereafter (Kruger *et al.*, 2006). Farm worker communities have been associated with poor health, migrancy, social discrimination and poverty. Alcohol abuse, domestic violence and chronic

malnutrition are said to be commonplace in these communities, which are also reported to have the lowest literacy rate in the country (Lemke, 2005).

The lack of access to food often puts farm workers at risk of food insecurity, which potentially leads to the long vicious cycle of malnutrition (Kruger *et al.*, 2006). It can also be assumed that this population potentially lacks variety in its diet owing to the inability to access affordable and safe food.

2.5. Nutrient content of selected ALVs in South Africa

Taking into consideration the high prevalence of micronutrient malnutrition among vulnerable groups in SA, it has become necessary to explore underutilised foods in various communities in order to subjugate nutritional disorders (Gupta *et al.*, 2005). As mentioned earlier, it is estimated that a daily intake of 480 g of fruits and vegetables in children aged 5–14 years can be effective in guarding against diet-related chronic diseases. Food insecurity, mainly because of lack of access to food, is said to be one of the main causes of malnutrition in SA (Schönfeldt & Pretorius, 2011; Chopra *et al.*, 2009). Over the years, strategies such as micronutrient supplementation and food fortification have been employed in order to address micronutrient malnutrition (Faber *et al.*, 2010). In recent years, there has been an increasing amount of literature on dietary diversification through food-based approaches, with the inclusion of agriculture to address micronutrient deficiencies (Faber *et al.*, 2010). This is where the inclusion of ALVs is believed to have a potential contribution to make towards combating hidden hunger (Uusiku *et al.*, 2010). However, for this to occur, the use of ALVs needs to be included in dietary diversification intervention programmes (Faber *et al.*, 2010).

Sub-Saharan Africa alone harbours more than 45 000 species of plants, of which about 1 000, in the form of green leafy vegetables, are edible (Muhanji *et al.*, 2011). These are known as ALVs and are often available seasonally (Gupta *et al.*, 2005). Lack of knowledge with regard to the potential value of ALVs and limited information on their nutrient content are possible reasons for their underutilisation (Schonfeldt & Pretorius, 2011; Gupta *et al.*, 2005). The limited available data however, emphasise that these vegetables contain antioxidants and can be good sources of significant amounts of iron, β -carotene, and zinc in daily diets (Smith & Eyzaguirre, 2007). The nutritional value of a vegetable is determined by

its nutrient and anti-nutrient content (Afolayan & Jimoh, 2009). There is no doubt that ALVs are well-endowed with vitamins such as β -carotene, ascorbic acid, riboflavin, folic acid and minerals such as iron, calcium and phosphorus (Gupta *et al.*, 2005). As a result, if exploited, they can be very useful in contributing to the reduction of many micronutrient deficiencies. Schonfeldt & Pretorius (2011) have stated that consumption of ALVs that grow naturally in an area can be a contributor to the reduction of food insecurity. This is because these vegetables are locally available and inexpensive, thus making them more suitable for incorporation in local diets. Addressing micronutrient deficiencies using food-based approaches is essential because it plays a major role in enhancing the availability and consumption of micronutrient-rich foods (Gupta *et al.*, 2005).

The nutritional value of vegetables is very much determined by the area where they are found. It is likely that ALVs of the same species may differ in nutritional composition if grown in different locations. Uusiku *et al.* (2010) stated that the levels of iron in ALVs are often influenced by factors such as soil type and pH, availability of water to the plant, plant age, variety and the use of fertilisers. Different communities within SA have various indigenous vegetables that grow in the wild and are consumed traditionally. Studies carried out on the nutritional quality of ALVs in SA are therefore often specific to the ALVs that are indigenous to and commonly known in a specific location/province. Faber *et al.* (2010) found *Cleome gynandra* (spider plant), *Amaranthus spp* (amaranth) and *Citrullus lanatus* (wild watermelon) leaves to be known and consumed mostly in a rural Limpopo site, whereas Afolayan & Jimoh (2009) found *Chenopodium album* L. (lambsquarters), *Sonchus asper* (L.) Hill (spiny sowthistle), *Solanum nigrum* L. (black nightshade) and *Urtica urens* L. (dwarf nettle) to be indigenous to Alice in the Eastern Cape.

Schönfeldt & Pretorius (2011), as part of the Sustainable Rural Livelihood Programme (SRL) in SA, carried out analyses on the nutrient content of five traditional South African dark green indigenous leafy vegetables that were identified as most commonly consumed by rural communities. These vegetables were: *Amaranthus tricolor* (misbredie), *Cucurbita maxima* (pumpkin leaves), *Vigna unguiculata* (cowpea leaves), *Cleome gynandra* (spider plant) and *Corchorus tridens* (wild jute). The analysis was carried out on both cooked and raw samples of these various vegetables. The findings (Table 2.4) of their study showed that these vegetables were good sources of protein, β -carotene and minerals such as calcium, iron, phosphorus and magnesium. Uusiku *et al.* (2010) confirmed through their review of ALVs that cooking had differing effects on the micronutrient content of ALVs, varying from no noticeable change in the iron and zinc content, to enhancement of the bioavailability of β -

carotene and the reduction of vitamin C, as a result of leaching. The leaves of *Chenopodium album* L., *Sonchus asper* (L.) Hill, *Solanum nigrum* L. and *Urtica urens* L. were found to be excellent sources of iron, with *Sonchus asper* (L.) having the highest iron content (Afolayan & Jimoh, 2009).

Table 2.4: Concentrations^a of β -carotene and selected minerals in raw and cooked dark green leafy vegetables

Species		Iron (mg)*	Zinc (mg)*	Total β -carotene (μ g)*
<i>Amaranthus tricolor</i> (Misbredie)	Raw	16.2	0.8	1601
	Cooked	8.5	0.7	2343
<i>Cucurbita maxima</i> (Pumpkin leaves)	Raw	15.9	0.9	1695
	Cooked	15.7	0.7	796
<i>Vigna unguiculata</i> (cowpea leaves)	Raw	3.9	0.5	2249
	Cooked	3	0.5	2614
<i>Cleome gynandra</i> (Spider plant)	Raw	14.3	1.0	4117
	Cooked	14.5	1.0	6047
<i>Corchorus tridens</i> (Wild jute)	Raw	6.3	0.8	3663
	Cooked	6.8	1.3	6135

(Adapted from Schönfeldt & Pretorius, 2011).

^a Values are averages of duplicate analysis

*Nutrients in ALV (mg/100g edible portion)

2.6. Knowledge of and the use of ALVs

2.6.1. The use of ALVs

The use of ALVs by communities has been reported all over Africa. These vegetables do not serve only as food, but are also known to have medicinal attributes and can sometimes be used to generate household income (Ezebilo, 2010).

2.6.1.1. ALVs as food

ALVs are a potentially valuable source of nutrition in areas where the climate is hot and dry with minimum rainfall. Because most of these vegetables grow in the wild without cultivation and have the ability to withstand harsh climatic conditions, they can fill a valuable niche in the production of food in rural areas where the climate is not conducive to the production of more exotic vegetables like spinach and Swiss chard (Faber & Wenhold, 2007). In SA, the Vhavenda are known to consume about 53 different species of traditional vegetables and also have a wealth of knowledge about these plants. These vegetables are usually consumed as the main accompanying dish to the Vhavenda staple foods, which are maize meal, sorghum or millet (Nesamvuni *et al.*, 2001). In rural and urban areas in Limpopo and KZN in South Africa, communities were also found to consume various types of ALVs (Faber *et al.*, 2010). In these areas ALVs were prepared and consumed with stiff maize meal porridge, beans or other legumes (Faber *et al.*, 2010).

There is growing concern about the decline in consumption of ALVs. The negative perceptions people have of these vegetables have been attributed to westernisation. Dweba & Mearns (2011) found that the consumption of traditional vegetables by the younger generation in the eManthlaneni village was decreasing. They indicated that the younger people generally eat only two of the 33 traditional vegetables that were mentioned by the elderly women (Dweba & Mearns, 2011).

2.6.1.2. ALVs and health promotion

In recent years, there has been growing knowledge with regard to the health-promoting and health-protecting properties of non-nutrient bioactive compounds associated with ALVs. This has directed increased attention to vegetables as vital components of daily diets (Smith & Eyzaguirre, 2007). Countless numbers of ALVs continue to be used for prophylactic and

therapeutic purposes by rural communities and they have long benefited and still continue to benefit significantly from the dietary vitamin and mineral content of ALVs (Smith & Eyzaguirre, 2007). The knowledge of the health-promoting and -protecting attributes of ALVs is clearly connected to their nutritional and non-nutrient bioactive properties. These non-nutrient bioactive properties are said to come from phytochemicals in these vegetables that have been linked to protection against cardiovascular and other degenerative diseases (Smith & Eyzaguirre, 2007). In some countries like Kenya, it was found that these phytochemicals posed a risk of toxicity if the ALVs were consumed in large quantities or over a long period of time. However, the toxicity of these vegetables is not considered a problem because the toxic substances are denatured and destroyed during cooking; therefore these vegetables still remain good alternatives to combat malnutrition (Grubben, 2004; Wu *et al.*, 2005).

While the body of scientific evidence supports the nutritional value of ALVs in local diets and their positive effect on health, not much effort has been exerted on the exploitation of these plants in order to address the complicated food, nutrition and health problems in Sub-Saharan Africa (Smith & Eyzaguirre, 2007). According to Heywood (2011), the use of ALVs as traditional medicine is closely linked with issues of human nutrition, especially in the case of indigenous peoples, because to these people there is no distinction between food or medicine and health. To indigenous peoples, foods are medicine and vice versa (Heywood, 2011). ALVs can potentially have health-related functions, including antibiosis, immune stimulation, nervous system action and detoxification, as well as anti-inflammatory, anti-gout, antioxidant, glycaemic and hypolipidaemic properties (Johns, 2003). People living in rural Limpopo in SA use the amaranth leaves mixed with charcoal to soothe constipation and other stomach ailments (Faber *et al.*, 2010). These amaranth leaves were thought to be rich in antioxidants and have antibacterial functional properties, which assist in the promotion of good health by playing a role in the prevention of cancer and hypertension (Faber *et al.*, 2010).

2.6.2. Knowledge, Perceptions/attitudes affecting use of ALVs

Knowledge, as defined by Gadgil *et al.* (1993), is an outcome of model-making about the functioning of the natural world, and indigenous knowledge can be defined as a cumulative body of knowledge and beliefs handed down through generations by cultural transmission

about survival and the relationship of beings, (including humans) with one another and with their environment.

Elderly women are regarded as custodians of the indigenous knowledge associated with how traditional vegetables are used and preserved (Dweba & Mearns, 2011). In their study in the eMantlaneni village in the Eastern Cape Province of South Africa, Dweba and Mearns (2011) found elderly women to be more knowledgeable than young women about the number of indigenous vegetables in the village. They identified 33 traditional vegetables whereas the younger women identified only five (Dweba & Mearns, 2011). On the other hand, a study carried out in the Eastern Cape region in SA by Shava reported considerable evidence that the younger generation had extensive knowledge of traditional vegetables (Shava, 2000). The reason behind the discrepancy between these two studies could be that the younger generation in Shava's study was reported to have a close relationship with the elderly, therefore creating an environment for possible knowledge transfer (Dweba & Mearns, 2011; Shava, 2000).

Many researchers have shown that indigenous knowledge of traditional vegetables has faded away in communities (Dweba & Mearns, 2011; Jansen van Rensburg *et al.*, 2007; Odhav *et al.*, 2007). The introduction of new and exotic vegetables, changes in lifestyle and the stigma attached to the use of traditional vegetables have been blamed for the loss of this knowledge (Jansen van Rensburg *et al.*, 2007). The associating of these traditional vegetables with poverty and primitiveness is the most common contributor to the loss of knowledge in some communities in South Africa (Jansen van Rensburg *et al.*, 2007; Dweba & Mearns, 2011).

It is evident from various studies that the younger generation in communities have a negative attitude towards ALVs, whereas the elderly people seem to be fonder of these vegetables. Dweba & Mearns (2011) observed the negative attitude of the young women in the eMantlaneni village towards traditional vegetables. This study revealed that focus group participants preferred modern foods, associated traditional vegetables with rural communities and elderly people and that they would never serve these vegetables at public gatherings. These statements indicated the participants' negative attitude towards these vegetables. The same group of participants also associated the traditional vegetables with poverty, hence giving the authors an indication that there was a bleak future for the consumption of these vegetables by the younger generation (Dweba & Mearns, 2011).

According to Faber *et al.* (2010), the respondents in their study from a rural Limpopo and rural KZN site perceived the indigenous amaranth leaves as nutritious. They received comments from respondents such as “has vitamins and prevents us from going hungry”, “feel very strong”, “freshens our skins”. In the rural Limpopo site, Amaranth was not seen as the most popular edible leaf vegetable. It was less popular than the spider plant, but it was considered better tasting than spinach (Faber *et al.*, 2010).

2.7. Conclusion

Many children in SA suffer from micronutrient deficiencies, particularly deficiencies in iron, zinc and vitamin A. These deficiencies are associated with a high prevalence of morbidity and mortality in children. Deficiencies of these micronutrients are also associated with poor physical growth and cognition, especially in children of school going age. Diets of school-aged children in SA are said to lack variety, and although many school children consume fruits and vegetables, their daily intake of fruits and vegetables is still below recommended amounts. Farm communities in SA have been associated with poverty and are said to be the most vulnerable population with poor nutritional status. The literature shows that ALVs can potentially be good sources of iron, zinc and β -carotene. These vegetables are known to grow in the wild and are available in many rural communities. The poor nutritional status of children in SA and the escalating prevalence of micronutrient deficiencies have led to a strong impetus to determine the nutritional composition of ALVs. The incorporation of ALVs in eating patterns can potentially diversify diets and, furthermore, potentially improve the micronutrient intake of children.

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter describes the research paradigm applied and the methods used to collect and analyse data. It gives an overview of the research design used and describes the sample population and the process of data collection and data analysis.

3.2. Study design

This study has a cross-sectional design with a qualitative and quantitative approach to data collection. The quantitative part of the study design enabled the researcher to describe the current nutrition status of the study population and also to establish the prevalence of nutritional deficiencies and other health states within the study population (Last, 2012).

A qualitative explorative research approach is often used to gain insight into people's attitudes, behaviours, value systems, concerns and cultures. It has special value for investigating complex issues (Trochim, 2006). This research approach, which consisted of four focus group discussions (FGDs), was used to assess the extent of the participants' knowledge and use of ALVs. Furthermore, data collected on socio-demographic and socio economic characteristics provided insights into the meaning and interpretation of the results obtained from the FGDs (De Vos *et al.*, 2011). This research approach was applicable to this study because it generated rich information which allowed the researcher to gain in-depth information and insight into the topic of study. Furthermore, it enabled the gathering of detailed data that provided direct quotations through the use of open-ended questions. A quantitative approach was used to establish the nutritional status of the study population and also to establish the nutrient composition of the ALVs studied.

3.3. Ethical approval

Ethical approval was sought from the Ethics Committee of the North-West University (NWU) and was granted under the ethics number NWU-00033-09-A1. Permission was also granted from the Department of Education of the NW Province to conduct the study using school infrastructure. Written formal consent was obtained from primary caregivers of the children.

