THE PREVALENCE OF IRON DEFICIENCY AND THE ASSOCIATED FACTORS IN CHILDREN AGED 6-59 MONTHS IN CENTRAL EQUATORIA STATE, JUBA- SOUTH SUDAN

BY

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DECLARATION

I hereby declare that this dissertation is my original work with the assistance of my supervisors and to my knowledge it has not been submitted to any other institution of higher learning.

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DEDICATION

I dedicate this work to my late mum Ms. Ludia Yangi and Dad Yoweri Murye and to my Husband Michael Monday Elisama, and my children; Phoebe, Gwonja, Chaplain and Yomima for bearing with me during my time of studies when I had to take some of their time. May the almighty Lord richly bless them with eternal blessings. To my late mum, may your soul rest in eternal peace.

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ABBREVIATIONS

CES:	Central Equatoria State
CPA:	Comprehensive Peace Agreement
DDQ:	Dietary Diversity Questionnaire
FAO:	Food and Agriculture Organization
FFQ:	Food Frequency Questionnaire
GAM:	Global Acute Malnutrition
GOSS:	Government of South Sudan
ID:	Iron Deficiency
IDA:	Iron Deficiency Anemia
IDPs:	Internally Displaced Persons
IOM:	Institute of Medicine
IUDs:	Intrauterine Devices
IUGR:	Intrauterine Growth Retardation
MAM:	Moderate Acute Malnutrition
MOH:	Ministry of Health
MUAC:	Mid upper arm circumference
NHANES:	National Health and Nutrition Examination Survey
NSCESE:	New Sudan Center for Statistics and Evaluation
PEM:	Protein Energy Malnutrition
SAM:	Severe Acute Malnutrition
SPSS:	Statistical package for social sciences
UNICEF:	United Nations Children’s Fund
WHO:	World Health Organization

DEFINITION OF TERMS

Anemia: Hemoglobin (Hb) concentration below cut-off levels depending on age, sex and physiological status.

Anthropometric indices: These are calculated from anthropometric measurements of weight, height and age.

Bioavailability refers to the degree to which iron is available for absorption in the gut and utilized for normal metabolic functions.

Iron Deficiency Anemia: An advanced stage of iron depletion defined as iron deficiency (Hb < 110g/l).

Iron Deficiency: A state of insufficient iron to maintain normal physiological functions of tissues.

Nutritional Status: The condition of the health of a person that is influenced by the intake and utilization of nutrients. Normal nutritional status implies balanced food intake and normal utilization of nutrients. (http:/nutrition/vegguide.html#food).

Stunting: When young children have a low height for their age.

Underweight: When children are too light for their age.

Wasting: When children have a low weight for their height.

ABSTRACT

The general objective of this study was to determine the prevalence of iron deficiency and the associated factors in children aged 6-59 months in south Sudan's Central Equatoria state in Juba.

A cross-sectional study was conducted among 243 children in the period between August and September 2012 to assess the nutritional and iron status of the children using anthropometric measurements. The iron status was determined by measuring Haemoglobin concentration using a hemocue and the values represented as severe, moderate and or mild.

The average house hold size was found to be 8.5 with 78.2% of the households in a monogamous marriage. Up to 43.4% of the respondents had completed secondary school, and 11.2% were illiterate. Findings showed that 79.7% of the children had low HB levels with a mean Hb of 9.6g/dl. The prevalence of severe anemia was 4.1%, moderate 51.2% and mild anemia 24.4%. The prevalence of wasting was 10.5% while underweight was 15.4% of whom 4.6% were severely underweight while 10.8% were mildly underweight. Most of the children in the study were introduced to complementary foods as early as 4 months of age with Exclusive breastfeeding practiced by only 22.3%, although 92.1% of the children were given the first milk (colostrum). 57.7% of the complementary food used was cereal porridge, (21.6%) milk, (15.8%) soup, (2.1%) juice, and 2.1%) used water as the first food introduced to their babies. 97% of the children had received the full immunization recommended for their ages. 57.3% of the surveyed children reported to have experienced one or more signs of illness in the past two weeks preceding the survey date with diarrhea and cough ranking the highest with a prevalence of 22.7% each. 97.8% of the households consumed cereals as the main food and fruits the least consumed

CHAPTER ONE: INTRODUCTION

1.0 Background

Iron is one of the most abundant minerals on the earth of which human body requires only minute quantities (Hallberg, 2000). It is an integral part of protein and enzymes that maintain good health and plays a major role in oxygen transport. Approximately 73 percent of the body's iron is normally incorporated into hemoglobin and 12% in the storage complexes ferritin and hemosiderin. A very important 15% of the mineral, however, is incorporated into a variety of other iron-containing compounds essential to cell function (IOM, 1998). Iron deficiency (ID) is a state of insufficient iron to maintain normal physiological functions of tissues. It can exist with or without anemia. Iron deficiency is one of the leading global risk factors of disease, disability and death. It is also the most prevalent nutritional deficiency in the World with approximately one billion people affected (DiSilvetro et al, 2004).

IDA occurs when hemoglobin production is considerably reduced, leading to a fall in its levels in the blood. The World Health Organization recommends cut-off values for IDA in different age, gender and physiological groups. It is one of the micronutrient deficiencies that affects under five years of age population in both the developed and developing nations. (Wardlaw et al., 2004). Nutritional anemia, caused by iron deficiency is among one of the ten causes of hospital admissions among children south Sudan. (CDC &WFP, 2004).

1.1 Statement of the problem

In most countries, national policies have been implemented to provide iron supplements to pregnant women, and to a lesser extent to young children, as a primary strategy for preventing iron deficiency and anemia (WHO, 2006). Unfortunately iron in breast milk is poorly absorbed. The baby has to depend much on its iron stores which last only 6 months and thereafter, supplement from diet. Poor weaning practices and inadequate feeding during childhood contribute to the development of iron deficiency (IOM, 1998).

Nutritional anemia is among the major causes of hospital admission in children in south Sudan. Although a nationally representative data on iron deficiency are limited, it is true that malnutrition rates are very high (about 80%), (MOH & WHO, 1997). After decades of war, the people of south Sudan are still struggling to settle. There is still much dependency on relief food, with very limited agriculture. Food insecurity is rampant since most food in the market is expensive and many families cannot afford to have a balanced diet. Floods and drought also contribute to poor harvests. As a result, there are high levels of food insecurity, malnutrition, and disease outbreaks, leading to malnutrition including Iron Deficiency. The most commonly consumed foods are basically cereals and legumes with little vegetables. This may increase the risk of iron deficiency because even the little iron in cereals has its absorption impaired by phytates. Diseases such as malaria, schistosomiasis and other parasitic infestations may also aggravate iron deficiency.

Central Equatoria State is affected by both natural and man - made disasters. Food and drought, depending on the meteorological patterns, affects low – lying areas contributing to poor harvests, food insecurity, malnutrition, disease outbreaks, and displacements and damaged infrastructure. Tribal conflicts caused by cattle rustling leads to displacement, loss of lives and property, and hinder the delivery of economic and social services in the area.

The quality of diets is especially important for small children who can only eat small quantities of food at one time. During times of shortage, they eat even less than normal rations. Where the quality and quantity of food deteriorate due to conflict, families may not have the ability or the appropriate knowledge to make the necessary changes in the child's diet to ensure adequate nutrients intake by the child. Deterioration in the variety of food can lead to weight loss and vitamin and mineral depletion.

1.2 Justification of the study

The results of this study would help establish baseline for the nutritional and iron status of children under five. This would provide information necessary for developing strategies to improve nutrition among children in South Sudan. This study will also provide information on the current status of iron deficiency to the benefit of the Ministry of Health in the Government of South Sudan in working towards reducing the prevalence of iron deficiency among children under five years in the country. It will also inform policy makers to make policies that focus on setting priorities to improve nutrition for children under five years by increasing food production, food diversification and the use of Micronutrient powders to reduce deficiency of micronutrients.

1.3 Objectives

1.3.1 Main Objective

The main objective of this study was to assess the prevalence of iron deficiency and the associated factors in children aged 6 – 69 months in the Central Equatorial State in South Sudan.

1.3.2 Specific Objectives

1. Determine the socio-demographic and economic characteristics of the study households.

2. To determine the nutritional status of children under five.
3. To determine the breastfeeding and weaning practices
4. To determine the food consumption patterns of children under five years
5. To determine the anemia status and factors associated with iron deficiency in children under five years.

1.4 Study hypotheses

1. Breastfeeding and weaning practices are significantly associated with Iron Deficiency in children under five
2. There is association between nutritional status and iron deficiency in children under five in south Sudan.
3. Morbidity is a factor for iron deficiency in children under five years
4. Food consumption patterns associated with iron deficiency in children under five

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

2.1 Iron Deficiency

Iron deficiency is the commonest form of malnutrition worldwide, affecting 43% of the world's children, and is particularly common in Asia and Africa. It is a state in which there is insufficient iron to maintain the normal physiological function of blood and tissues such as the brain and muscles. Iron deficiency is a state in which there is insufficient iron to maintain the normal physiological function of tissues such as the blood, brain, and muscles. ID can exist in the absence of anemia if it has not lasted long enough or if it has not been severe enough to cause the hemoglobin concentration to fall below the threshold for the specific sex and age group. Evidence from animals fed on iron-deficient diets indicates that iron deficiency becomes detectable at about the same time in the blood, brain, and tissue enzyme systems. The more severe stages of iron deficiency are associated with anemia. Although there have been increased efforts to develop improved interventions involving food fortification, supplementation and dietary education in a combined strategy to prevent and control iron deficiency, little progress has been made toward global elimination of iron deficiency. There is also lack of widespread knowledge of the seriousness of Iron deficiency and its consequences to young children according to UNICEF (UNICEF, 1998). In most countries, policies have been implemented to provide iron supplements to pregnant women and to a lesser extent to young children as a primary strategy for preventing iron deficiency and anemia.

Not many studies have been done to establish the prevalence of iron deficiency in south Sudan. Most of the studies on malnutrition in south Sudan have been associated with emergency feeding centers with historically high GAM and SAM rates. Although supplementation programs are available, coverage is very low. There are no policies and national programs of fortification of food put in place.

Micronutrients malnutrition contributes to a vicious cycle of poor health and depressed productivity; trapping families in poverty and eroding economic security in dozens of countries worldwide. Ensuring adequate intake of these essential nutrients by vulnerable populations will offer enhanced protection from a range of disabilities and diseases, help children grow and learn, and improve health and productivity for adults.

Iron deficiency is the most prevalent nutrient deficiency in the world. It is responsible for approximately 20,854 deaths and a reduction of 2 million disability-adjusted life years (DALYs) among children under five years of age.

Iron deficiency has its greatest impact on the health and physical and intellectual well-being of preschool children and women of childbearing age, though it may also affect other population groups. Although often more severe in poor and rural communities, iron deficiency also occurs in wealthier and urban populations.

2.1.1 Causes of Iron Deficiency (ID)

A major etiological factor in iron deficiency is early introduction of cow’s milk, which is very low in iron content. From the age of 4 months, children must obtain iron from exogenous sources and are at risk if not provided with the additional dietary supplies. Pediatricians and nutritionists recommend a healthy weaning diet consisting of home prepared iron rich foods, but the reality is different. Not only do parents start weaning earlier than the recommended 4-6 months, but the foods they choose to give their children are of low iron content. The reasons for such a poor diet include poverty, lack of access to cheap food, lack of cooking skills and equipment, and a chaotic home environment where there are no fixed mealtimes.

Again even when the diet contains adequate iron, low bioavailability may limit the amount absorbed. Iron in food exists in two main forms – haem iron in meat from haemoglobin and myoglobin, which is well absorbed, and non-haem iron in cereals and vegetables which is less absorbed. Absorption may also be promoted by vitamin C in fruits and vegetables but is inhibited by phytates in flours, by polyphenols in legumes and tannin in tea and coffee, and by calcium in milk and cheese.

2.1.2 Stages of Iron Deficiency (ID)

Iron deficiency occurs in three sequentially developing stages.

The first stage is ***depleted iron stores***. This occurs when the body no longer has any stored iron but the hemoglobin concentration remains above the established cutoff levels. A depleted iron store is defined by a low serum ferritin concentration (<12 μg/L). It is important to note that because ferritin is an acute-phase reactant, its concentration in the blood increases in the presence of subclinical and clinical inflammatory/infectious diseases; thus, it cannot be used to accurately assess depleted iron stores in settings where poor health is common.

The second stage is known as ***iron-deficient erythropoiesis***. Developing red blood cells have the greatest need for iron, and in this stage the reduced transport of iron is associated with the development of iron-deficient erythropoiesis. However, the hemoglobin concentration remains above the established cut off levels. This condition is characterized by an increase in the transferrin receptor concentration and increased free protoporphyrin in red blood cells.

The third and most severe form of iron deficiency is ***iron deficiency anemia*** (IDA). IDA develops when the iron supply is inadequate for hemoglobin synthesis, resulting in hemoglobin concentrations below the established cutoff levels. To diagnose IDA, measurements of iron deficiency as well as hemoglobin concentration are needed. For practical purposes, the first and second stages are often referred to collectively as ***iron deficiency.***

Table 1: Hemoglobin and Hematocrit levels below which anemia is present in a population

Age and gender group	**Haemglobing/dL**	**Haematocrit mmol/**
6-59 months	110	6.83
5-11years	115	7.13
12-14 years	120	7.45
Non-pregnant women (above 15 years)	120	7.45
Pregnant women	110	6.83
Men (above 15 years)	130	8.07

(WHO, 2001).