The children also gave assent to participate in the study. Study subjects were assured that data obtained during the study would be treated as confidential, stored as anonymous and used solely for the purpose of this research.

3.4. Study population

The study population consisted of two groups of children and their primary caregivers. Both groups of children were randomly selected, using simple random sampling from two purposively selected schools in the Ventersdorp and Potchefstroom districts in the NW Province, SA (Galloway, 1997). The first group consisted of 154 children who were in grade two to grade four in 2011 in the two schools. Dietary assessment was carried out on these children. The second group consisted of 155 children in grade R to grade four in 2012 in the two schools. Anthropometric and biochemical measures were carried out on these children. During the analysis of results of children in the second group, 16 children were excluded; therefore, results for only 155 children were reported. The children assessed on dietary information were not the same children assessed for anthropometric and biochemical measures. However, all the children resided in the same community. The ages of all the children included in the study ranged from 5–13 years.

Primary caregivers (N=114) of children in grade R to grade four were purposively selected to collect socio-demographic data on households. From the same group of primary caregivers, twenty-nine (n=29), three males and 26 females, were purposively selected to participate in the FGDs.

Inclusion criteria for participation in FGDs

- Primary caregiver of a child in grade two to grade four who participated in the larger study in the two selected schools.
- Eighteen years and older.
- Person responsible for gathering and preparing food in the household.
- Able to communicate in Setswana, English or Afrikaans.
- Signed informed consent.

3.5. Study setting

The study was conducted in two semi-rural farm schools situated in the Ventersdorp and Potchefstroom districts in the NW Province, SA. The activities on these farms include rearing of chicken, cattle, pigs and goats. Maize and sunflower are also cultivated. The schools are situated on the farms and are fully sponsored by the South African Department of Education and also, occasionally, by the farm owners themselves. According to Steyn *et al.* (2006a), using schools as a setting for health promotion activities can be advantageous because schools can influence health-related beliefs and behaviours, which can later be established as adult patterns over a long period of time. On this basis, this strategy was employed for this study.

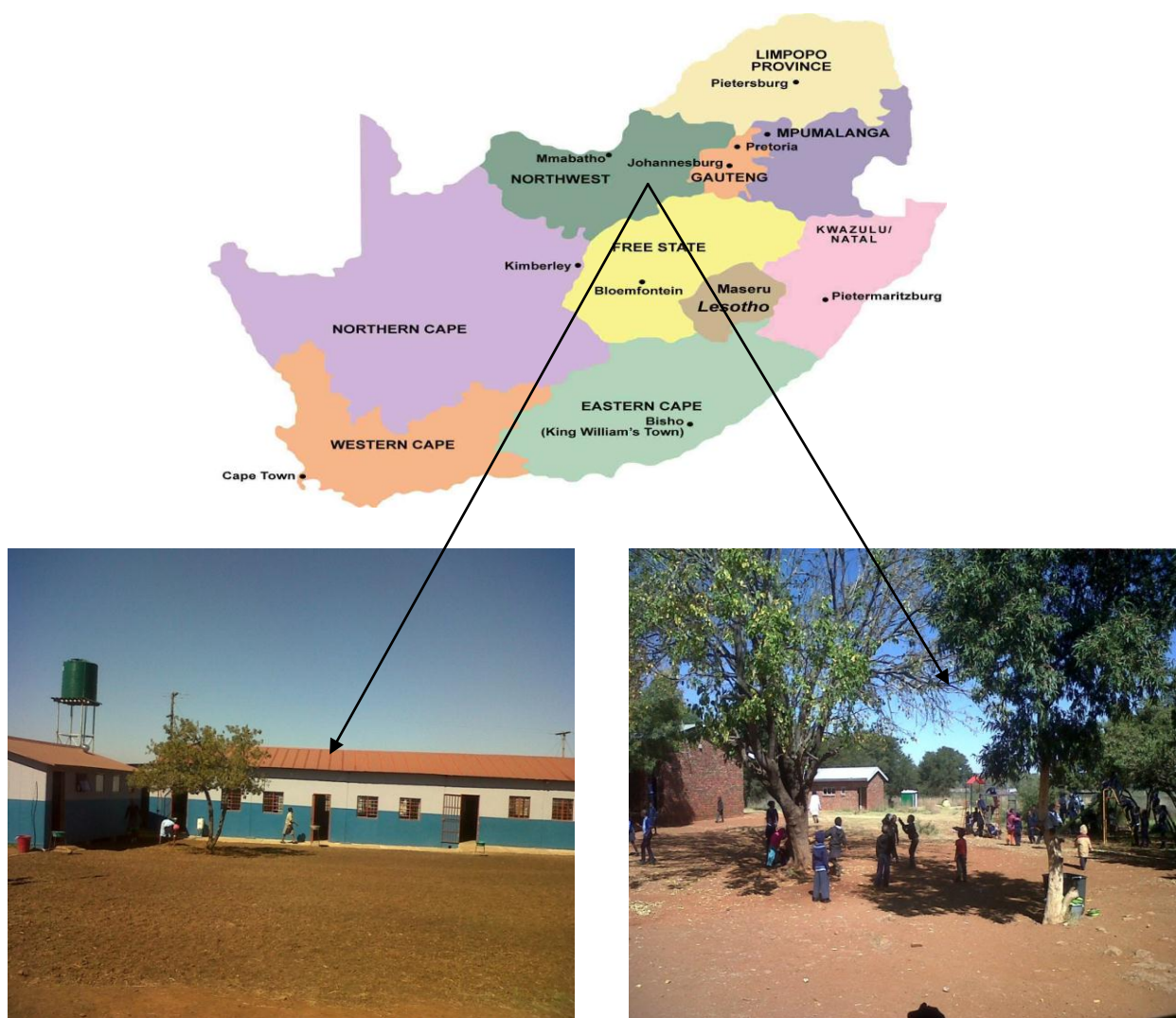


Figure 3.1: Location of study area and the two schools

3.6. Method of data collection

All the data used in this study were collected by the larger study from May 2011 to March 2012. Invitations were sent out to primary caregivers of children to participate in the study (addendum B)

3.6.1. Socio-demographic and socioeconomic data of households

The socio-demographic and socio-economic data on households was collected in May 2011. A questionnaire was developed and validated for the larger study and it was further adapted to suit this current study (addendum A). Data collected with this tool included information on households, such as household income, food, infrastructure and social grants. Information on primary caregivers was also collected. This included information on the primary caregiver's age, level of education, occupation and the number of children in his or her care.

3.6.2. Anthropometry

Weight and height measurements of children from grade R to grade four in the two schools were collected in March 2012. Children wore minimal clothing and no shoes and their weight was measured using a digital Tanita Ironman Innerscan body composition monitor scale. Weight measurements were taken to the nearest 0.1 kg. Height was measured with the Leicester height measure mounted on a board. During height measurement, the subject stood upright, wearing no shoes, on a flat surface against a wall with the head in the Frankfort plane. Measurements were taken to the nearest 0.5 cm (Mamabolo *et al.*, 2005). All measurements were taken twice. If the difference between the two measurements was more than 0.5 kg and 1.0 cm for weight and height measurements respectively, then a third measurement was taken and recorded. The mean of the two values closest was then reported. The ages of the children were calculated from birth dates reported on the school registration lists.

3.6.3. Dietary intake assessment

Food consumption of children from grade 2 to grade four was measured using repeated 24-hour dietary recall records. These data were collected in 2011. The 24-hour dietary recall record was administered on three non-consecutive days by trained fieldworkers in the form of interviews. To ensure the accuracy of information received, children were interviewed

together with their primary caregiver in a language they preferred and understood. The interviewer probed both caregiver and child during the interview in order to assist them in remembering and describing what they had eaten. Primary caregivers were assisted in estimating the portion sizes of the food their children ate. This was done by showing them photographs of commonly eaten foods in a validated food portion photograph book (FPPB) (Venter *et al.*, 2001) and by using common utensils and containers. Primary caregivers mentioned the food their children had consumed the previous day and indicated the portion size either by pointing out the appropriate photograph in the FPPB or by using a utensil or container. Each interview took about 30 to 45 minutes.

3.6.4. Biochemical analysis

Zinc, iron and vitamin A status were determined in order to establish the micronutrient status of the children in the study. Blood samples of the children from grade R to grade four were drawn in March 2012 to determine iron, zinc and vitamin A levels. This was carried out by three registered nurses. Blood was drawn into 2x6 mL serum tubes from non-fasting subjects with the use of a sterile Venofix infusion set (BRAUN, 23G, 0.65x20 mm) and syringes. All blood samples were transported within 1–2 hours to the laboratory at the Centre of Excellence for Nutrition, North-West University, to be centrifuged and stored at -84 °C until further analysis. Haemoglobin (Hb) and erythrocyte zinc protoporphyrin (ZPP) were measured immediately in the laboratory (as described below).

For serum preparation, blood contained in 2x6 mL serum tubes was clotted in the tubes, centrifuged at 3500rpm for 10 minutes at room temperature (Universal 16RTM, Hettich), and transferred into storage tubes. Ethylenediaminetetraacetic acid (EDTA) blood was prepared by drawing 4 mL blood into EDTA test tubes. Hb concentration was measured on whole blood in the EDTA tubes using the Beckman Coulter (Coulter Ac.T5diff CP). After the Hb was measured, the tubes were centrifuged for 10 minutes at 3500rpm. The plasma was transferred into Eppendorf tubes and stored at -80 °C for analysis. The remaining red blood cells (RBC) in the tubes were washed with 5 mL saline solution, inverted and spun off. This procedure was repeated three times. A drop of RBC was then taken to measure ZPP. ZPP was measured using an Aviv ZPP Hematofluorometer. Care was taken throughout to ensure that the samples were protected from direct light. The tubes used for the zinc sample were trace element-free (tubes washed with 10–20% HNO₃) to avoid contamination with zinc and iron (van Jaarsveld *et al.*, 2005).

Serum ferritin was measured using a Ferritin Elisa kit, which is an enzyme immunoassay procedure for the quantitative analysis of serum ferritin (Ramco Laboratories, Inc. 4100 Greenbriar Drive Suite 200 Stafford, Texas 77477). Serum transferrin receptor (sTfR) was determined by using an *in vitro* enzyme immunoassay for quantifying human sTfR as an aid to diagnose iron deficiency anaemia (Ramco Laboratories, Inc. 4100 Greenbriar Drive Suite 200 Stafford, Texas 77477).

Samples were sent to the Medical Research Council (MRC) in Cape Town for analysis of serum retinol, zinc and C-reactive protein (CRP). Serum retinol was measured by reversed-phase HPLC (SpectraSERIS) (van Jaarsveld *et al.*, 2005). Serum zinc was analysed with a flame atomic absorption spectrophotometer (Philips Pye Unicam SP9, Cambridge, United Kingdom) with a commercial control serum (Seronom Trace Elements Serum; SERO AS, Billingstad, Norway) as a quality control (van Jaarsveld *et al.*, 2005). CRP was measured as a marker of infection. This was measured by an immunoturbidimetric method (Technicon method no. SM4-0183G89, Technicon RA-1000 auto analyser; Technicon Instruments, NY) with the use of Bayer TESTpoint Serum Protein Controls (Bayer Diagnostics, Fernwald, Germany) (van Jaarsveld *et al.*, 2005).

3.6.5. Nutrient composition of ALVs

ALVs were analysed for iron, zinc and β -carotene composition. Nutrient analysis was conducted on selected vegetables: *Amaranthus cruentus*, *Cleome gynandra*, *Cucurbita maxima* and *Vigna unguiculata*. Samples of ALVs were prepared and immediately frozen at -20 °C and stored until analysis. Analysis was carried out on raw ALVs that had been frozen and stored for six months.

Samples were sent to Microchem laboratories accredited by the South African National Accreditation System (SANAS). The ICP-OES method (S.O.P.C No 45) was used for the analysis of iron and zinc (mg/100 g). With the use of the Rapid Nitric-Perchloric Acid Digestion Method, approximately 0.5 g of each freeze-dried sample is digested (Schönfeldt & Pretorius, 2011). Analysis of β -carotene was carried out at the MRC. Composite samples were analysed in triplicate by High Performance Liquid Chromatography (HPLC) (SpectraSERIS; Thermo Separation Products, Fremont, CA) on the same day by using a validated method. Three 2 g samples of each composite sample are extracted with tetrahydrofuran: methanol (1:1, by vol). A β -carotene standard (synthetic, crystalline, Type II, product C-4582; Stigma Chemical Co, St Louis, MO) is purified by HPLC, and an aliquot of

the purified standard solution with a known concentration was used as the external standard for the quantification of β -carotene in the sample extract (van Jaarsveld *et al.*, 2005).

3.6.6. Focus group

The FGD was used to assess the extent of the knowledge and use of ALVs among selected primary caregivers in the semi-rural farm community. For the purpose of this study, the term “knowledge” was used as “an outcome of model-making about the functioning of the natural world” (Gadgil *et al.*, 1993), and it referred mostly to indigenous knowledge, which was further described as “a cumulative body of knowledge and beliefs handed down through generations by cultural transmission about survival and the relationship of beings (including humans) with one another and their environment” (Gadgil *et al.*, 1993). Within this context, caregivers were considered to be knowledgeable if they could express or give out any form of relevant information on ALVs, their use and any other perceptions and beliefs associated with their use. The term “use” in this context referred to the purposes that ALVs served within the community and the processes that were involved in preparation for their purpose (Oxford online dictionary, 2012).

3.6.6.1. Structure of the focus group

Participants were categorised into four age groups: 18–30 years, 31–40 years, 41–50 years, and above 51 years old. The rationale for this grouping was to have different age groups in the focus group so as to gather rich information. The group was homogeneous in terms of the fact that they had the same socio-economic background and were living in the same community; they were primary caregivers of children in grades two to four in the selected schools and were the ones most involved in food preparation for the child. McLafferty (2004) stated that there are several ways of creating homogeneity in focus groups and that homogeneity is not classified only by age and gender. In explorative studies homogeneity can also be classified according to status, class, occupation and other characteristics. Homogeneity in a group is very important because if participants perceive each other as fundamentally similar then they will spend less time explaining themselves to each other and more time discussing the issues at hand (de Vos *et al.*, 2011). By including different age groups it was hoped to stimulate the interaction between the participants, because elderly people, especially elderly women, are regarded as custodians of the knowledge associated with traditional vegetables (Dweba & Mearns, 2011; Vorster *et al.*, 2007).

Two participants were selected from each age group to form a focus group with eight participants each. McLafferty (2004) states that a focus group should be neither too large nor too small because either will result in providing unsubstantial information. Focus groups usually include from six–ten participants, as groups of this size allow everyone to participate, while still evoking a range of responses (De Vos *et al.* (2011).

A week before data collection, potential participants were visited in their homes and asked if they were willing to participate in the FGD on “the knowledge and use of ALVs within their surroundings”. A list of participants in the different age group categories was used as a guide for finding participants. In cases where a potential participant was not available, a replacement in the same age group was found. Thirty-two invitations were sent out. Information was given verbally, and the invitation letter included information on what would be discussed at the focus group, the purpose of the study, the kind of participants that would take part, the dates and the venue. Participants were also informed of what was expected of them during the focus group and what would be offered to them in terms of incentives for taking part. They were assured that they could withdraw at any time from the study without consequences and that support would be available to them even after the group discussion, if needed. Finally, they were assured that data generated during the FGD would be used solely for the purpose of the current study (De Vos *et al.*, 2011). On the day of the FGD, group one consisted of eight participants; group two had seven participants; group three, seven participants and group four, seven participants. Altogether, a total of 29 participants took part in the FGD (three males and 26 females).

3.6.6.2. Focus group discussion guide

A discussion guide with six open-ended questions was designed to collect data on the knowledge and use of ALVs (addendum C). The discussion guide directed and stimulated the group discussion (McLafferty, 2004). The questions in the discussion guide were derived from the third study objective and were constructed to acquire valuable data from the study population. These questions were further reviewed and discussed with an expert in conducting focus group discussions. The purpose of this reviewing exercise was to test the content and construct validity of the data collection tool. The content validity test assessed the extent to which the questions in the discussion guide appeared logically to attain the desired results from the study population (Bowling, 2002). At this stage, probing words were added to the questions in the discussion guide and the questions were also simplified to make them more comprehensible to the study population. Construct validity was necessary

to confirm that the data collection tool measured the underlying concepts it purported to measure (Bowling, 2002).

The questions in the discussion guide appeared as follows:

1. Can you tell me more about the ALVs in your community/surroundings?
2. You have mentioned all these ALVs; let us talk about where you get them.
3. These ALVs, how do you use them?
4. These ALVs, how and why do you store them?
5. Please tell me more about the beliefs about these ALVs.
6. Please tell me more about your feelings and your views regarding these ALVs.

To further ensure validity of the discussion guide, a pilot study was carried out. In this context, the term validity was used to refer to the degree to which the data collection tool could generate results that accurately reflect what the research intended to achieve. A pilot study in qualitative research enables the researcher to focus on specific areas in the research that may have been previously unclear (Denzin & Lincoln, 1994). The pilot study helped improve the discussion guide by identifying words that were too technical for the study population. Piloting was also used as a tool to find out the most appropriate number of participants for a focus group, and gave an estimate of how much time was required to obtain rich and meaningful data (McLafferty, 2004).

The pilot study was conducted on two Setswana-speaking employees (one male and one female) of the Nutrition Department of the NWU Potchefstroom campus. They were both also proficient in the English language. The female was employed as a laboratory assistant and the male as a research assistant. Verbal consent was sought from the participants before the discussion. The discussion was conducted in English by the researcher. The discussion guide that was tested consisted of six open-ended questions. Ethical procedures were explained to the participants and they were ensured that data acquired from the discussion was meant solely for research purposes. The discussion, which was recorded on a tape recorder with the consent of the participants, lasted 21 minutes. Data from the pilot study were not included in the analysis of the current study. However, it gave valuable information that the discussion guide was reliable and had been used effectively in the current study population.

A photo atlas from the Agricultural Research Council (ARC) with pictures of ALVs was used to facilitate the process of data collection (Figure 3.2). The atlas enabled participants to point

out the ALVs if they did not remember their names. It also assisted in connecting the common names of the plants to their botanical names. This research was able to identify more plants because of the use of the photo atlas.



Figure 3.2: Participants identifying ALVs looking at pictures from photo atlas (*photo by: M. van der Hoeven*)

3.6.6.3. The FGDs

The FGDs were held on the 28th and the 29th of June 2011. Two groups were held on the 28th and the other two were held on the 29th of June 2011. Only four FGDs were held because data saturation was reached during the fourth FGDs. On the day of the FGDs, participants were fetched from their homes to meet at one of the schools where the FGDs was to take place. A classroom was prepared for the discussion. At the time of the FGDs, schools had closed for the holidays so this minimised any possible disturbances. Participants were welcomed with coffee and tea before being asked to be seated in a circle around a table (Figure 3.3). The circle seating arrangement allowed for participants to see each other during the discussions and also encouraged a group atmosphere and bonding. Because the setting is a very important element in the use of focus groups, every effort was made to ensure that the environment was comfortable and conducive to discussion among

the participants. The school environment was chosen to make participants feel that they were in a familiar environment, making data collection easier (de Vos *et al.* 2011).



Figure 3.3: Participants seated with facilitator and researcher during a focus group discussion (*photo by M. van der Hoeven*)

The FGDs commenced with the introduction of the research team, and welcoming of the participants by the facilitator who also conducted the discussions in Setswana. Participants were then assisted to fill informed consent forms. The discussion followed immediately, starting with the first question on the discussion guide. Every session was recorded by means of a tape recorder. Notes were also taken to protect against machine failure and, more importantly, to provide a means of observation of the non-verbal accounts provided by participants, which a tape recorder cannot capture (Sim, 1998). The first FGD took 51 minutes, followed by the second FGD, which lasted 65 minutes. The third FGD took 48 minutes and finally, the fourth FGD lasted 42 minutes. Refreshments were served at the end of each session. An incentive of R10 was given to each participant to thank them for their participation.

3.7. Statistical data analysis

3.7.1. Socio-demographic and socio-economic parameters

Analysis of socio-demographic and socioeconomic data was performed using the IBM Statistical Package for Social Sciences (IBM SPSS 20.0 for Windows) and MS Excel. Analysis of this data was carried out using simple descriptive statistics which included frequencies and means.

3.7.2. Anthropometric measures

Height-for-age Z-scores (HAZ), weight-for-age Z-scores (WAZ) and Body Mass Index-for-age Z-scores (BMIAZ) were analysed using the WHO Reference 2007 SPSS macro package. Stunting and underweight using WAZ and BMIAZ was defined by $Z < -2SD$ (WHO, 2012). Prevalence of stunting and underweight by gender was analysed using descriptive statistics. All statistical analysis was done using IBM SPSS Statistics 20 software.

3.7.3. Dietary analysis

Dietary data were captured using the MRC FoodFinder Dietary Analysis program, which contains locally compiled food composition tables. Dietary data were analysed as nutrient intakes. For continuous variables, descriptive statistics (medians and 95% CI) were calculated. All statistical analysis was done using IBM SPSS Statistics 20 software. The median micronutrient intake of the children was compared with the Estimated Average Requirement (EAR) for children aged 5–13 years to determine the adequacy of the intake of iron, zinc and vitamin A in the diets of the children.

3.7.4. Biochemical data analysis

Anaemia was defined as Hb concentration <11.5 g/dL for children aged 5–11 years, <12 g/dL for children aged 12–13 years). Iron deficiency was defined as serum ferritin concentration <15 μ g/L or serum transferrin receptor (sTfR) concentration >8.3 mg/L (Elisa kit specific). Serum ferritin ≥ 15 to <20 μ g/L was defined as marginal iron deficiency (WHO, 2011a) Zinc deficiency was defined as serum zinc concentration <65 μ g/dL (Hotz *et al*, 2003). Vitamin A deficiency was defined as serum retinol <20 μ g/dL and serum retinol ≥ 20 to <30 μ g/dL was defined as sub-clinical vitamin A deficiency (WHO, 2011b). The acute phase

response was defined as serum concentrations of CRP > 5 mg/L. All children with CRP > 5 mg/L were excluded from the study. The IBM SPSS Statistics 20 software was used to analyse the data. Statistical significance was set at $P < 0.05$. Differences by gender and age were assessed by the Chi-square test, independent sample t test and the Mann-Whitney U test for categorical variables. Table 3.1 gives a summary of the WHO criteria that was used in this study to indicate the level of public health significance of deficiencies in iron, zinc and vitamin A.

Table: 3.1: Level of public health significance of deficiencies.

Deficiency	Level of deficiency indicative of a public health problem	
Anaemia	¹ <i>Mild public health problem</i>	prevalence of anaemia 5 to <20%
	<i>Moderate public health problem</i>	prevalence of anaemia 20 to <40%
	<i>Severe public health problem</i>	prevalence of anaemia $\geq 40\%$
Iron deficiency	<i>Level not defined</i>	
Zinc deficiency	³ A population is at high risk if more than 20% of the population zinc status is <65 $\mu\text{g/dL}$	
Vitamin A deficiency	² <i>Mild public health problem:</i> $\geq 2\%$ to <10% of a population with serum retinol <20 $\mu\text{g/dL}$ <i>Moderate public health problem:</i> $\geq 10\%$ to <20% of a population with serum retinol <20 $\mu\text{g/dL}$ <i>Severe public health problem:</i> $\geq 20\%$ of a population with serum retinol <20 $\mu\text{g/dL}$	

¹WHO (2011a); ²WHO (2011b); ³Hotz *et al.* (2003)

3.7.5. Nutrient composition data on ALVs

The composition of iron, zinc and β -carotene in the ALVs was compared with the RDA of iron, zinc and vitamin A for children aged 5–13 years. To calculate the potential contribution of the ALVs to the RDAs for these nutrients, the USDA-recommended vegetable intake of 240 grams per day for children was used. The potential contribution was presented as a percentage.

Calculations:

Potential contribution (mg/day) = nutrient composition ALV (mg/100 g) x 240 g/day / 100 g

% potential contribution = Potential contribution (mg/day) / RDA (mg/day) x 100

3.7.6. Focus group discussions

Analysis of the data gathered from the focus groups on the extent of their knowledge and use of ALVs was carried out. Recorded discussions were transcribed and translated from Setswana to English. A quality check was carried out on the transcribed data and translated carefully and correctly to ensure that the original meaning was not lost in translation. Transcribed notes were compared with notes taken during the group discussions. The inductive approach to qualitative analysis was used to analyse and interpret the data obtained from the focus groups transcripts. This approach enabled research findings to be extracted by identifying frequent, dominant or significant themes that emerged from the raw study data (Thomas, 2006). Colour coding was used to identify possible themes that emerged from the focus group discussions. After assessing all the transcripts, data with the same colour codes were grouped together and themes and subthemes were developed to describe the findings. Direct quotes from participants were included in the description of the findings to give more meaning to the context.

CHAPTER 4: RESULTS

4.1. Introduction

This chapter presents the quantitative and qualitative results obtained during this study which was conducted to assess the potential contribution of ALVs to the nutritional status of children in a semi-rural farm community in the NW Province. The results are presented in three sections; 1) a situational analysis of the studied community, 2) the nutritional composition of selected ALVs, and 3) the extent of the knowledge and the use of ALVs in the semi-rural farm community.

4.2. Situational analysis of the semi-rural farm community

The situational analysis presents the socio-demographic and socio-economic status of households within the community and identifies gaps in nutritional status in children in the community.

4.2.1. Socio-demographic and socioeconomic status of community

In total, 114 primary caregivers of children from grade R to grade four in the farm schools were interviewed with regard to their household situation. The socio-demographic characteristics of households are presented in Table 4.1. Females (90.4%) dominated as primary caregivers. Most primary caregivers had secondary school education (44.8%) while 36% had only primary school education. On average, a household consisted of three children (aged 0–18 years) and two adults (aged 18 years and older). A large number of households shared toilet facilities (73.7%) and had access to drinking water by means of communal taps (57.9%). Although electricity was the main energy source for cooking (46.5%), wood was also largely used (34.2%). A majority of households within this community (67.5%) had a total monthly household income of between R501 and R2000 (Figure 4.1). The main sources of income for households were social grants and permanent or temporary jobs on the farms and in surrounding areas, accounting for 84.2% and 58% respectively. More than three quarters of households (78.9%) had three people or fewer contributing to the household income.

Table 4.1: Socio-demographic and socioeconomic characteristics of households

	(n = 114)	Frequency (%)
Gender of primary caregiver		
Male	11	9.6
Female	103	90.4
Level of education of primary caregiver		
None	22	19.3
Primary school	41	36.0
Std 6–8/Gr 8–10	37	32.5
Std 9–10/Gr 11–12	14	12.3
Occupation of primary caregiver		
Employed	66	58.0
Unemployed	48	42.0
Material of house		
Brick/concrete	74	64.9
Mud	5	4.4
Tin	13	11.4
Plank, wood	4	3.5
Other	18	15.8
Toilet facilities		
Share toilet with other households	84	73.7
Do not share toilet with other households	30	25.4
Flush toilet	27	23.7
Bucket, pot	19	16.7
Pit, vip	59	51.8
None	9	7.9
Source of drinking water		
Own tap	46	40.4
Communal tap	66	57.9
River, dam	1	0.9
Borehole, well	1	0.9
Primary energy source for cooking		
Electricity	53	46.5
Gas	4	3.5
Paraffin	15	12.2
Wood	39	34.2
Coal	1	0.9
other	2	1.8
*Households receiving any form of food aid	25	21.9

* Excluding national school feeding scheme

4.2.1.1. Household food

Most households (71.9%) did not grow additional foods for their own use to complement the food they purchased from the supermarkets. The two main reasons for not growing food for their own use were that land was unavailable, or when land was available, that money constraints made it impossible to purchase seeds and other supplies to maintain a home garden.

Households with a home garden often grew foods such as peaches, tomatoes, pumpkin, onions, spinach and cabbage. In almost all households (78.1%) there was no member who received any form of food aid, excluding the national school feeding scheme. Many households spent between R200 and R600 on food on a monthly basis (57%), whereas 29% spent between R600 and R1000. No household spent more than R2000 on food on a monthly basis (Figure 4.2).

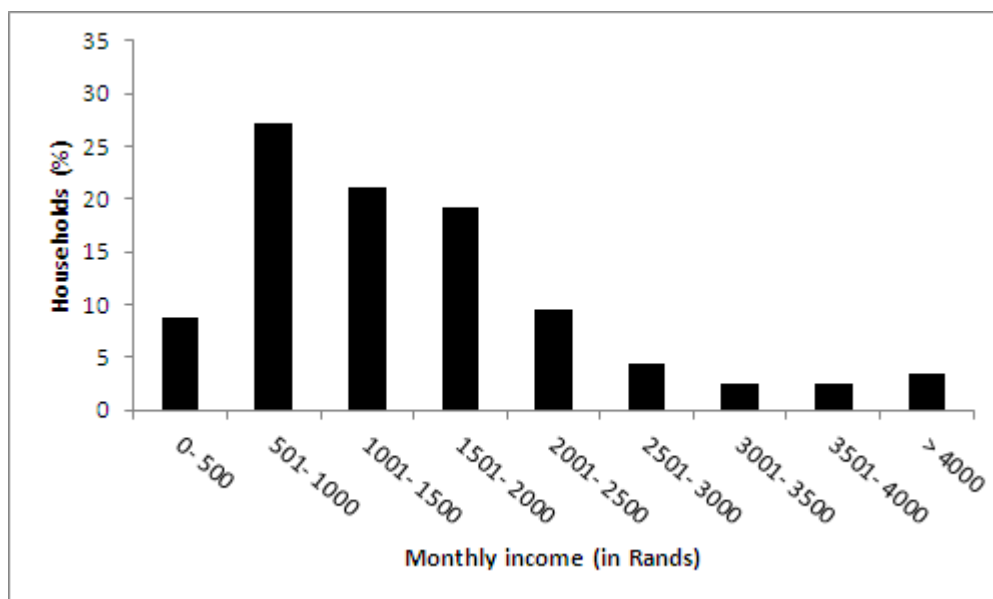


Figure 4.1: Total monthly household income

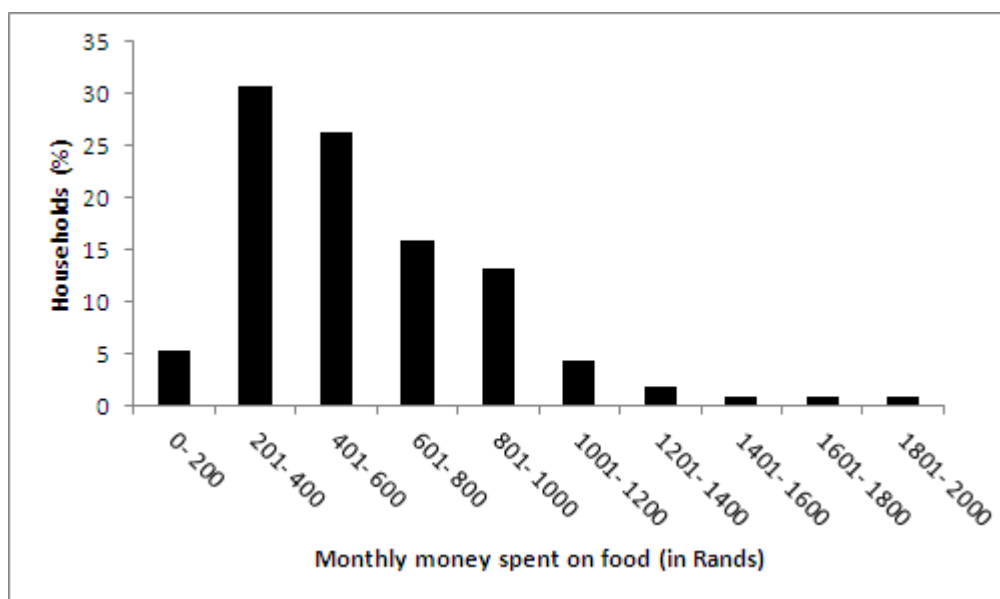


Figure 4.2: Money spent on food in households

4.2.2. Anthropometric status of children

Table 4.2 presents the mean z-scores of children by gender and Figure 4.3 presents the prevalence of stunting and underweight in children by gender. Stunting (11%; $n = 154$) was the most prevalent nutritional disorder among children with a prevalence of 12.5% and 9.5% in males and females respectively. There was no significant difference in the prevalence of stunting between males and females ($p = 0.55$). One child's stunting results were missing. Prevalence of underweight based on WAZ and BMIAZ combined was (13.2%) in females and (10.5%) in males.