2.2 Determinant factors of low Hemoglobin and Anemia

2.2.1 Dietary Iron

In food, iron occurs either as heme iron in animal sources or as non-heme in plant sources (Hunt, 2002). In many developing countries, non heme iron which has low bioavailability is the primary form of dietary iron as the diet is mainly cereal and legume based (Zimmerman et al, 2005).

There have been increased efforts to develop improved interventions involving food fortification, supplementation and dietary education in a combined strategy to prevent and control iron deficiency, but little progress has been made toward global elimination of iron deficiency. There is also lack of widespread knowledge of the seriousness of IDA and its consequences to children. (UNICEF, 1998). In most countries, policies have been implemented to provide iron supplements to pregnant women and to a lesser extent to young children as a primary strategy for preventing iron deficiency and anemia (WHO, 2006).

2.2.2 Iron absorption

Iron absorption refers to the amount of dietary iron that the body obtains and uses from food. Healthy adults absorb about 10-15% of dietary iron, but individual absorption is influenced by several factors including the bioavailability of the two types of iron consumed, individual iron status, presence of inhibitors such as phytates and enhancers such as ascorbic acid. In developing countries however, the absorption is often about 5% or less due to high intake of cereal based diets with low amount of meat and vitamin C which involves its bioavailability (Zimmerman et al, 2005).

2.2.3 Iron uptake and bioavailability

There are two types of iron in the human diet; both of them are mostly absorbed in the proximal part of the duodenum. Heme iron originates from meat products and consists of iron complexed with the porphyrin ring from either hemoglobin or myoglobin. It only accounts for approximately 10%~20% of dietary iron, but for up to 50% of the iron actually entering the body (Carpenter and Mahoney, 1992). Specific receptors for heme iron on the microvilli of the enterocytes have been identified (Krishnamurthy et al., 2007; Worthington et al., 2001) and the iron is easily absorbed and split from the complex by heme oxygenase inside the cell.

The second type of iron is non-heme iron from plants. Unlike heme-iron, its uptake depends on the composition of the meal and other factors in the degradation pathway. Absorption by the enterocytes involves reduction from ferric (Fe^{3+}) to ferrous (Fe^{2+}) iron (Mackie et al., 2001) before co-transport with a proton across the membrane by divalent metal transporter 1 (DMT1) (Andrews, 1999; Gunshin et al., 1997). Iron is then released into the bloodstream by ferrous ion transporter (FPN) and absorbed by cells through the "transferrin cycle": iron-transferrin is bound by transferrin receptors and internalized by endocytosis. Proton pumps create an acidic environment inside the endosome and iron is released from the transferrin. Iron is now available to the cell either for biologically active compounds or for storage, and the transferrin and transferrin receptors are recycled back to the membrane and the cycle can be repeated.

2.2.4 Iron enhancers

Vitamins: Ascorbic acid (the active form of Vitamin C) keeps iron available for absorption through several mechanisms. First, it promotes acidic conditions in the stomach and intestines, thereby providing optimal conditions for iron absorption; second, it chelates ferric iron and maintains it in a stable and soluble complex, even at higher PH. Finally it reduces ferric iron to its ferrous form, thereby preventing it from precipitating as ferric hydroxide (Teucher et al., 2004). Vitamin A or β-carotene also enhances iron absorption through formation of soluble iron complexes and to a certain extent it can reverse the effect of several inhibitors such as phytates and polyphenols (Layrisse et al., 2000).

Meat is an important enhancer of the bioavailability of non-heme iron. The "meat factor" is still largely unexplored, but recent findings suggest that it is due to peptides of myosin, generated by pepsin degradation in the gut, which binds and keeps iron in solution. Other suggestions to explain the "meat factor" involve sulphydryl groups of e.g., cysteine, to reduce ferric iron to ferrous iron, and the induction of gastric juice production by proteins (Carpenter and Mahoney, 1992).

2.2.5 Iron inhibitors

The interactions between inhibitors and enhancers decide the final absorption level of the element in the gut. Despite these cofactors involved in iron uptake, the main inhibitor of Fe absorption is phytic acid (PA). One of the best known properties of PA is its anti-oxidative ability by binding and thereby inactivating Fe ions in solution. This prevents the ferric irons from participating in the Fenton reaction (the formation of the hydroxyl radical ·OH as a consequence of oxidation of Fe^{2+} to Fe^{3+} during reaction of Fe^{2+} with H_2O_2 or peroxides).

The chelating properties of PA not only result in the binding of cations in seeds. When released during food or feed processing or in the gut, PA also binds minerals and makes them unavailable as nutritional factors. Iron and zinc uptake have both been shown to be inhibited when the phytic acid: metal ratio increases above 10:1 (Gharib et al., 2006; Glahn et al., 2002). In human studies, phytic acid has been reported to inhibit absorption of iron, zinc, calcium, magnesium and manganese but surprisingly not copper (Egli et al., 2004; Hallberg et al., 1989; Lonnerdal, 1997; Phillippy, 2006; Reddy et al., 1996). Removal or degradation of PA would therefore increase the bioavailability of many cations and the nutritional value of the meal, and several strategies to reduce it are therefore considered. Some of the strategies include the following:

Milling of cereals, this removes the phytic acid, but this treatment also removes the major parts of the minerals and dietary fibers and cannot therefore be a nutritional solution to the problem. Similarly, soaking or extracting in aqueous solutions can remove up to two thirds of the PA by the action of endogenous phytase activity, but loss of minerals, water-extractable proteins and vitamins also occurs (Hurrell, 2004). Heat treatments have minor effects usually due to leaching of minerals into the boiling water. Different processing and cooking methodologies for reduction of PA have been compared between wheat variety, and the results have been that if one method is efficient in reduction of PA in one wheat variety, this may not apply for another. Furthermore, the method with the highest phytic acid reduction (germination for 48 h) still only reduced its content by up to 40% (Masud et al., 2007). Avoiding PA formation in the first place or catalyzing its degradation by the use of PA hydrolysing enzymes would therefore be more beneficial approaches to dephytinisation

Other divalent cations, such as Ca^{2+} (Hallberg et al., 1992 ;), $Zn2^{+}$, Co^{2+} and Mn^{2+} (Yeung et al., 2005) competitively inhibit iron absorption, probably because they use the same transporters (the DMT1) to enter the enterocytes, or because they co-precipitate with iron in phytic acid salts. The mode of Ca^{2+}-inhibition is still being debated (Roughead et al., 2005), as Ca^{2+} seems to have larger impact on heme iron absorption than on non-heme iron absorption, which could be due to mucosal uptake inhibition.

IDA is an advanced stage of iron depletion defined as iron deficiency and low hemoglobin. The risk of deficiency is highest when iron needs are proportionately greater than energy needs. This occurs in infants and young children, adolescents, menstruating and pregnant women, reflecting the demands from growth and concurrent expanding red blood cell volume and periods of increased physiological need. The situation is further aggravated when there are pathological losses, for example, hookworm infestation and when absorption is impaired during acute periods of illness, such as malaria. It is, therefore possible to influence the onset of iron deficiency by reducing iron losses and / or by increasing iron absorption for the diet.

Dietary iron intake is closely related to energy intake. A cereal –based diet may contain about 7mg Fe/1,000 kcal. Relative differences in iron and energy requirements between adult and men and children are reflected in the variation in the percent of dietary iron that must be absorbed to meet physiological needs. However, it has also been established that even when a diet with meat and vitamin c –rich foods is eaten, only 30% of the total dietary iron is absorbed (Cook, 1990), whereas, between 1 and 8% of the non-haem iron from a solely vegetable –based diet will be absorbed.

The balance between the amount of iron required and absorbed is affected by three factors; Changed physiological requirements, extensive iron losses, and inadequate intake of iron in the diet. IDA therefore develops if there is an imbalance among these factors and more rapidly so in the absence of adequate stores. To address the problem of IDA it requires efforts that are directed towards preventing excessive blood loss through parasitic infestation and less so toward improving the dietary factors.

2.3The relationship between Socio -demographic and socio-economic conditions

Population –based studies, in which the prevalence of anemia in urban areas is compared to that observed in rural areas, indicate that iron deficiency anemia is more frequently found in the rural areas than in the urban. The major reasons for being higher in rural areas may be associated with low availability of iron –rich foods, especially those high in heme iron and in vitamin C, as well as the early introduction of foods during the first six months of life when breastfeeding is supposed to be exclusive.

Most studies show that the percentage of children with anemia is significantly higher among those from low-income families. Sigulem et al. have attempted to interpret the interrelationship between the prevalence of anemia at the ages below and above 24 months and family income. No statistical significance was observed in the cases of anemia among infants aged less than 24 months whose families had an income lower or higher than one minimum wage. On the other hand, the association between the existence of anemia and the two income levels was significant in infants older than 24 months.

Parent's level of education may also be considered as an important socioeconomic factor for the occurrence of anemia. A higher level indicates increased chances of having a job and income, and consequently, easier access to iron-rich foods. The mother's level of education influences the practices related to the child's feeding and health care.

A low – meat diet is often more common in low-income families, causing a poor use of biological iron. Apparently, economically underprivileged individuals consume fewer iron-rich foods and also have a low intake of bioavailable iron, due to their trivial diets, which include cereals, and low amounts of meat and foods rich in vitamin C.

Another contributing factor is the number of household members, and especially a household where there are two or more siblings aged less than five years. This household may have a higher risk for anemia. Families with a large number of young children have an increased demand for food and cannot provide their children with appropriate health and nutritional care.

2.4The relation between Iron, Breastfeeding and Weaning Practices

Iron stores, from birth to the sixth month of life, when the infant receives exclusive breastfeeding, meet the infant's physiological requirements. Children at this age therefore do not need to be supplemented, and solid foods do not have to be introduced. This is due to the high bioavailability of iron in human milk, from which approximately 50% of the iron is absorbed, thus compensating for low iron content (0.1-1mg of iron/litre of blood). However, this bioavailability can decrease by 80% when infants are fed other foods. Therefore, early introduction of complementary foods is a risk factor for the development of iron deficiency anemia. Osorio has shown that infants who were breastfed for more than four months had a mean hemoglobin level around 3g/dL higher than those who were not. After the sixth to the twelfth months, iron requirements increase with body weight, as the infant's weight will have tripled by the end of the first year of life. Approximately 30% of the iron that is necessary for erythropoiesis should come from the food. As the infant shows accelerated growth and depends on food as a source of iron, he/she tends to show negative iron balance. This situation is totally different from adults, who recycle about 95% of the iron required from the lysis of red blood cells, and need to obtain only 5% of the iron from food.

2.5The relationship between Iron and food consumption patterns

The wide variety of factors that stimulate and inhibit iron absorption include two powerful stimulators of non-heme iron absorption and are meats and vitamin C. several animal tissues, including beef, poultry, fish, goat, liver and pork, increase iron content once they provide a high availability of heme iron and enhance the absorption of non-heme iron. When ascorbic acid is added to the diet, there is a remarkable increase in iron absorption.

Phytates, tannins (polyphenols), calcium, phosphates, eggs, and other types of food however, inhibit iron absorption by forming precipitates that bind to iron, thus hindering its absorption. The inhibitory effect of whole cereals is also attributed to phytate content. The inhibitory effect of whole cereals is also attributed to its phytate content, while the inhibitory effect of calcium on iron absorption has a considerable nutritional importance. Studies of nutritive components of food have shown that milk-derived calcium strongly inhibits the absorption of heme and non-heme iron.

2.6The relation between Iron, Morbidity and immunization

The literature on the association between iron deficiency and infections is controversial. Some authors say that any iron deficiency suppresses the immune system and increases the risks for infection, while other authors affirm that the immune system profits from a slight iron deficiency. The changes in iron metabolism induced by inflammation and infections are important confounding factors when iron content is assessed. It is also well known that gastrointestinal and respiratory infections often predispose to the reduction of serum iron levels in the body due to the reduced production of hemoglobin and decreased iron absorption.

No studies that associate iron deficiency with diarrheal diseases have been found but there are vast possibilities of anemia after an acute infection episode although these possibilities vary according to the length and severity of the disease. Reeves et al have shown that mild diarrheal diseases affect approximately 60% of children aged less than one year, between the ninth and the twelfth months of life, and that these diseases are associated with low hemoglobin concentration.

Repeated infections of children who have borderline nutritional status, especially in the developing countries, rapidly tip them into frank nutritional deficiencies which may be of micronutrient type (like Vitamin A and iron deficiency anaemia) or severe gross types (like kwashiorkor or marasmus) leading to poor growth or death. Common infections like tuberculosis, polio, whooping cough, tetanus, malaria, measles and diphtheria still result in high incidence of morbidity and mortality in the developing countries(1). The emergence of human immune deficiency virus infection (HIV/AIDS) has only added to the already complicated scenario.

2.8 Consequences of Iron Deficiency in infants and young children

Anemia is a serious condition that impacts cognitive development. The effects of iron deficiency that are observed in the first six months of life can lead to permanent brain damage. An afflicted child is likely to remain vulnerable to infection and continue to have lower immunity toward infection throughout childhood. Also, the overall appetite is reduced and this vicious cycle perpetuates a series of events that must be stopped, to ensure the child's health. Although it is well established that iron-deficiency anemia among children is responsible for higher morbidity and subsequent mortality, systemic studies to quantify them are practically difficult for a number of epidemiological reasons, and therefore, are not available. Iron-deficiency anemia rarely exists in isolation, and to disentangle the proportion of the role played by anemia from the total level of malnutrition and other precipitating factors, although desirable, is difficult to get at the community level.

Studies have also shown that children with iron deficiency present worse performance in psychomotor tests than do non-anemic children. The greatest prevalence of iron deficiency among breastfed infants coincides with the final period of rapid brain development (six to 24 months), when the motor and cognitive skills take shape. Long-term prospective studies have also identified persistent cognitive deficiencies in 10-year-old children who had suffered from anemia during the first months of infancy.