Table 4.2: Mean Z-scores of children by gender

Gender	HAZ	WAZ [‡]	BMIAZ
mean $\pm$ SD (n)			
Male	-0.7 $\pm$ 0.9 (80)	-0.8 $\pm$ 0.9 (69)	-0.6 $\pm$ 0.8 (80)
Female	-0.7 $\pm$ 1.0 (74)	-0.6 $\pm$ 0.9 (52)	-0.5 $\pm$ 0.9 (73)
Total	-0.8 $\pm$ 1.0 (154)	-0.7 $\pm$ 0.9 (121)	-0.5 $\pm$ 0.9 (153)

Height-for-age Z-scores (HAZ).

Weight-for-age Z-scores (WAZ).

Body Mass Index-for-age Z-scores (BMIAZ).

[‡] Available only for children <11 years of age ($n = 121$).

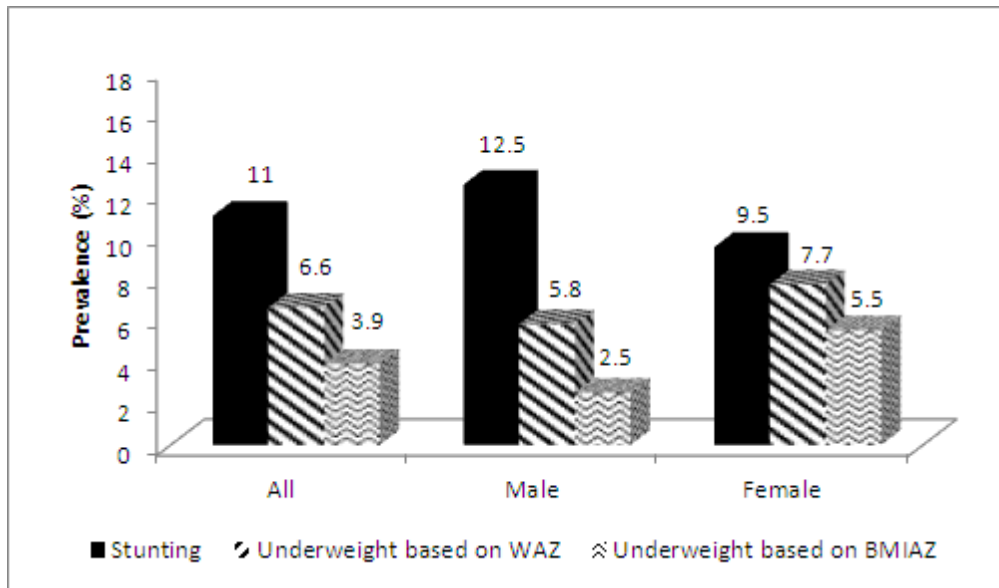


Figure 4.3: Prevalence of stunting and underweight of children by gender

Table 4.3 presents the mean z-scores of children by age category and Figure 4.4 presents the prevalence of stunting and underweight in all children by age category. The mean age of the children was 7.9 ± 2.2 years. Stunting was the most prevalent nutritional disorder among children in all age categories, with the highest prevalence (17.6%) in children aged 9–13 years. There was a trend for higher prevalence of stunting in older children when compared to the younger children ($p = 0.06$). The prevalence of underweight based on WAZ was 6.8% and 5.6% in children aged 5–8 years and 9–13 respectively. The prevalence of underweight based on BMIAZ was significantly higher in children aged 9–13 years ($p = 0.008$).

Table 4.3: Mean Z-score of children by age category

Age category	HAZ	WAZ [‡]	BMIAZ
mean $\pm$ SD (n)			
5-8 years	-0.6 $\pm$ 1.0 (103)	-0.7 $\pm$ 0.9 (103)	-0.5 $\pm$ 0.8 (102)
9-13 years	-1.0 $\pm$ 0.9 (51)	-0.8 $\pm$ 1.0 (18)	-0.7 $\pm$ 1.0 (51)

Height-for-age Z-scores (HAZ).

Weight-for-age Z-scores (WAZ).

Body Mass Index-for-age Z-scores (BMIAZ).

[‡] Available only for children <11 years of age ($n = 121$).

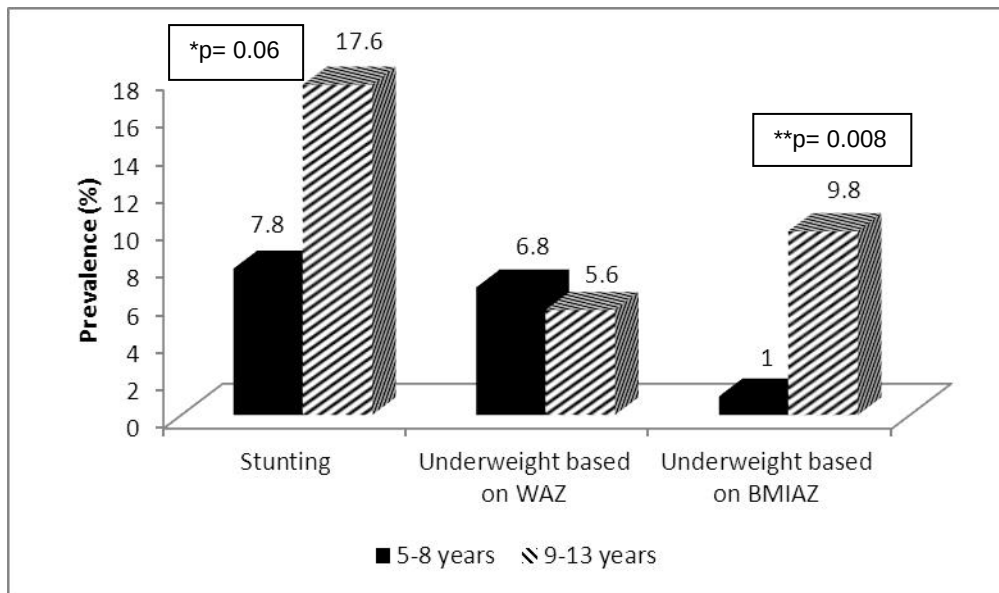


Figure 4.4: Prevalence of stunting and underweight in children by age category
p values calculated using Pearson Chi-Square test

4.2.3. Dietary intake of children

Table 4.4 presents the median dietary intake of children ($n = 154$) aged 5–13 years. The Estimated Average Requirement (EAR) for iron, zinc and vitamin A is presented in Table 4.4 for age groups 5–8 years and 9–13 years (Institute of Medicine, 2003). The median intake of iron, zinc and vitamin A was more than the EAR for these nutrients in children aged 5–8 years. In children aged 9–13 years, the median intake of iron and zinc was above the EAR. However, the median vitamin A intake for boys and girls was below the EAR for boys.

Table 4.4: Median dietary intake of iron, zinc and vitamin A of children from 24-hour recall (*n* =154)

Median nutrient intake per day	Median	25 th percentile	75 th percentile	EAR
5–8 years (<i>n</i> =67)				
Iron (mg/d)	14.9	13.7	15.4	4.1
Zinc (mg/d)	8.6	8.8	10.2	4
Vitamin A (RE mcg/d)	400.0	413.7	678.7	275
9–13 years (<i>n</i> =87)				
Iron (mg/d)	15.3	14.5	16.2	5.9 ^a / 5.7 ^b
Zinc (mg/d)	8.9	9.5	10.9	7
Vitamin A (RE mcg/d)	441.6	456.8	578.6	445 ^a / 420 ^b

^aEstimated Average Requirement (EAR) for males

^bEstimated Average Requirements (EAR) for females

4.2.4. Iron, zinc and vitamin A status of children

The mean haematological values of iron, zinc and vitamin A status of the children (*n* =155) are presented in Table 4.5. Females had significantly higher serum Hb (*p*= 0.01) and serum retinol (*p*= 0.02) concentrations than males. Table 4.6 presents the prevalence of deficiencies in iron, zinc and vitamin A. The most prevalent micronutrient deficiency in the children was zinc deficiency (74.8%). There was no significant difference in the prevalence of zinc deficiency between males and females (*p*= 0.46). Males (13.8%) were more anaemic than females (6.7%); however, this difference was not significant (*p*= 0.15). The prevalence of iron deficiency (serum ferritin <15 µg/L) and vitamin A deficiency (serum retinol <20 µg/dL) was 15.5% and 3.2% respectively. The prevalence of marginal iron deficiency (serum ferritin ≥15 to <20 µg/L) was 18.1%.

Table 4.5: Iron, zinc and vitamin A status of the school going children aged 5–13 years (n=155)

	Total (n=155)	Males (n=80)	Females (n=75)	P* gender
Serum ferritin (µg/L) [‡]	23.4 (21.4, 25.9)	23.7 (21.1, 26.5)	23.1 (19.5, 27.5)	0.97**
Mean ± SD				
sTfR (mg/L)	5.5 ± 5.0	5.7 ± 4.7	5.3 ± 5.4	0.59
Haemoglobin (g/dL)	12.7 ± 1.0	12.5 ± 1.1	12.9 ± 0.9	0.01
ZPP (µmol/mol haem)	40.7 ± 29.3	41.7 ± 36.2	39.7 ± 19.7	0.68
Serum zinc (µg/dL)	60.3 ± 8.9	59.7 ± 8.7	60.8 ± 9.1	0.46
Serum retinol (µg/dL)	33.1 ± 7.4	31.8 ± 7.5	34.5 ± 7.2	0.02
CRP (mg/L)	1.1 ± 1.2	1.2 ± 1.2	1.0 ± 1.1	0.60

*p value for difference between male and female using independent samples t-tests

**p value for differences between male and female obtained using Mann-Whitney U test

[‡]Serum ferritin reported as Geometric mean (95% CI)

Table 4.6: Prevalence of deficiencies in iron, zinc and vitamin A in school going children aged 5–13 (n=155)

	Total (n=155) (%)	Male (n=80) (%)	Female (n=75) (%)	P* <i>gender</i>
Iron deficiency				
Serum ferritin <15 µg/L	15.5	12.5	18.7	0.29
≥15 to <20 µg/L	18.1	18.8	17.3	0.82
sTfR > 8.3 mg/L	9.7	11.3	8	0.49
ZPP >40 µmol/mol haem ^a	34.2	38.8	29.3	0.22
ZPP >70 µmol/mol haem ^b	3.9	1.3	6.7	0.08
Anaemia				
Haemoglobin <11.5 g/dL (5–11 years)	10.3	13.8	6.7	0.15
<12 g/dL (12–13 years)				
Zinc deficiency				
Serum zinc <65 µg/dL	74.8	77.5	72	0.43
Vitamin A deficiency				
Serum retinol <20 µg/dL	3.2	5	1.3	0.19

^aZPP cut-off point for children older than 5 years with washed red blood cells

^bZPP cut-off point for children older than 5 years

*p value for difference between male and female using Pearson Chi-Square test

4.3. Nutrient composition of selected African Leafy Vegetables

Table 4.7 shows the zinc, iron and β -carotene composition of selected uncooked ALVs. *Amaranthus cruentus* and *Cleome gynandra* had more iron, zinc and β -carotene content than *Cucurbita maxima* and *Vigna unguiculata*. *Amaranthus cruentus* had the highest iron content, whereas *Cleome gynandra* had the highest zinc and β -carotene content. *Cucurbita maxima* had the lowest zinc and β -carotene content whereas *Vigna unguiculata* had the lowest iron content.

Table 4.7: Micronutrient composition of uncooked selected African Leafy Vegetables (values per 100 g edible portion)

African Leafy Vegetable	Iron (mg)	Zinc (mg)	β -carotene (μ g RAE)
<i>Amaranthus cruentus</i> (Amaranth)	3.2	1.0	314
<i>Cleome gynandra</i> (Spider plant)	3.0	1.4	363
<i>Cucurbita maxima</i> (Pumpkin)	1.6	0.5	120
<i>Vigna unguiculata</i> (Cowpeas)	1.4	0.7	182

RAE= retinol activity equivalents

Note: ALVs samples were analysed in duplicate

Table 4.8 illustrates the RDA of iron, zinc and vitamin A for children. This table was used as a guideline to calculate the percentage potential contribution of iron, zinc and β -carotene from each ALV.

Table 4.8: Dietary Reference Intakes (DRIs): Recommended Dietary Allowances (RDA) of iron, zinc and vitamin A for different age groups

Life stage group	Iron (mg/d)	Zinc (mg/d)	Vitamin A (μ g/d) ^a
Children			
4–8 y	10	5	400
Males			
9–13 y	8	8	600
14–18 y	11	11	900
Females			
9–13 y	8	8	600
14–18 y	15	9	700

^a As retinol activity equivalents (RAEs). 1 RAE= 1 μ g retinol, 12 μ g β -carotene

Adapted from Food and Nutrition Board, Institute of Medicine (2003)

4.3.1. Potential contribution of African Leafy Vegetables to the RDAs for iron, zinc and vitamin A in children

Table 4.9 and 4.10 show the potential contribution of ALVs in meeting the RDAs for iron, zinc and vitamin A in children, using the USDA-recommended vegetable intake of 240 grams per day for children (as described in chapter 2). *Amaranthus cruentus* can potentially contribute 77% and 96% of the RDA for iron in children aged 5–8 years and 9–13 years respectively. In all age categories, *Cucurbita maxima* potentially contributes the least to the RDA for zinc (15-24%) and vitamin A (4-6%) in children. *Cleome gynandra* can potentially contribute the most to the RDA for zinc (42-68%) and vitamin A (12-18%) in children. The ALV that potentially contributes most to the RDA for iron, zinc and vitamin A in children in all age categories is *Cleome gynandra*.