In South Africa, six to eight-year-olds who were observed to have low iron reserves, presented with retarded growth in comparison with those who had normal reserves. A boost in the growth of iron-deficient preschool children was seen after supplementation of this mineral. Also, 12 to 18-month-old children with iron deficiency presented the same rate of psychomotor development as did non-anemic children, after four months of treatment with iron supplements.

Iron deficiency can also negatively affect cellular immunity, even before the child becomes anemic, and this can lead to an increase in illnesses such as diarrhea, respiratory disease and other infections. These effects can be reduced by iron supplementation or food fortification.

Infants born of mothers with iron deficiency anemia are more likely to have low iron stores and to require more iron than can be supplied by breast milk at a younger age. There is convincing evidence linking IDA to lower cognitive test scores and that these effects can be long lasting. Numerous studies have shown a relationship between iron deficiency and/or iron deficiency anemia with muscle function, physical activity, workplace and school productivity, and mental acuity and concentration in children and adults. There is also increased susceptibility to heavy metal (including lead) poisoning in iron deficient children. (UNICEF/UNU/WHO/MI, 1998).

2.9 Treatment of Anemia

If the cause is dietary iron deficiency, eating more iron-rich foods such as beans and lentils or taking iron supplements, usually with iron(II) sulfate, ferrous gluconate, or iron amino acid chelate ferrous bisglycinate, synthetic chelate NaFerredetate EDTA will usually correct the anemia. Vitamin B12 injections can sometimes be recommended by the physician.

There is evidence that the body adapts to oral iron supplementation, so that iron is often effectively started at a comparatively low dose, and then slowly increased. There can be a great difference between iron intake and iron absorption, also known as bioavailability. Scientific studies indicate iron absorption problems when iron is taken in conjunction with milk, tea, coffee and other substances. There are already a number of proven solutions for this problem, including:

Fortification with ascorbic acid, which increases bioavailability in both presence and absence of inhibiting substances, but which is subject to deterioration from moisture or heat. Ascorbic acid fortification is usually limited to sealed dried foods, but individuals can easily take ascorbic acid with basic iron supplement for the same benefits.

Micro encapsulation with lecithin, which binds and protects the iron particles from the action of inhibiting substances, is also another way of treating anemia. The primary benefit over ascorbic acid is durability and shelf life, particularly for products like milk which undergo heat treatment. Using an iron amino acid chelate, such as NaFeEDTA, this similarly binds and protects the iron particles. A study performed by the Hematology Unit of the University of Chile indicates that chelated iron (ferrous bis-glycine chelate) can work with ascorbic acid to achieve even higher absorption levels

Separating intake of iron and inhibiting substances by a couple of hours and using non-dairy milk (such as soy, rice, or almond milk) or goats' milk instead of cows' milk is also useful in reducing loss of iron. Gluten-free diet also resolves some instances of iron-deficiency anemia, especially if the anemia is a result of celiac disease. Consuming heme iron, found only in animal foods such as meat, fish and poultry, as it is more easily absorbed than non-heme iron, found in plant foods and supplements.

Iron bioavailability comparisons require stringent controls, because the largest factor affecting bioavailability is the subject's existing iron levels. Informal studies on bioavailability usually do not take this factor into account. Scientific studies are still in progress to determine which approaches yield the best results and the lowest costs

2.10 Gaps in Knowledge

There is no information existing on the prevalence of micronutrient deficiencies in South Sudan. No documented information on customs, beliefs, and behaviors that affect nutrition in each livelihood zone, including food consumption patterns in different states of South Sudan. There is also no detailed information on the availability of micronutrient –dense foods.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.0 Research Design

A cross-sectional study with descriptive and analytical components was carried out. Questionnaires were used to collect information on socio demographic characteristics of the study population, illnesses, health and sanitation practices, dietary habits, breastfeeding and weaning practices, and blood analysis using a hemocue B- analyzer to establish the hemoglobin levels of children under five years. The study population was of African origin.

3.1 Methodology

3.1.1 Study site

This study was conducted in South Sudan's Central Equatoria State in the county of Juba. Juba is the capital and largest city of the Republic of South Sudan. It also serves as the capital of Central Equatorial, the smallest of the ten states of South Sudan. The city is situated on the White Nile and functions as the seat and metropolis of Juba County.

The population of Juba County is estimated to be 372,410. Juba has a tropical wet and dry climate, and as it lies near the equator, temperatures are hot year-round. However, little rain falls from November to March, which is also the time of the year with the hottest maximum temperatures, reaching 38 °C (100 °F) in February.

3.1.2 Geographical Location and Demography

South Sudan lies between latitudes 3° and 13ºN, and latitudes 24º and 36ºE. It is covered in the tropical forests, swamps, and grassland. The White Nile passes through the country, in Juba.

Central Equatoria state is situated in the south of south Sudan and is bordered by Eastern Equatoria to the East and Democratic Republic of Congo (DRC) and Uganda to the south, and Western Equatoria to the west. The population of CES is 1,103,557 with 581,722 males and 521,835 females. 15% of the population is under five, and 49% under the age of 18.

Juba is one of the fastest-growing cities in the world. In 2011, the population of the city of Juba was estimated at approximately 372,410.

3.2 Sampling

3.2.1 Study population

The study population was the households with children under five years.

3.2.2 Sample size determination

The sample size was determined using the (fisher et al, 1991) formula.

$$n = \frac{z^2pq}{d^2}$$

Where: n = sample size to be selected from each population of interest.

z = the standard normal deviate usually set at 1.96 which corresponds to the 95% confidence interval.

P = the proportion of anemia prevalence in the target population was found to be 80%.

Q = 1-p = 0.2, proportion of children expected to be not iron deficient.

d= degree of accuracy required at 0.05.

$$N = \frac{1.96^2 \times 0.8 \times 0.2}{(0.05)^2} = 245$$

Attrition 5% = 12

= 245+12 = 257 households.

3.2.3 Inclusion and exclusion criteria

Inclusion: Children under five years with their consent and that of their parents.

Exclusion: children above five years of age and those children who were too sick to be weighed or measured for height.

3.2.4 Sampling Procedure

Juba County is divided into sixteen payams. A payam is an administrative division in the county. Three of the sixteen payams from Juba County were purposively chosen because of representativeness. Juba, Munuki and Kator payams were chosen for the study. The number of households for each payam were randomly selected and the study households were systematically selected, i.e. the study subjects were systematically chosen.

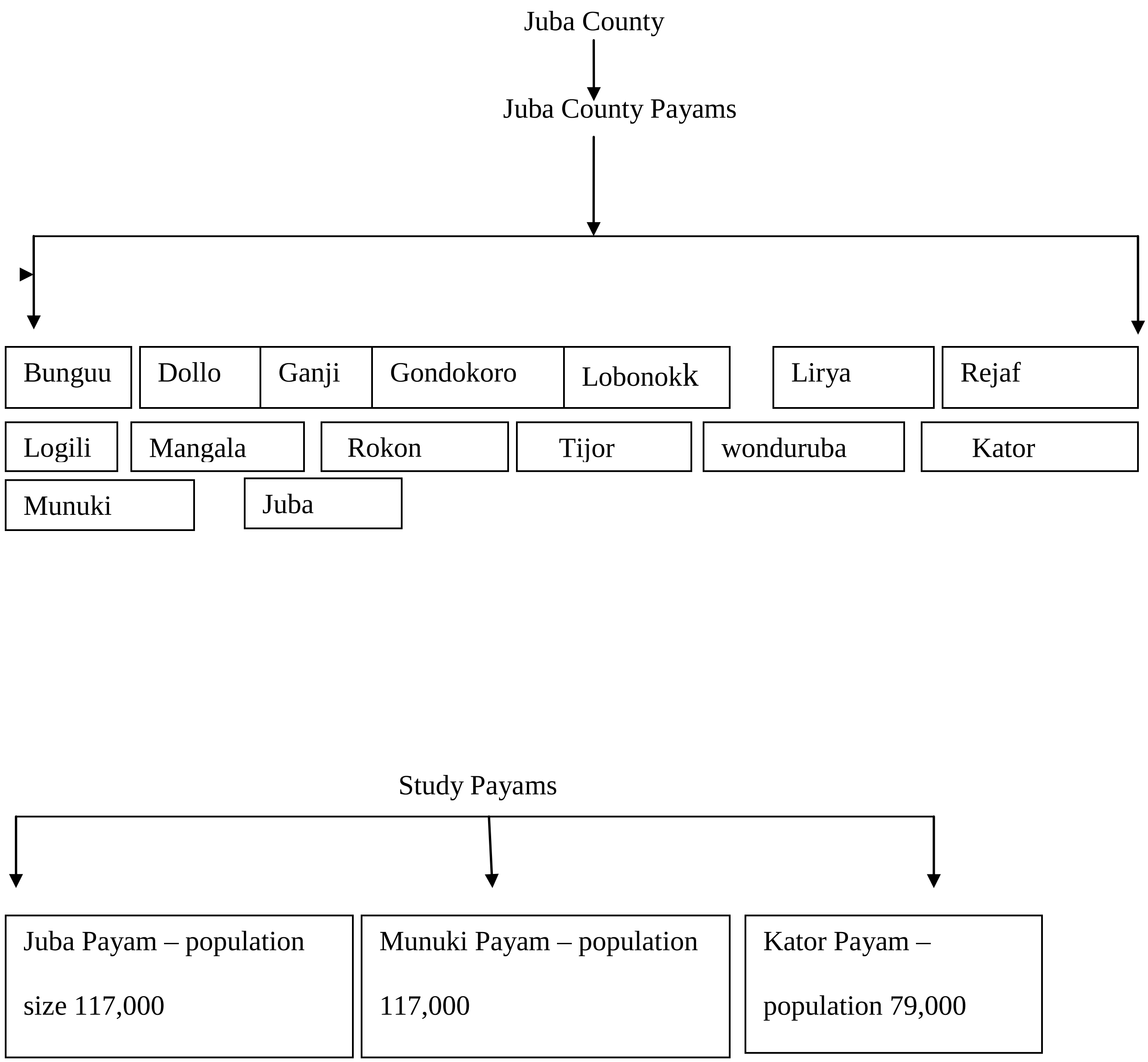


Figure 1: Sampling Frame

3.3 Data collection Tools and Equipments

Semi structured questionnaires, weighing scale for children, MUAC tapes, weighing pants, and height boards were used to collect data from under five children and their parents.

3.3.1 Recruitment and training of research assistants

Two research assistants were trained to carryout anthropometric measurements of children under five and to assist with filling of questionnaires.

3.3.2 Pretesting of the questionnaires

Ten questionnaires were pre-tested in Rajaf (one of the payams within Juba County). This helped in identifying issues that needed to be addressed before the real data collection started and to assess the clarity and simplicity of the language that was used in the questionnaires, ie to ensure that questions were well understood by field assistants and by the respondents. The enumerators were trained on how to take weight and height measurements and reading of child health cards, or estimation of age using calendar events.

3.4 Data collection procedures

3.4.1 Household Demographic and Socio-economic Data

Semi-structured questionnaire were used to collect socio-demographic and socioeconomic data of the parents or caretakers of the population under study. This was done at each household where there was an under five. Data included marital status, education and occupation of members of the households, health of the selected child, breastfeeding and weaning practices, and the immunization status of the child under study.

3.4.2 Food consumption patterns

A qualitative questionnaire was used to collect information on the types of foods and number of meals consumed by the index child over the past one week. Probing questions were used to get information on the food types consumed, ingredients used to prepare meals, and the type of snacks used and the number of times the child ate the particular food in a week.

3.4.3 Nutritional status

Age: The date of birth of the index child was extracted from the child's clinic card, birth certificates, and/or mother's recall.

Weight and Height Measurements: weight was measured to the nearest 0.1kg using a Salter spring balance. The child was hang in a specially designed bag and readings taken.

Height: a vertical measuring height board was employed. After removing shoes, the subject was helped to stand on a flat surface of the height board with feet parallel and with heels, buttocks, shoulders and back of head touching the upright of the height board. The head was held comfortably erect, with the lower border of the orbit of the eye in the same horizontal plane as the external canal of the ear. Infants and children under two years of age were laid on the board, with eyes looking vertically with head positioned firmly against the fixed headboard. The knees are extended and feet flexed at right angles to the lower legs. The upright sliding foot piece was moved to obtain firm contact with the heels and the length read to the nearest 0.1cm.

Mid Upper Arm Circumference (MUAC): The mid-point between the elbow and the shoulder was determined. The tape measure is placed around the LEFT arm (the arm should be relaxed and hang down the side of the body) and the MUAC is measured while ensuring that the tape neither pinches the arm nor was left loose. The measurement was then read from the window of the tape or from the tape and the MUAC was then read to the nearest 0.1 cm.

A measurement in the green zone means the child is properly nourished; a measurement in the yellow zone means that the child is at risk of malnutrition; and a measurement in the red zone means that the child is acutely malnourished. MUAC cut-off points are as follows: 16cm – considered healthy, 13.5 is considered moderate wasting, and < 12.5 is considered severely wasted.

3.4.4 Measurement of Hemoglobin (Hb)

The Hb was measured using the hemocue-B Haemoglobin analyzer and it was expressed in g/dl of blood with a cut off of Hb below 110g/dl of blood. The hemocue B-Hemoglobin analyzer is a portable, rapid and accurate method of measuring hemoglobin. It is easily used by any healthcare workers after a short period of training.