Table 4.9: Potential contribution of African Leafy Vegetables to the RDAs for iron, zinc and vitamin A in children aged 5–8 years

African leafy vegetable	Iron (mg)			Zinc (mg)			Vitamin A (µg)		
	Composition in ALV (mg/100g)	Potential contribution		Composition in ALV (mg/100g)	Potential contribution		Composition β-carotene in ALV (µg RAE /100g)	Potential contribution	
		(mg/d)	% of RDA		(mg/d)	% of RDA		(µg RAE/d)	% of RDA
<i>Amaranthus cruentus</i> (Amaranth)	3.2	7.7	77.0	1.0	2.4	48.0	314	754	15.7
<i>Cleome gynandra</i> (Spider plant)	3.0	7.2	72.0	1.4	3.4	68.0	363	871	18.1
<i>Cucurbita maxima</i> (pumpkin)	1.6	3.8	38.0	0.5	1.2	24.0	120	288	6.0
<i>Vigna unguiculata</i> (cowpeas)	1.4	3.3	33.0	0.7	1.7	34.0	182	437	9.1

RDA: iron 10 mg/d, zinc 5 mg/d, vitamin A 4800 µg/d (as retinol equivalents, 1 RAE= 1 µg retinol, 12 µg β-carotene)

USDA-recommended intake of 240 g/d of vegetables for children was used to calculate potential contribution of ALVs to RDAs for iron, zinc and vitamin A

RDA = recommended dietary allowances

RAE = retinol activity equivalents

Table 4.10: Potential contribution of African Leafy Vegetables to the RDAs for iron, zinc and vitamin A in children aged 9–13 years

African leafy vegetable	Iron (mg)			zinc (mg)			Vitamin A (µg)		
	Composition in ALV (mg/100g)	Potential contribution		Composition in ALV (mg/100g)	Potential contribution		Composition β-carotene in ALV (µg RAE /100g)	Potential contribution	
		(mg/d)	% of RDA		(mg/d)	% of RDA		(µg/d)	% of RDA
<i>Amaranthus cruentus</i> (Amaranth)	3.2	7.7	96.3	1.0	2.4	30.0	314	754	10.5
<i>Cleome gynandra</i> (Spider plant)	3.0	7.2	90.0	1.4	3.4	42.5	363	871	12.1
<i>Cucurbita maxima</i> (pumpkin)	1.6	3.8	47.5	0.5	1.2	15.0	120	288	4.0
<i>Vigna unguiculata</i> (cowpeas)	1.4	3.3	41.2	0.7	1.7	21.3	182	437	6.1

RDA: iron 8 mg/d, zinc 8 mg/d, and vitamin A 7200 µg/d (as retinol equivalents, 1 RAE= 1 µg retinol, 12 µg β-carotene)

USDA-recommended intake of 240 g/d of vegetables for children was used to calculate potential contribution of ALVs to RDAs for iron, zinc and vitamin A

RDA = recommended dietary allowances

RAE = retinol activity equivalents

4.4. Knowledge and use of African Leafy Vegetables

4.4.1. Socio-demographic data of respondents from the focus group discussions

The FGDs had 29 primary caregivers as participants, of which the majority (89.7%) was female. Most participants (48.3%) achieved only primary school education. The median number of children for which a caregiver was responsible was three. Most participants (55.2%) were mothers of children in the farm schools. Unemployment was very high, with 38% of the respondents having no work. Most participants received one or more social grants. These grants were not mutually exclusive, meaning that a participant could receive more than one social grant at the same time. The child support grant was the most common type of grant received by participants (75.9%). The majority of the elderly participants received the Older Person's Grant. Most (89.7%) households did not receive any food aid. This excludes the food the school going children received from the national school feeding scheme. Working radios and televisions were common within households. Only 34.5% had a working fridge-freezer combination. Most participants indicated that their household had access to drinking water by means of communal taps (55.2%) and own taps (44.8%). More than half of the participants indicated that their husbands were the head of the household (58.6%) and 34% indicated that they themselves were the head of the household.

4.4.1.1. Household food and income

A large number of respondents (72%) indicated that they themselves often decided on the amount of money spent in food for the household, whereas 10.3% indicated that their husbands decided on this matter. With regard to home-grown food for subsistence, 72.4% of respondents indicated that the household did not cultivate any food. Most (86.2%) households spent approximately between R201 and R1000 on a monthly basis on food (Figure 4.5). Only one household spent approximately R1601–1800 monthly on food. This household had an income range of R2001–2500. On average, two people (2.69 ± 1.58) in a household contributed to the income of the household. More than half of respondents (58.6%) indicated that their household received a total monthly income of R1001–R2500. Only one respondent indicated that the household received more than R4000 on a monthly basis as income. In this particular household, the caregiver interviewed was unemployed. This particular household also had seven children all aged below 18 years and received the most grants (old age, disability and child support grants).

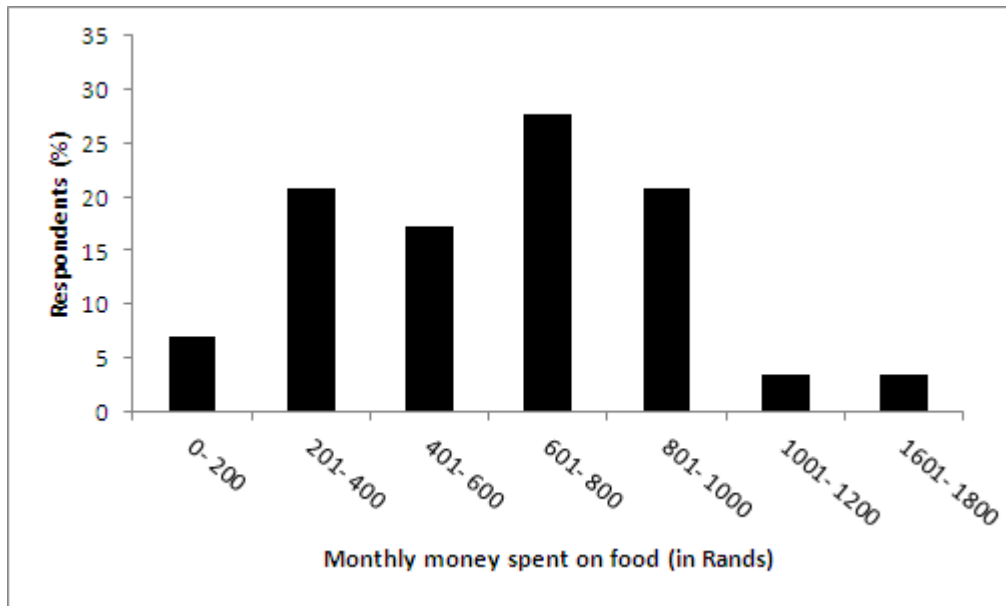


Figure 4.5: Money spent on household food

4.4.2. Dynamics of the focus group discussions

The FGDs took place with no interruptions in an environment where primary caregivers had the freedom to express their views and opinions. There was no obvious observable tension between the caregivers during the discussions. Overall, caregivers were fully engaged in the discussions. Differences were observed, however, between the genders and the various age groups. The FGDs were female-dominated, usually including only one male at a time. As a result, the females tended to dominate the discussions. However, the facilitator was able to insist on regular male participation, and therefore, the males were able to express their knowledge as well, eventually avoiding biases. At times, the elderly participants tended to hold back their comments, leaving the younger participants to dominate the discussions. One elderly woman said: *“I just don’t understand...see the younger ones are managing well on their own with the information”*. The group facilitator was able to bridge these gaps and ensure that the elderly participants were more engaged in the discussions as the FGD progressed.

4.4.3. Qualitative results from the focus group discussions: the knowledge and use of African Leafy Vegetables

Respondents identified and mentioned a wide variety of ALVs which they were aware of and used within their community. These ALVs were used mainly as relish to accompany staple starch foods to enhance taste. One ALV, *Physalis peruviana*, commonly known as sepatlapatla, was identified as also having medical attributes. A respondent said the following about the vegetable: *“It gives you strength. It heals the stomach, the lady parts and the kidneys. It helps if you have pain and such. It helps with menstrual pains”*. Table 4.11 below gives a list of some of the ALVs that respondents had knowledge of and used. The ALVs that were known and used most by primary caregivers, as indicated in the FGDs, were *Amaranthus spp* and *Chenopodium album*.

Table 4.11: African Leafy Vegetables most used and identified by primary caregivers in focus group discussions

Local name	Botanical name	Use	FG1	FG2	FG3	FG4
Lekgomane	<i>Lagensia siceraria</i>	Relish	☺	☺	†	†
Lerotho	<i>Cleome gynandra</i>	Relish	☺	☺	†	†
Sthwanya	Unknown	Relish	†	†	☺	☺
Sepatlapatla	<i>Physalis pyruviana</i>	Relish & medicinal (curing ailments associated with pain)	☺	†	☺	†
Spaile	<i>Brassica carinata</i>	Relish	☺	☺ *	†	☺ *
Senkgane/Sekgapapane/ Imbikilicane	<i>Chenopodium album</i>	Relish	☺ *	☺ *	☺ *	☺ *
Sekgalo	Unknown	Relish	☺ *	☺	☺	☺
Sehuwe	Unknown	Relish	☺	†	☺	☺ *
Thepe	<i>Amaranthus blitum</i> , <i>Amaranthus spp</i> <i>graecizans</i> , <i>Amaranthus cruentus</i> & <i>Amaranthus tricolor</i>	Relish	☺ *	☺ *	☺ *	☺ *

☺ 88% of primary caregivers in focus group knew ALV and were familiar with its use

☺* ALV mostly used in household

† ALV not known and not used

FG = Focus group

Respondents expressed their knowledge with regard to the ALVs within their community by discussing the availability and accessibility of these vegetables, how they were prepared for consumption, how they were stored and their perceived importance in nutrition and general health.

4.4.3.1. Theme 1: Availability of and access to African Leafy Vegetables

ALVs were known to grow naturally in the wild bushes, planting farmlands and in areas where water was widely available (for example, river banks, swamps and water-logged areas).

“We get all the types of wild spinach from the farms and fields, like thepe and senkgane. On these farms, they grow maize and sunflowers and more. The wild spinach will grow in between these crops.”

“By the river, where it is wet. You don’t find it where there isn’t a lot of water.”

ALVs were not available throughout the year. Most of them grew in the summer and during rainy seasons. During these periods they were consumed by respondents.

4.4.3.2. Theme 2: Preservation and storage

Knowledge with regard to storing and preserving ALVs was widespread among respondents in the FGDs. The responses received also indicated that this knowledge was passed on from one generation to the other.

“Back then, our mothers used to dry them and save them for the future.”

Washed fresh leaves were often dried in the sun and stored in sacks for consumption in winter and other times of the year when the vegetables were not available. Cooked leaves were also dried and stored. To preserve these vegetables, other plant products such as beans were used to keep insects and pests away. Respondents indicated that storage did not change the taste of the ALVs.

4.4.3.3. Theme 3: Preparation (how African Leafy Vegetables are cooked)

The method of cooking the ALVs was similar among respondents in all the focus groups. They differed, however, in the different ingredients that they added during cooking. Some of the additional ingredients used during preparation included salt, onions, tomatoes, oil, peanut butter, milk and other spices. This was according to individual preference. These vegetables were chiefly used as condiments for main starch-based dishes. The leaves were often hand-picked, washed, and boiled with plenty of water, which was drained afterwards.

“With Thepe you pick it and then cook it the way you know.... if you have potatoes, you can add them. If you have onions, you can add them and also a bit of milk. If you have any spices, you add them, and there you will have a nice meal that you can enjoy with pap.”

“You can also cook it by picking it, washing it, and boiling it. Then you add salt, maybe spices, and then eat it... It does not really need all that stuff, like potatoes, tomatoes”.

These above quotes underlined the differences in the personal preferences of respondents.

Most ALVs were said to have a bitter taste and were often boiled and drained two to three times in plenty of water to get rid of the bitterness. Respondents had mixed views and perceptions about this particular method of cooking. Some believed it was rather useful because it improved the taste of the vegetables, whereas others believed that it was not ideal as it led to nutrient loss in the ALVs. Throughout the discussions it was observed that the knowledge of how to cook these vegetables was transferred through generations and, as a result, some practices, though perceived as inappropriate, were still being used.

“With seruwe you cook it. Then you drain the water two to three times. Back home, my grandmother used to drain the water and then add peanuts and some oil. My grandmother believed they add flavour to the wild spinach and that peanuts were nutritious.”

“We always saw our elders draining the water...and they would always say do not forget to drain the water.”

4.4.3.4. Theme 4: Respondents’ perceptions, beliefs and feelings regarding the use of African Leafy Vegetables

ALVs were perceived as good and nutritious, containing vitamins which respondents believed were essential in providing energy, boosting the immune system and preventing against illness and infections.

“I believe that the wild spinach can help protect a person’s skin. The liquid from the spinach travels throughout your body, rejuvenates it, and protects you from various diseases.

“Children from our day were very healthy because of it.”

ALVs were appreciated as an affordable source of food because they were often picked from the bush and field. As a result, some respondents said they preferred it to meat and other meat products.

“I feel proud of them because most of the time when you do not have money, you just go out, find them and collect them. Sometimes, you may have pap but nothing to eat it with. Then you can look for wild spinach, and you go to bed with a full stomach.”

“It is better than meat because you do not spend a lot.”

Generally respondents had a positive attitude towards the consumption of ALVs and mentioned how they enjoyed the taste of the vegetables. The various methods by which the ALVs could be prepared made them more enjoyable for consumption as well.

“When you cook it, my goodness, it tastes so good!”

“I feel hungry just talking about it!”

“Even if you come with meat, we are fine with our wild vegetables.”

The results from the FGDs gave evidence that the knowledge of ALVs and their associated use was mostly indigenous knowledge, acquired through interaction with others and transferred from one generation to the other. Perceptions and beliefs surrounding the use of these vegetables were also transferred and acquired through a system based on indigenous knowledge. Respondents had a positive attitude towards the consumption of ALVs and they also had reasonable knowledge of their existence and use.

CHAPTER 5: DISCUSSION

5.1. Introduction

Years after the mandatory fortification of staple foods with micronutrients, children in SA still suffer from deficiencies of micronutrients such as iron, zinc and vitamin A, and have poor nutritional status (Dhansay *et al.*, 2007; Labadarios *et al.*, 2007; Labadarios & Louw, 2007). This has led to increased morbidity in children. If not addressed, micronutrient deficiencies in children can lead to poor growth and development and poor cognition, which can later have a detrimental effect on school performance. Various strategies can be employed to address micronutrient deficiencies in general. These strategies include fortification, supplementation and dietary diversification. For interventions to be successful, these strategies need to be integrated into nutrition intervention programmes so that they complement one other. This discussion focuses on the potential use of ALVs to address micronutrient deficiencies. It will also focus on how the knowledge of and use of ALVs by primary caregivers can potentially contribute to the nutritional status of children.