3.5 Data quality control

The questionnaires were pretested in an area similar to the area of study (Rajaf) to test for clarity and relevance of questions to respondents. The weight measurement scales were calibrated daily before use. All the measurements of weight and height were recorded twice and the average calculated. Any problems were addressed daily during debriefing with the field assistants.

3.6 Data Management and Analysis

Data was analyzed using the Statistical Package for social Sciences (SPSS) version 16. Descriptive summary statistics such as frequencies, means, medians, and standard deviations were used to describe the characteristics of the study population. Inferential statistics: odds ratio, confidence interval, and p-value will be used to determine association between variables.

3.7 Ethical considerations

Research permits were obtained from Juba County at the mayor’s office to give permission to collect data from households in the three study Payams. Data was collected using structured questionnaires and mothers, who provided the information, were not forced to do so.

The respondents were assured of confidentiality of any discussion of any kind. The enumerators in their training were made to know that it was unethical not to keep confidential any information they got from the respondents.

CHAPTER FOUR: RESULTS

4.1 Socio-demographic characteristics of the study population

A total of 243 children aged between 6 months and 59 months were surveyed, one from each household. The mean age of the children was 29±15.4 months. Of the children included in the study, 49.8% were males while 50.2% were females.

4.1.1 Household Size

The mean household size was 8.5±3 people. The smallest household had 2 members while the largest had 17 members. Children below 5 years of age constituted 24% of the population with a mean of 2±0.9 per household.

4.1.2 Marital Status of Respondents

By marital type of the household head, majority (78.2%) of the respondents were monogamously married while the rest (21.8%) were in polygamous marriage. Figure 2 shows the distribution of the heads of the households by the marital status.

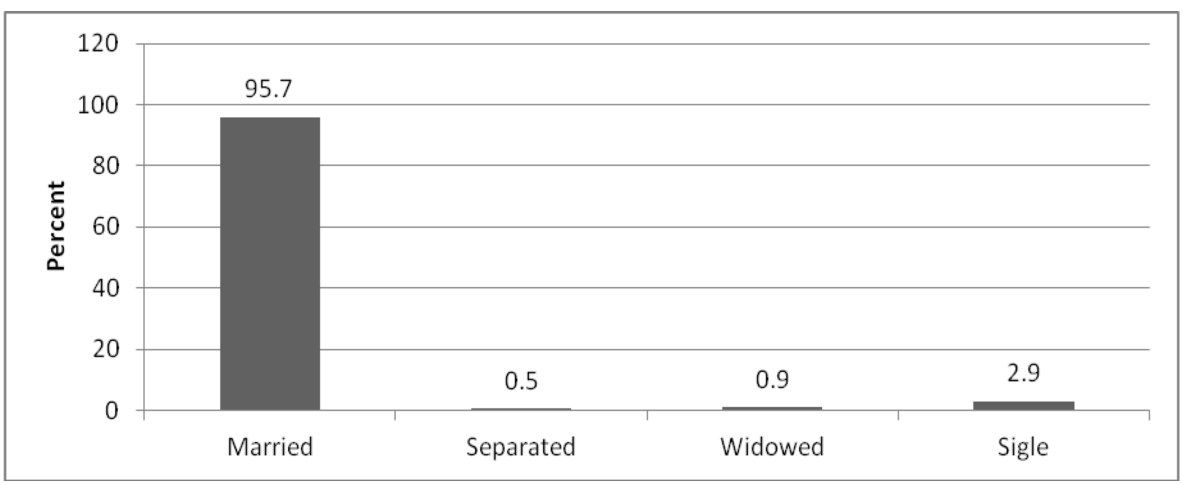


Figure2: Distribution of respondents by marital status

4.1.3 Education of the Respondents

Majority (43.4%) of the caregivers/mothers had completed secondary education. 27.3% had attended college, 9.3% completed primary school, 8.8% were primary school dropouts, while 11.2% were illiterate as shown in table 2 below.

Table 2: Distribution of the respondents by the highest levels of educational attainment

Highest educational level of the care giver		
	Frequency	Percent
College	56	27.3
Completed Secondary	89	43.4
Completed Primary	19	9.3
Pry dropout	18	8.8
illiterate	23	11.2
Total	**205**	**100.0**

4.1.4 Socio-economic Characteristics of Household heads

The main source of income for the households was salaried employment (80.1%) followed by casual labor (12.1%). A small number of respondents (2.9%) practiced farming while 4.9% were self-employed. Table 3 describes the distribution of the household heads of the children by their main source of income.

Table 3: Distribution of the household heads by main source of income

Main source of income for the household		
Salaried	165	80.1
Farmer	6	2.9
Self-employed	10	4.9
Casual laborer	25	12.1
Total	**206**	**100**

Table 4: The minimum, maximum, mean and standard deviation of age, weight, and height, MUAC, WHZ, HAZ and WAZ of children

	N	Minimum	Maximum	Mean	Std. Deviation
Age (months)	242	6	59	29.0	15.3
Height (cm)	242	61.0	112.0	85.5	12.4
Weight (Kg)	243	5.0	19.9	11.4	3.1
MUAC (cm)	240	9.8	19.3	14.4	1.5
WHZ	240	-4.23	5.3	-.47	1.2
HAZ	236	-4.7	4.5	-.9	1.5
WAZ	241	-4.8	2.7	-.8	1.2

Table 5: Prevalence of moderate and severe malnutrition among the study children by different age groups

Table 5 shows the level of malnutrition among the children by their different ages.

	Weight-for-length/height (%)		Length/height-for-age (%)		Weight-for-age (%)	
Age groups	**% < -3SD**	**% < -2SD**	**% < -3SD**	**% < -2SD**	**% < -3SD**	**% < -2SD**
(6-11)	5.7	22.9	2.9	11.4	8.1	10.8
(12-23)	5	8.3	10	31.7	6.7	20
(24-35)	0	5.5	11.1	22.2	3.6	20
(36-47)	0	7.7	9.4	18.9	1.9	9.4
(48-59)	2.8	13.9	5.7	20	5.4	16.2
All	**2.5**	**10.5**	**8.4**	**21.9**	**5**	**15.7**

4.2Mid Upper Arm Circumference (MUAC)

According to MUAC results, only 2.1% of the children were found to be severely malnourished (MUAC <11.5cm). Table 6 shows the result of MUAC assessments. No significant gender difference was found in the risk of malnutrition using the MUAC assessment (χ = 0.718, df = 3, sig. =.869, CI =95%).