5.2. Situational analysis of study community

The current study confirmed that the community studied was socio-economically vulnerable and that, therefore, the children were more likely to have a poor nutritional status. The high unemployment rate, high dependency on social grants and low household income in proportion to household size were clear indications of poor socio-economic status. Sharing of toilet facilities amongst households and the common use of pit toilets exposed households to poor sanitation and other health hazards. Although the majority of households in this study had access to electricity, wood was also largely used as a fuel source for cooking. This was an indication of the poor household infrastructure available to the community studied. The findings of this study are consistent with the description of farm communities in the North West Province given by Lemke (2005). South African farm communities are known to be the least privileged of the country's workforce as they earn the lowest wages. They are also more vulnerable to health hazards as they live in conditions with poor sanitation (Lemke, 2005).

With the low socio-economic status of this community, it was not surprising that stunting (11%) was the most prevalent nutritional disorder in children, regardless of gender and age. The difference by

gender in the prevalence of stunting was not significant ($p= 0.55$). However, there was a trend of higher prevalence of stunting in older children aged 9–13 years ($p= 0.06$). The public health significance of stunting in this study was categorised as low, since fewer than 20% of children were stunted (Onis *et al.*, 2012). Stunting in populations is often associated with high rates of unemployment, poor sanitation facilities and high household density (Mamambolo *et al.*, 2005). The prevalence of underweight (based on BMIAZ) was significantly lower in younger children (5–8 years) than in older children ($p= 0.008$). Findings in this study were consistent with what other researchers have found in South African children. At the national level, stunting was the most prevalent nutrition disorder in children aged 1–9 years. The prevalence of underweight (based on BMIAZ) amongst the same children decreased with age (Kruger *et al.* 2007). An independent study carried out on children aged 9–13 years by Oldewage-Theron *et al.* (2010) in rural Qwa Qwa reported prevalences of stunting and underweight (based on BMIAZ) of 11.3% and 4.9% respectively. Samuel *et al.* (2010) also reported the prevalence of stunting to be 15% in children aged 7–11 years in a peri-urban settlement.

A possible explanation for the higher prevalence of stunting and underweight (based on BMIAZ) in older children in this current study might be related to malnutrition during early life that manifests later in life. Longitudinal data from rural Zimbabwe by Alderman *et al.* (2006) showed that improved nutritional status of pre-schoolers, as measured by height at a given age, is associated with increased height as a young adult. Insufficient household income implied that most households did not have enough money to obtain nutritious food. The majority (71.9%) of households did not grow their own food and were mostly dependent on food purchased from supermarkets and tuck shops in the local area. Although food purchased in supermarkets is cheaper, transport costs are involved in reaching these supermarkets. Nearby tuck shops are more convenient but they are usually more expensive than supermarkets. Lack of access to food at household level, excluding the national school feeding, could possibly expose children in this community to risks and consequences of chronic malnutrition. A limitation to the results of this study might be its cross-sectional design (Shah *et al.*, 2003). The sample size of children in the older age category was smaller ($n =51$) than that of the younger age group ($n =103$). Therefore, caution must be applied in interpreting these results, as the findings of the prevalence of stunting and underweight in children aged 9–13 years might not be transferable.

The prevalence of iron deficiency (serum ferritin $<15 \mu\text{g/L}$) was low (15.5%) amongst children in this study. Anaemia ($\text{Hb} <11.5 \text{ g/dL}$ and $\text{Hb} <12 \text{ g/dL}$; age 5–11 years and 12–13 years

respectively) in children was a mild (10.3%) public health problem (WHO, 2011a). It should be noted that not all anaemia is caused by iron deficiency; other factors such as deficiencies in folate and vitamin B12 and infections or parasites can also cause Hb concentration levels to fall (Gibney *et al.*, 2004; Kennedy *et al.*, 2003). In the 2005 NFCS-FB, Labadarios and Louw (2007) reported that 28.1%, 6.9% and 5.2% of children aged 1–9 years in the NW Province, where this present study was conducted, were anaemic, had depleted iron stores and iron deficient respectively. However, it should be noted that the 2005 NFCS-FB survey measured iron deficiency as serum ferritin <12 µg/L. Therefore care should be taken when comparing these results. The prevalence of anaemia in this study population was lower than what was reported at the provincial level six years ago. This implies a possible gradual improvement in iron status in children. This may be caused by the fortification of maize meal and bread with iron, although there are no data yet on the bioavailability of this iron (van Stuijvenberg *et al.*, 2008). In this community, maize meal, especially, is being consumed in large amounts (personal communication: M. van der Hoeven).

The measurement of ZPP also gave an indication of the iron status of children. According to Beard (2007), a high ZPP concentration is one of the first indicators of insufficient iron in the bone marrow. This current study showed that the prevalence of iron deficiency, using measurements of ZPP (>40 µmol/mol haem), was 34.5%. This indicated a high prevalence of iron-deficient erythropoiesis, which can cause further public health concern as regards to iron deficiency (Worwood, 2007). ZPP can be a more sensitive parameter than Hb in measuring iron deficiency (Biesalski & Erhardt, 2007). Two cut-offs (>40 µmol/mol haem and >70 µmol/mol haem) were used for the measurement of iron deficiency using ZPP because there are discrepancies in the cut-offs believed to be most appropriate in vulnerable populations. Often the cut-off of >40 µmol/mol haem tends to be too strict, so that children who are potentially deficient are excluded. As a result, the cut-off of >70 µmol/mol haem was also used (Metzgeroth *et al.* 2005). Zimmermann and Hurrell (2007) recommend a cut-off of >40 µmol/mol haem for children five years and older on washed RBC. However, data analysis was carried out using both cut-off values for purposes of comparison. In this study, the cut-off of ZPP >40 µmol/mol haem seemed to be more appropriate.

Although iron deficiency was not high, the prevalence of children who were at risk of deficiency (marginal iron deficiency) was more than 18% (serum ferritin ≥15 to <20 µg/L). This could possibly explain why there was a high prevalence of increased ZPP (>40 µmol/mol haem) concentrations amongst children. All this confirms that iron deficiency could potentially become a public health concern in this community if the causes of deficiency are not addressed. Deficiency in iron may

have detrimental effects on cognition, immune function and growth. Halterman *et al.* (2001) reported that children with iron deficiency, with and without anaemia, had lower average math scores when compared with children with normal iron status. Baumgartner *et al.* (2012) also reported beneficial effects of iron supplementation on cognition in school children aged 6–11 years in SA. Stoltzfus *et al.* (2001) confirmed that iron supplementation improved language and motor development in anaemic pre-school children (6–59 months).

The prevalence of vitamin A deficiency (serum retinol <20 µg/dL) was also found to be low (3.2%) in this study. Dhansay *et al.* (2007) reported that the prevalence of vitamin A deficiency was 49.6% and over 50% at the provincial and national levels respectively in children aged 1–9 years. This reported prevalence was much higher than what was observed in this study. Vitamin A deficiency has long-term consequences on growth, development, and health, especially in children (Faber *et al.*, 2002). If ignored, vitamin A deficiency predisposes the body to infections that further lead to increased morbidity and mortality (Nojilana *et al.*, 2007). Vitamin A supplementation has been reported to reduce morbidity in children caused by measles and parasitic infections (Coutsoudis *et al.*, 1991; Shankar *et al.*, 1999).

It is difficult to explain the low prevalence of iron and vitamin A deficiency in this current study. In 2003, SA implemented a mandatory fortification programme to fortify staple foods such as maize meal and wheat flour with iron, zinc and vitamin A (van Stuijvenberg *et al.*, 2008). The staple food for this current study population was maize meal. This can possibly explain why the prevalence of iron deficiency (based on serum ferritin) and vitamin A was only 15.5% and 3.2% respectively. It might be possible that the national food fortification programme is starting to show an impact on the nutritional status of children, although this needs to be confirmed. Furthermore, iron and vitamin A-rich foods such as organ meat (liver) are being consumed in this community (personal communication: M. van der Hoeven). However, the causes of the low prevalence are not certain and this needs to be further investigated.

With the low prevalence of deficiencies in iron and vitamin A, it was expected that dietary intake of these nutrients would be adequate or close to adequate. Generally, in this current study population the intake of iron and vitamin A was above the EAR. Although there is uncertainty about the effectiveness of the iron fortificant used in maize meal (Stuijvenberg *et al.*, 2008), the consumption of the maize meal porridge in large quantities can potentially contribute to the iron status of children. The consumption of liver in the study population can also potentially affect the vitamin A and iron status. This could explain why the prevalence of these nutrient deficiencies was low. However, it does not explain the high risk of iron deficiency. Further research is required to assess the long-term dietary intake of children in this community to establish the reasons for this.

It should also not be ignored that other factors apart from the nutrient content of the diet can contribute to these nutrient deficiencies. Factors such as the bioavailability of the nutrient content of the diet and the health status of children need also to be taken into consideration. Maize meal, which is the most frequently consumed staple in this community, is known for its high phytate content. The phytate in the cereal binds the iron in insoluble complexes, therefore making it unavailable for absorption (van Stuijvenberg, 2001). Hurrell *et al.*, (2003) demonstrated that phytate degradation improved the iron absorption from cereal porridges. Hookworm infestation can also affect iron status. Hookworms attach themselves to the mucosa of the upper small intestine and feed on the blood and tissue, causing chronic intestinal blood loss (van Stuijvenberg, 2001). Stoltzfus *et al.* (1998) reported that deworming programmes were potentially effective in improving iron status and preventing moderate anaemia in school children in areas where hookworm was endemic.

Most developing countries rely largely on plant sources for intake of vitamin A. However, the bioavailability of β -carotene from plant sources has been found to be low (De Pee *et al.*, 1998). The burden of repeated infections and parasitic infections also contributes to poor vitamin A status. Mahalanabis *et al.* (1979) suggested that infestation with *Giardia lamblia* and *Ascaris lumbricoides* affected vitamin A absorption. A recent study from Long *et al.* (2006) reported that children infected with *Giardia lamblia* who received vitamin A supplementation had fewer diarrhoeal and fever episodes when compared with those receiving a placebo in a placebo-controlled, double-blind trial.

This study confirmed that zinc deficiency (serum zinc <65 µg/dL; 74.8%) was the most prevalent micronutrient deficiency amongst children. This result was consistent with what was observed at the provincial and national level in children aged 1–9 years. Labadarios *et al.* (2007) reported a zinc deficiency prevalence of 41.1% and 45.3% at the provincial and national levels respectively. Samuel *et al.* (2010) also reported a high prevalence (46%) of zinc deficiency (serum zinc <70 µg/dL) in school children aged 7–11 years in SA; however, their study was conducted before the fortification of maize meal with zinc oxide. With a high dietary zinc intake, it was surprising that most children in this current study were deficient in zinc. Also, with the mandatory fortification of maize meal and bread in 2003, it was expected that deficiency in zinc should have been less than what was reported in this study. Faber *et al.* (2005) reported that fortified porridge, which supplied 100% of the RDA of zinc in infants, failed to improve serum zinc concentrations. It is difficult to explain the high prevalence of zinc deficiency in this population; however, it can be speculated that it may be associated with low zinc bioavailability in diets and other environmental factors that may lead to the deficiency. Samuel *et al.* (2010) reported that zinc deficiency amongst primary school children could be a result of the high phytate content in their diet. Diets with phytate:zinc ratios above 18 are classified as having low zinc availability (Samuel *et al.*, 2010). Further research needs to be carried out in this current study population to assess the phytate content of their diets.

Zinc deficiency in children can be highly detrimental because it can hinder digestion and absorption, exposing children to morbidity from diarrhoea, further worsening nutritional status by depleting all nutrients (Black, 2003). It has been associated with stunting and risk of being deficient in vitamin A (Whitney & Rolfes, 2008). Zinc deficiency can also affect cognitive development in children by altering their attention, activity and other aspects of neuropsychological function (Black 1998). Growth retardation, delayed sexual maturation, delayed wound healing and impaired appetite can result from deficiency in zinc (Whitney & Rolfes, 2008). Behavioural disturbances and skin lesions can also manifest as a result of zinc deficiency. (Walker & Black, 2004).

5.3. Nutrient composition of selected African Leafy Vegetables

The second objective in this research was to evaluate the iron, zinc and β -carotene composition of *Cleome gynandra*, *Cucurbita maxima*, *Amaranthus cruentus* and *Vigna unguiculata*.

5.3.1. Iron

The results indicated that all the ALVs were good sources of iron. The range of dietary iron in the ALVs in this study varied from 1.4 to 3.2 mg/100 g edible portion. *Amaranthus cruentus* was the best source of iron. These findings were consistent with what was reported by Uusiku *et al.* (2010) and Grubben (2004). Fasuyi (2006) also found *Amaranthus cruentus* to have higher iron content when compared with *Talinum triangulare* and *Telfairia occidentalis*. This study also established that *Cleome gynandra* was a potentially good source of iron after *Amaranthus cruentus*. The iron content of *Cleome gynandra* was comparable to what was reported by Chweya and Mnzava (1997). These authors carried out a summary of studies that assessed the nutrient composition of *Cleome gynandra*. This current study confirmed that consumption of 240 grams of raw *Amaranthus cruentus* could potentially provide 77% and 96.3% of RDA for children 5–8 years and 9–13 years respectively. Consumption of 240 grams of raw *Cleome gynandra* could potentially provide 72% and 90% of RDA for children 5–8 years and 9–13 years. These ALVs represent great contributions; however, these results should be interpreted with caution. It should be taken into account that the absorption of non-haem iron is dependent on the iron status of the person and on other factors that inhibit and enhance absorption of the nutrient. Phytic acid content in ALVs can inhibit the absorption of iron. The phytic acid content in ALVs can range from 9 mg to 655 mg/100 g edible portion. This inhibiting factor contributes to the low bioavailability of iron from ALVs. The β -carotene and ascorbic acid content of ALVs can serve as enhancers of iron (Uusiku *et al.* 2010).

5.3.2. Zinc

The zinc content of the ALVs in this study varied from 0.7 mg to 1.4 mg/100g edible portions. Zinc content of ALVs is said to be very variable, even within the same species. In *Amaranthus* spp., zinc content ranges from 0.02 to 8.4 mg/100 g, whereas in *Chenopodium album* it ranges from 0.03 to 3.1 mg/100 g edible portion (Uusiku *et al.*, 2010). The zinc content of ALVs in this study was

therefore comparable to that mentioned in other studies. The zinc content of *Cleome gynandra* (1.4 mg/ 100g edible portion) was the highest in this study; however, it was lower than what was reported by Chweya & Mnzava, (1997). This result was not surprising because the nutritional value of any ALV may vary with soil fertility, environment, plant type and plant age (Uusiku *et al.*, 2010). From this current study, it was confirmed that consumption of 240 grams of raw *Cleome gynandra* could potentially contribute 68% and 42.5% of RDA for children 5–8 years and 9–13 years respectively. Care should be taken in interpreting these results, however, because like iron, zinc is mostly adversely affected by phytate. A phytate:zinc molar ratio of 15:1 is associated with reduced zinc bioavailability (Uusiku *et al.*, 2010). The high iron content in ALVs can also affect the absorption of zinc. Zinc can also bind with transferrin, which is the main carrier for iron, so in some cases, zinc can compete with iron for transferrin (Whitney & Rolfes, 2008).

5.3.3. β -carotene

The β -carotene content of ALVs in this study ranged from 182 μg RAE to 314 μg RAE/ 100 g edible portion. This was similar to what was reported by Schönfeldt and Pretorius (2011). They reported the β -carotene content of raw ALVs to range from 133 μg RAE to 343 μg RAE/ 100 g. This current study confirmed that *Cleome gynandra* was the best source of β -carotene. This was also observed by Schönfeldt and Pretorius (2011). In this present study the potential contribution of β -carotene that ALVs had on the RDA for children was low compared with iron and zinc. *Amaranthus cruentus* and *Cleome gynandra* could potentially contribute the most. Consumption of 240 grams of raw *Amaranthus cruentus* could potentially contribute 15.7% and 10.5% of RDA for children aged 5–8 years and 9–13 years respectively. Consumption of 240 grams of raw *Cleome gynandra* could potentially contribute 18.1% and 12.1% of RDA for children aged 5–8 years and 9–13 years respectively. Repeated infections and parasitic infestations in children can affect the bioavailability of this nutrient (Gibney *et al.*, 2004). The chemical nature of the ALVs, cooking, storage time and storage conditions can also affect the retention of carotenoids in ALVs, therefore affecting the amount available for absorption (Uusiku *et al.*, 2010)

A limitation to this study was that analysis of ALVs was not carried out on cooked samples, which is usually how these vegetables are consumed. Therefore, these results need to be interpreted with caution. The findings gave an indication, however, of the nutrient composition and the potential amounts the ALVs could contribute to the diets of children provided the children meet the recommended daily vegetable intake. Cooking is known to have varying effects on ALVs. Uusiku *et*

al. (2010) reported that cooking often made no noticeable change to the iron and zinc content of ALVs and could lead to an increase in the bioavailability of β -carotene.

5.4. Knowledge of and the use of African Leafy Vegetables

5.4.1. Dynamics of the focus group discussions

All four focus groups were composed of primary caregivers of various age groups (18–30 years, 3–40 years and 41–50 years) The rationale behind mixing different age groups in the FGDs was to stimulate interaction between participants. This was achieved because participants were fully involved in the discussions, therefore producing rich data. Moreover, the homogeneity of the participants in the FGDs was based on their role as primary caregivers of children and the fact that they were the ones most involved in food preparation, since the main focus of the FGDs was to acquire indigenous knowledge regarding ALVs and their use. As a result, the age and gender mix did not negatively impact the findings or the interaction between participants within the focus groups; rather, it stimulated the discussions, as each generation brought unique information to the discussion. Participants in this study produced rich and resourceful information, confirming what McLafferty (2004) noted about this type of homogeneity in focus groups. The purpose (that is, the role) of a focus group should dictate the degree of homogeneity, and exploratory studies should use heterogeneous groups to attain rich data, while using homogeneous groups to facilitate rapport (McLafferty, 2004). Kitzinger (1994) also reported that mixing of different groups made it easier to address and identify health-related problems in rural settings.

5.4.2. Qualitative discussions from the focus groups

Caregivers appeared to have a great knowledge base of ALVs in their surroundings in terms of their use, more specifically, as food. These findings are similar to what Lewu & Mavengahama (2011) found in four districts in KZN in SA. *Chenopodium album*, which was commonly used by respondents in this study, was also known to be regularly consumed in the greater Durban area of KZN in SA (Odhav *et al.*, 2007). This species of vegetable is known to be a good source of zinc (Grubben, 2004). With the high zinc content of these vegetables, it was encouraging to observe that they are known and possibly being consumed by the study population, considering the high prevalence of zinc deficiency in children in this community.

Urbanisation has often been associated with the loss of indigenous knowledge of ALVs and their use, even by people who live in rural areas (Frison *et al.*, 2011 & Gockowski *et al.*, 2003). Access to a market also greatly influences the use of traditional vegetables. People who did not have easy access to places where food is sold tend to rely more on foods that grow naturally (Vorster *et al.*, 2007). This could explain why some primary caregivers within the FGDs knew more about ALVs. Some primary caregivers lived in Rysmierbult, which was about 44 kilometres away from the closest town where markets could be accessed.

5.4.2.1. Theme 1: Availability of and access to African Leafy Vegetables

ALVs grew on farm lands and were possibly more accessible to primary caregivers who worked on farm lands, as they could pick them while working. However, the availability of these vegetables can be compromised if they grow in between cultivated crops. These vegetables are at risk of being destroyed by farmers who may have less knowledge about them and often perceive them as weeds and as a result destroy them with pesticides, reducing their availability. Vorster *et al.* (2007) acknowledged that traditional leafy vegetables were still being perceived as weeds by research and extension personnel who criticised farmers for not keeping them under control. Continuous destruction of these vegetables can eventually lead to their extinction. Therefore, there is a need for farmers to be educated on the importance of these plants for the survival of poor households, in order to improve their availability to farm communities.

ALVs were available in areas where water flowed. Rainfall was also a great indicator of the availability of ALVs. *Amaranthus spp.* are known to be readily available in wet seasons when other vegetables become scarce (Anon., 2011). It is important to educate farm communities on possible ways of cultivating these vegetables in order to improve accessibility to them even during periods of drought. They can also be introduced to ways of collecting rain water which can be stored and used for irrigation. This may include the collection of rain water using water storage tanks or buckets. Seeds of wild vegetables are usually not kept by rural communities; they believe that seeds of these species are stimulated to germinate by land cultivation (Lewu & Mavengahama, 2011). This mindset has to be changed and possible strategies for planting ALVs during off-season periods using recycled water could be considered and deployed (Vorster *et al.*, 2007).

5.4.2.2. Theme 2: Preservation and storage of African Leafy Vegetables

Sun drying fresh raw leaves was a popular method of preserving ALVs practiced by almost all the respondents. Sun drying of vegetables is a cheap and convenient way to preserve ALVs, especially for a poor population such as this one. However, this method may lead to great loss of essential micronutrients such as vitamin A. Ndawula *et al.* (2004) found that the β -carotene content of fresh raw cowpea leaf decreased significantly in dried samples, regardless of the drying method. However, the leaves that were dried by the sun-drying method had a lower β -carotene content compared with those dried using other methods. Kiremire *et al.* (2010) in a similar study, but on *Amaranthus hybridus*, *Amaranthus blitum* and *Amaranthus cruentus*, reported that open-air sun drying resulted in the greatest losses in β -carotene (58%) content in these vegetables. The percentage retention of nutrients differed in all the three vegetables. *Amaranthus cruentus* experienced a loss of β -carotene of up to 96.4% (Kiremire *et al.*, 2010). Drying techniques involve exposing vegetables to heat, light and oxygen, which increases the rate of carotenoid oxidation (Kiremire *et al.*, 2010; Ndawula *et al.*, 2004).

In some cases, ALVs were cooked before they were dried in the sun. In terms of nutrient retention, this may potentially be a better method than directly sun drying the fresh leaves. However, the leaves must be blanched and not thoroughly cooked. Some respondents indicated that they cooked ALVs before sun drying them. Knowledge of cooking ALVs first before sun drying gave a possible indication that some caregivers had an understanding of the importance of retaining nutrients in vegetables during preservation: however, it cannot be ruled out that they did this for some other reason not assessed in this study. This knowledge could also have been transferred through generations and as a result become an accustomed practice. Taking all this into consideration, there is a dire need to educate farm communities on appropriate methods of preserving ALVs that lead to minimal nutrient loss. Mnkeni *et al.* (2001) advised that all vegetables should be blanched in steam before drying, to deactivate the action of enzymes and also to prevent the loss of some nutrients. Ndawula *et al.* (2004) observed that blanching reduced the loss of β -carotene in raw cowpea leaves. The blanched cowpea leaf had a higher ($p < 0.05$) β -carotene content than the un-blanched leaf (Ndawula *et al.*, 2004).

This study population did not have many storage options for preserved ALVs. Refrigeration was not a feasible way of preserving or storing food because only 34.5% had access to a working fridge or freezer. This meant that the majority had to rely on other traditional methods of preservation and

storage. These traditional methods (mainly packaging in sacks) have their disadvantages. Some nutrients, especially vitamin A, can easily be lost during storage if the vegetables are not stored in a dark room. Stored vegetables may also be prone to pest attack, therefore leading to damage.

5.4.2.3. Theme 3: Preparation of African Leafy Vegetables

ALVs are often known to accompany starchy staples. In this farm community, this practice was not an exception. Faber *et al.* (2010) observed that Blackjack (*Bidens spinosa*), commonly known as *uqadolo* in rural KZN in SA, was usually eaten with stiff maize meal porridge or legumes. In this NW population the main starch-based dish was stiff maize meal, commonly known as “*pap*”.

Variation in the preparation of ALVs made every meal unique. Dweba & Mearns (2011) stated that lack of variety in cooking methods of traditional vegetables could make them less appealing, therefore affect consumption. When referring to how they prepared ALVs, respondents often tended to mention how their grandparents prepared the vegetables. This information led to the assumption that grandparents were known to have knowledge of the preparation of these vegetables and that they passed this knowledge to their grandchildren. This study population perceived the older generation as custodians of knowledge related to ALVs, which was passed to their grandchildren in the hope that it will be transferred and not lost through generations. Interactions within the FGDs indicated that indigenous knowledge was not lost in this study population, but rather transferred. This was evident through the younger caregivers' knowledge of ALVs and their use. This finding was similar to that of a study conducted by Shava (2000) in the KwaTuku village in the Pedi District of the Eastern Cape, who found the younger generation to have extensive knowledge of ALVs in their surroundings. He attributed the younger generation's knowledge to the close relationship they had with the elderly people in their community (Shava, 2000).

When describing how they cooked ALVs, caregivers linked the methods used to the loss and the addition of nutrients during cooking. They perceived the cooking in excessive water that was later drained as a method that led to nutrient loss, and they associated added ingredients during cooking with improving the nutritional content of the cooked vegetables. This implied that they were possibly aware of the nutritional benefits of these plants. Dweba and Mearns (2010) also observed this cooking method in the eMantlaneni village in SA. In fact, draining and discarding of water used in cooking vegetables is likely to cause the loss of water-soluble vitamins such as vitamin B complex

and vitamin C (Dweba & Mearns, 2011). Faber *et al.* (2010) observed that boiling of Amaranth did not completely destroy its β -carotene content, as boiled Amaranth still provided considerable quantities of vitamin A per 100 g (Faber *et al.*, 2010). It is essential to ensure, however, that they are not over-boiled. Literature shows that ALVs are rich in various vitamins and therefore public health nutrition interventions should be geared to preserving these vitamins in the food sources during preparation.

5.4.2.4. Theme 4: Perceptions, attitudes, beliefs and feelings regarding African Leafy Vegetables

It was evident through the FGDs that the ALVs played a great role in the lives of respondents. The responses received were related to the roles ALVs played in improving health, their monetary benefits and lastly, their taste. Nesamvuni *et al.* (2001) stated that there is a growing awareness among researchers of the potential benefits of indigenous plants in terms of providing people with their basic needs, such as food.

The knowledge held by these participants of the nutritional benefits of these vegetables is what propels them to consume them regularly. This is similar to what Nesamvuni *et al.* (2001) observed in the Vhavenda in SA. For a population with a low level of education, this study population seemed to know a great deal about the importance of vegetables for good nutrition. More research on the nutritional composition of ALVs needs to be carried out and documented so as to further educate communities on the specific nutrients that are obtained from specific vegetables. This would further encourage their consumption. ALVs provide various micronutrients other than β -carotene, such as calcium, magnesium, zinc and vitamin C, which can potentially contribute to the dietary requirements of populations (Faber *et al.*, 2010).

ALVs have been known to play a role in reducing household food insecurity and many resource-poor households depend on them (Dovie *et al.*, 2007; Dweba & Mearns, 2011). Respondents viewed ALVs as the most affordable source of food, because they often collected them from the bush. Improving the availability of and access to these plants may not only contribute to the alleviation of micronutrient deficiencies but could also ensure that communities are fed and not hungry. From the socio-economic data of this population, 72.4% indicated that they did not grow any food for their own consumption within the household. The reasons for this were various, including unavailability of land or of money to buy seeds. This was an indication that they were most likely to be reliant on food plants that grew naturally, food purchased from shops, social

grants, or incentives in the form of food from farm owners. Therefore, the unavailability of these vegetables could potentially contribute to household food insecurity.

Populations studied by Dweba & Mearns (2011) and Voster *et al.* (2007) labelled ALVs as inferior foods. This perception was common amongst the younger generation in these studies. They labelled these foods as “poverty foods”. This negative attitude also contributed to the loss of knowledge about ALVs in these populations. This perception was not, however, observed in this current study population. Respondents in this study perceived ALVs as helpful, acknowledging that they were a less privileged community in terms of household income and food security. Their socio-economic characteristics indicated that 86.2% of households spent approximately between R201 and R1000 on food on a monthly basis, which was insufficient to sustain the whole household. The differences in the perceptions reported in this and other studies could be that this study population was less exposed to an urban lifestyle, making them comfortable with what was at their disposal. This perception should be encouraged because it could contribute to the potential consumption and use of ALVs.

Faber *et al.* (2010) observed similar perceptions in rural Limpopo. Participants in their study area valued the spider plant, a plant that occurs naturally, because it had no monetary costs associated with it. One participant in their study made the following comment: “*Once it starts to rain everybody is happy because then they know lerotho is coming*”.

Comments received from the FGDs about the taste of ALVs were evidence that the respondents chose to consume these vegetables because they liked the taste. Dweba & Mearns (2011) stated that personal preference with regard to certain foods affects the choices people make about the foods they eat.

5.5. Potential contribution of African Leafy Vegetables to nutritional status of children

The prevalence of deficiencies in iron and vitamin A were low in this study population. However, the prevalence of marginal iron deficiency was quite high. Through the FGDs it was indicated that *Amaranthus cruentus* and *Chenopodium album* were the most consumed ALVs in households in this community. Raw *Amaranthus cruentus* was found to be the best source of iron when compared with the other ALVs studied. It also contributed the most to the RDA of children. Continuous consumption of these ALVs might be beneficial and can potentially contribute to a decrease in the

number children that are at risk of iron deficiency and further improve iron status in children. Raw *Amaranthus cruentus* and *Cleome gynandra* also contributed the most to the RDA of vitamin A for children. Raw *Amaranthus cruentus* potentially contributed 10–15% to the RDA for children, whereas raw *Cleome gynandra* potentially contributed 42–68% to the RDA for children. If consumption of ALVs is encouraged, they can potentially improve the vitamin A status of children in this community.

Zinc deficiency was a public health concern in this community. However, according to the findings of this study, raw *Cleome gynandra* could potentially contribute 68% and 42.5% to the RDA of zinc in children aged 5–8 and 9–13 years respectively. Although not assessed in this study, deficiency in zinc is associated with a high prevalence of stunting. Stunting was the most prominent nutritional disorder amongst children in this study. It is acknowledged that ALVs on their own cannot reduce the prevalence of micronutrient deficiencies in children. But they could contribute to other food-based strategies geared towards addressing these deficiencies and thereby improve nutritional status.

Most children in this study did not meet the recommended vegetable intake (personal communication: M. van der Hoeven). This could have resulted from financial constraints that hindered the purchase of vegetables. Often, fresh or frozen vegetables were inaccessible, either because of the distance to shops or because they were expensive (Kruger *et al.*, 2006). The promotion of ALVs as an alternative source of vegetables in this community would be beneficial because ALVs are available in the veld and because no monetary costs are attached to them. From the FGDs it was observed that in this community ALVs were widely used as a condiment with staple foods. Knowledge of cooking and preserving these ALVs was indigenous and was acquired and passed on through generations. Respondents in the FGDs had positive attitudes towards the use of ALVs, therefore implying a potential positive future response to interventions promoting the consumption of ALVs in order to contribute to the alleviation of micronutrient deficiencies.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

The aim of this study was to assess the potential contribution of ALVs to the nutritional status of children in a semi-rural farm community. To achieve this, a cross-sectional study was designed. A situational analysis was carried out on the study community to establish the socio-demographic and socio-economic status of households and the current nutritional status of the children. The focus of the child's nutritional assessment was on anthropometric status, biochemical iron, zinc and vitamin A status and the dietary intakes of iron, zinc and vitamin A. The iron, zinc and β -carotene content of ALVs was also assessed to establish their potential contribution to the RDA of children for iron, zinc and vitamin A. The knowledge and use of ALVs by primary caregivers was assessed in the form of FGDs.

This chapter will draw general conclusions and give recommendations for intervention studies geared towards the consumption of ALVs in order to contribute to the alleviation of micronutrient deficiencies in children.

6.2. Main findings

The situational analysis confirmed that this study community was socio-economically vulnerable and that children from this community were more likely to have a poor nutritional status. Although of low public health significance, stunting was the most prevalent anthropometric indicator of malnutrition. This was also supported by the low socio-economic status of households. Prevalence of deficiency in iron (serum ferritin $<15 \mu\text{g/L}$) and vitamin A (serum retinol $<20 \mu\text{g/dL}$) was low. The deficiency prevalence was 15.5% and 3.2% for iron and vitamin A respectively. Zinc deficiency (serum zinc $<65 \mu\text{g/dL}$) was the most prevalent (74.8%) micronutrient deficiency. Dietary intake of iron, zinc and vitamin A was generally sufficient amongst children. The nutrient composition of ALVs confirmed that all the ALVs studied were potentially good sources of iron, zinc and β -carotene and could contribute substantially to the RDA for iron, zinc and vitamin A in children aged 5–13 years, without taking into account inhibiting factors that lead to the low bioavailability of these nutrients. The iron content of the studied ALVs ranged from 1.4 to 3.2 mg/100 g edible portion. *Amaranthus cruentus* was the best source of iron. The zinc content of the ALVs ranged from 0.7

mg to 1.4 mg/100g edible portion, with *Cleome gynandra* having the highest zinc composition. The β -carotene composition of the ALVs varied and ranged from 182 μ g RAE to 314 μ g RAE/ 100 g edible portion, with both *Amaranthus cruentus* and *Cleome gynandra* being the best sources.

Respondents from the FGDs had knowledge of ALVs and used these vegetables. *Amaranthus spp* and *Chenopodium album* were the most commonly used ALVs by respondents in the FGDs. ALVs were used mainly as a condiment to accompany staple foods. The availability of and accessibility to ALVs was compromised by seasonality and by where they were mostly to be found. ALVs were mostly preserved by sun drying and stored in sacks. Preparation and cooking methods of ALVs were similar amongst respondents. They differed, however, in the various ingredients they used during cooking. ALVs were perceived as nutritious, affordable and effective in alleviating hunger during household food scarcity. Knowledge of ALVs and their use was indigenous and was transferred from one generation to another. Respondents in the FGDs had positive attitudes towards the use of ALVs.

6.3. Conclusions

Although not severe (with exception to zinc deficiency), micronutrient deficiencies exist in the rural farm community studied. ALVs are potentially good sources of iron, zinc and β -carotene and could contribute to the iron, zinc and vitamin A status of school children. The knowledge of ALVs and the positive attitude and perceptions with regard to their use by primary caregivers implied a potentially positive response in the future to interventions promoting consumption of ALVs in order to contribute to the alleviation of micronutrient deficiencies.

6.4. Recommendations

1. Zinc deficiency is of public health significance in this community and dietary diversification strategies which can include the use of ALVs should be geared towards addressing this deficiency in children; ALVs could possibly play a role in this regard.
2. Public health interventions should be aimed at improving the availability of and access to ALVs, and also educating farmers on the importance of conserving these plants and further educating farm communities on preservation and cooking methods that lead to minimal nutrient loss.
3. Suggestions for future research
 - Further research is required to establish the causes of the low prevalence of iron and vitamin A deficiencies in the community studied.
 - Further research is needed to establish the phytate content of diets of the community studied. This can assist in addressing zinc deficiency.
 - The potential of ALVs to address micronutrient deficiency needs to be investigated in an intervention.
 - The impact of the food fortification programme needs to be investigated by means of:
 - A national nutritional status survey
 - An *in vitro* study on the bioavailability of the added micronutrients and, if the results look promising, a human absorption study.

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ADDENDA

Addendum A: Socio-demographic and socio- economic questionnaire

ALV STUDY

Questionnaire

– Interview with caregiver–



School

Number first child (check class list – first on class list)

Number second child (check class list– second on class list)

Number third child (check class list– third on class list)

Interviewer

Date of interview (dd/mm/yyyy)

D	D	M	M	Y	Y	Y	Y
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Information on the caregiver

1. What is your date of birth? (dd/mm/yyyy)

D	D	M	M	Y	Y	Y	Y
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2. What is the gender of caregiver?

☐	1.Male	☐	2.Female
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3. How many children do you take care of (permanent – 24 hrs/day)?

	children
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4. What is your marital status?

	1. Single		2. Steady partner, not living together
	3. Married		4. Traditional marriage
	5. Living together		6. Widowed
	7. Divorced or separated		
	8. Other, please specify:		

5. What is your highest formal education level?

	1. None		2. Primary school
	3. Std 6-8/ Gr 8-10		4. Std 9-10/Gr 11-12
	5. Further studies incomplete		6. Diploma/Other postschool complete
	7. Degree		
	8. Other, please specify:		

6. What type of work do you do?

Information on the household

A *household* consists of a group of persons who occupy a common dwelling (or part of it) for at least four days a week and who provide themselves jointly with food and other essentials for living. In other words, they live together as a unit.

16. How many people does your household consist of?

	children (0-18 years)
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☐	adults
☐	Pensioners / elderly

17. Who is the head of your household (from the caregiver's perspective)?

☐	1. Father	☐	4. Wife	☐	7. Uncle	☐	10. Friend
☐	2. Mother	☐	5. Grandpa	☐	8. Aunt	☐	11. Self
☐	3. Husband	☐	6. Grandma	☐	9. Sibling	☐	12. Other

21. Who usually prepares the food in your household (from the caregiver's perspective)?

☐	1. Father	☐	4. Wife	☐	7. Uncle	☐	10. Child
☐	2. Mother	☐	5. Grandpa	☐	8. Aunt	☐	11. Self
☐	3. Husband	☐	6. Grandma	☐	9. Sibling	☐	12. Other

22. Who decides on what types of food are bought for your household (from the caregiver's perspective)?

☐	1. Father	☐	4. Wife	☐	7. Uncle	☐	10. Child
☐	2. Mother	☐	5. Grandpa	☐	8. Aunt	☐	11. Self
☐	3. Husband	☐	6. Grandma	☐	9. Sibling	☐	12. Other

23. Who decides how much money is spent on food for your household (from the caregiver's perspective)?

☐	1. Father	☐	4. Wife	☐	7. Uncle	☐	10. Child
☐	2. Mother	☐	5. Grandpa	☐	8. Aunt	☐	11. Self
☐	3. Husband	☐	6. Grandma	☐	9. Sibling	☐	12. Other

24. Do one or more members of your household receive a social grant (from the government)?
If yes, what type of grant do they get? (More than one answer can be given)

☐	1. No	☐	2. Child support grant	☐	3. Disability grant	☐	4. Old age pension
☐	5. Other, please specify _____						

25. Does anybody in your household receive food from a feeding scheme?

☐	1.No	☐	2. Yes	☐	3. Don't know
--------------------------	------	--------------------------	--------	--------------------------	---------------

26. How many people contribute to the total income in this household (including children receiving a grant, or other people receiving a grant)?

number of people

27. What is the total household income in general per month?

☐	1. None	☐	5. R1501-R2000	☐	9. R3501-R4000
☐	2. R1-R500	☐	6. R2001-R2500	☐	10. More than R4000
☐	3. R501-R1000	☐	7. R2501-R3000	☐	11. Don't know
☐	4. R1001-R1500	☐	8. R3001-R3500	☐	

28. How much money is spent on food monthly?

☐	1. R0-R200	☐	5. R801-R1000	☐	9. R1601-R1800
☐	2. R201-400	☐	6. R1001-R1200	☐	10. R1801-R2000
☐	3. R401-600	☐	7. R1201-R1400	☐	11. More than R2000
☐	4. R601-R800	☐	8. R1401-R1600	☐	12. Don't know

Information on the house and surroundings

29. What is your house mainly made of:

☐	1. Brick, concrete	☐	2. Mud	☐	3. Tin	☐	4. Plank, wood
☐	5. Other, please specify: _____						

30. How many rooms does your house have? (Including kitchen or cooking area, excluding bathroom or toilet, sheds, garages, stables or any other rooms unless people live in them.)

number of rooms

31. What type of toilet does your household have?

☐	1. Flush	☐	2. Bucket, pot	☐	3. Pit, vip	☐	4. None
☐	5. Other, please specify: _____						

32. Do you share your toilet with other households?

☐	1. No	☐	2. Yes
--------------------------	-------	--------------------------	--------

33. Where do you get your drinking water from most of the time?

☐	1. Own tap	☐	2. Communal tap	☐	3. River, dam	☐	4. Borehole, well
☐	5. Other, please specify: _____						

34. When cooking food, what fuel do you use most of the time?

☐	1. Electric	☐	2. Gas	☐	3. Paraffin	☐	4. Wood	☐	5. Coal
☐	6. Other, please specify: _____								

35. Do you or someone in your household have any of the following (please note that it needs to be in a working condition) (Tick all that apply)

☐	1. Fridge	☐	2. Freezer	☐	3. Fridge-freezer combination	☐	4. Microwave	☐	5. Stove
☐	6. Radio	☐	7. TV	☐	8. Landline (Telkom; telephone)	☐	9. Cell phone		

Information on home gardens

36. Do you grow any foods for your own use?

☐	1.No, continue with Q 37	☐	2.Yes, continue with Q 38
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37. Why do you not grow any foods for your own use? (continue with Q 39)

1. We have no need for more food; we can afford to buy all the food we need.
2. We do not have the land available.
3. We have the land available, but there is no money for seeds/plants and supplies.
4. We do not know how to grow food.
5. Other reason, please specify:

38. What foods do you grow for your own use? (continue with Q 39)

39. If you were to learn a new skill to generate income for yourself and your family, what would you like to learn?

Thank you for your participation and your time!

Addendum B: Letter of invitation to participate in study



INVITATION LETTER

**Africa Unit of Transdisciplinary Health
Research (AUTHeR)
Centre of Excellence for Nutrition (CEN)**

Tel: +27(18) 2099

Fax: +27(18) 2088

Potchefstroom, 18 April 2011

Dear parent/guardian,

Thank you for taking part in our research project. We would like to ask you questions about the following:

- **Dietary assessment** – We will ask you and your child questions regarding your child's eating habits.
- **Measurements of height and weight** – We would like to measure the height and weight of you and your child to learn more about your nutritional status.
- **Questionnaires** – We would like to ask you some questions about your family, where you living, your surroundings and vegetables you use in your household.

We will visit your child's school on ____ May 2011. Please fill in the form below this letter and tell us if this suits you. If you cannot make it, please tell us, so that we can make other arrangements.

You will be invited to visit the school on three separate days (once in May, once in July/August and once in September/October 2011). With a token of appreciation we would like to thank you for your time and participation, which you will receive on the third visit. We will refund your transport costs every time you participate.

Yours sincerely,

Marinka van der Hoeven

Name parent:.....

Name child 1:.....

Grade:.....

(if you have more than one child in grade 2-4):

Name child 2:.....

Grade:.....

Name child 3:.....

Grade:.....

- ☐ Yes, I will come to the school on ____ May 2011 to answer questions for the research.
- ☐ No, I cannot come to the school on ____ May 2011 to answer questions for the research, but I can come
_ May 2011.
- ☐ No, I will not come to the school at all.

Addendum C: Focus group discussion guide

Assessment of knowledge on and the use of indigenous and traditional plants in a semi-rural farm community in the North West Province in South Africa

Aim

To assess the knowledge on and use of the indigenous and traditional plants in a semi-rural farm community in the North West Province of South Africa.

Specific Objectives

1. To determine if the members of the community have access to the indigenous and traditional plants in their community.
2. To determine the knowledge on and the perceptions of indigenous and traditional plants.
3. To assess the different uses and preparation methods of these indigenous and traditional plants.

Focus group session guide

1. *Opening of the session (10 minutes)*
 - Introduction of facilitator and researchers
 - Welcoming of participants
 - Explanation of the general purpose of the focus group discussions

Good morning. Thank you for taking the time and making the effort of being here with us today. I am (Facilitator's name) and this is Jennifer Osei and Marinka van der Hoeven, my colleagues. We are a team from the University (NWU) and we are interested in learning more about what you know about indigenous and traditional plants in your community and how you use these plants.

Our discussion for the day will be on indigenous and traditional plants within your community and surroundings, and to get an understanding of your knowledge and use of these plants. When we say indigenous, we will be referring to those wild plants that grow naturally in your community and are being used within the community. And traditional will be used to refer to those wild plants that have been used because it is part of your culture. Questions will be asked to find out what you know about indigenous and traditional plants and what you use them for within your community.

I will guide you through the discussion process, asking you a few questions. Jennifer and Marinka will assist by taking tape records and hand written records of the discussion. It is going to take an hour to an hour thirty minutes to do this discussion.

Everything you say will be kept confidential and your name will not be disclosed.

It might be that I will be writing notes during the interview just to follow you.

I would like to confirm if you have given permission to be a participant and is comfortable with the discussion being recorded?

You are welcome to withdraw at any stage if you do not wish to participate any longer with no consequences.

Should you feel any discomfort after the discussion and would like to talk to someone I will make these arrangements for you.

Do you have any questions you would like to ask me before we start?

2. Rules and procurement (5 minutes)

- Everything discussed will remain confidential
- Only one person should speak at a time and opinions must be clearly spoken
- Recordings will be made to help recall everyone's opinion in order to get a clear idea on your knowledge of indigenous and traditional plants
- Feel free to ask any questions if a term that is not clearly understood is used
- Refreshments will be served during the session

3. Participants introduction and ice breaker (10 minutes)

- Give name
- Tell us about your interests and what you do
- Say how many children you have

Discussion guide (QUESTIONS)

1. Can you tell me more about the indigenous and traditional plants in your community/ surrounding?
2. You have mentioned all these plants; let us talk about where you get them?
3. These plants, how do you use them?
4. These plants, how and why do you store them?
5. Please tell me more about the beliefs about these plants.
6. Please tell me more about your feelings and your views regarding these plants.

Ending the discussion

- Summarize major points
- Ask participants if they have any questions

You are free to contact the researchers, Jennifer Osei at 078 337 4370 or Marinka van der Hoeven at 071 355 4090 at any time. If we find it necessary, will you mind if we have a further discussion with you?

Thank you for taking part in this focus group discussion.