Table 6: Distribution of the study children by MUAC assessments

Classification	Cut point	Sex of the child		Total
	<11cm	Male	Female	
Severe	<11.5 cm	2/ (1.7%)	3/ (2.5%)	5/ (2.1%)
Moderate	11.5 -12.5 cm	7/ (5.9%)	9/ (7.4%)	16/ (6.7%)
At risk	12.5 -13.5 cm	22/ (18.5%)	25/ (20.7%)	47/(19.6%)
Normal	≥ 13.5 cm	88/ (73.9%)	84/ (69.4%)	172/ (71.7%)
Total		**119, (49.6%)**	**121, (50.4%)**	**240, (100%)**

4.3Breastfeeding and weaning practices

At the time of the survey, only 38% were still breastfeeding. The mean age at which a baby was introduced to complementary foods was 3.8 ±1.5 months. Exclusive breastfeeding was practiced by 22.3 % of the mothers. About 92.1% of the mothers reported having given their babies the first milk (colostrum) while the rest (7.9%) discarded it. Only 1.3% of the mothers introduced complementary feeding at about 7 months of age. Majority (31.9%) of the mothers introduced complementary feeding at 4 months. Porridge, with (57.7%) was the most commonly used food for complementary followed by milk with (21.6%), and soup (15.8%), juice (2.1%) and water with (2.1%).

Figure 3 below shows the distribution of the children by the time they were introduced to breast after delivery or birth.

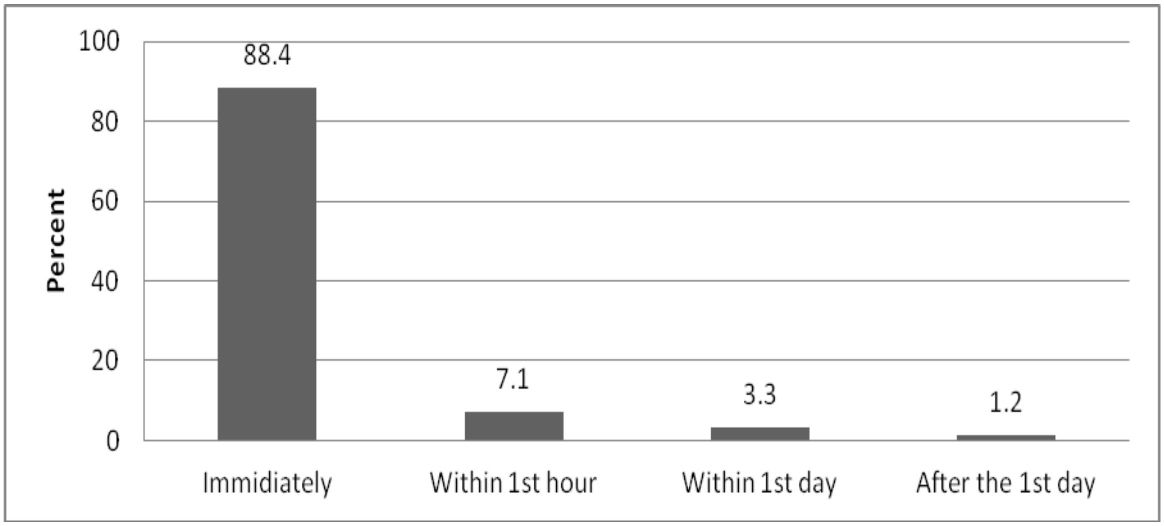


Figure 3: Distribution of the children by the times they were introduced to breast after birth

4.4Household Dietary Diversity Scores (HHDS)

The mean HDDS was found to be 9.9±2.3 food groups consumed as indicated in table 7.

Table 7: Distribution of the study households by the HDDS

	Frequency	Percent	Cumulative Percent
Low HDDS	8	4.4	4.4
Medium HDDS	11	6.1	10.5
High DDS	162	89.5	100.0
Total	**181**	**100.0**	

Majority (97.8%) of the households consumed cereals in the previous 24 hours preceding the survey. Most commonly consumed foods included cereals, vegetables, meat, legumes, nuts, seeds, oils and fats. Vitamin A rich foods such as fruits were the least consumed food group (63.3%). The figure below presents the patterns of consumption of the different food groups.

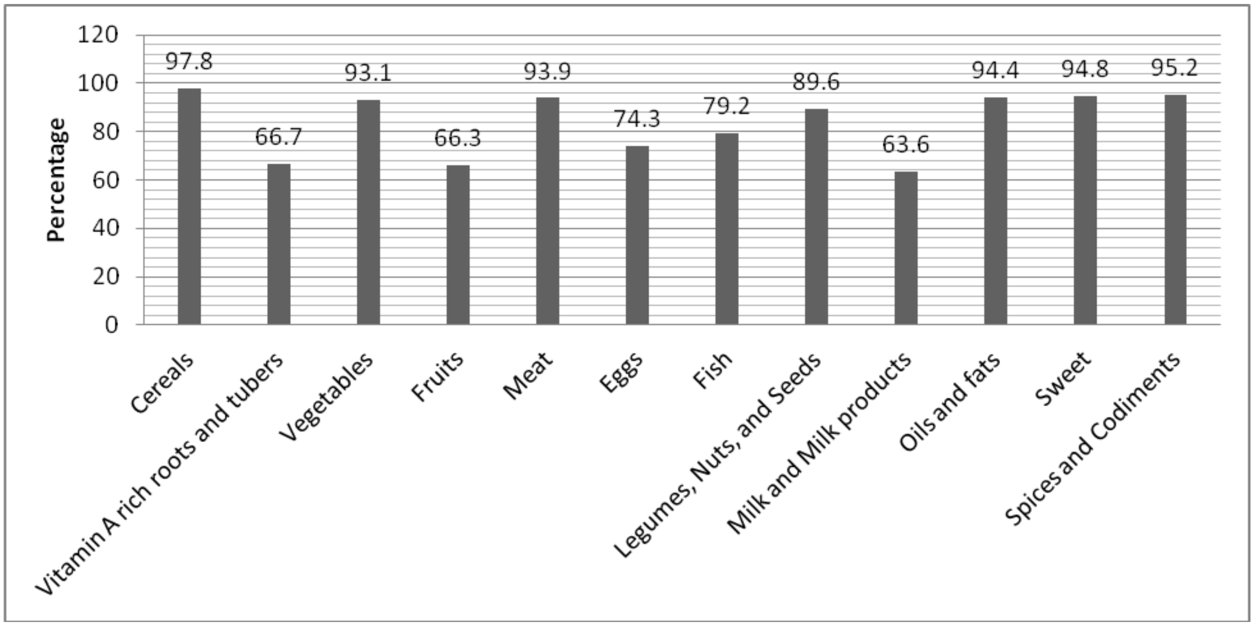


Figure 4: Household consumption pattern of the different food groups

Table 8 shows the number of times particular type of food is consumed by the children ranging from one week to one month.

Table 8: Food consumption frequencies

Food	Once a week	Twice a week	3 times a week	4 times a week	5 times a week	6 times a week	7 times a week	Once a month	Never consumed
Milk	4.0	2.6	6.2	8.4	5.7	1.8	31.3	0.4	39.2
Eggs	16.5	24.3	19.3	9.6	3.2	2.8	5.0	2.3	17.0
Beef	39.5	24.5	10.5	7.7	1.4	8.6	3.6	5.4	2.3
Liver	5.6	19	-	-	0.5	-	0.5	23.2	68.4
Chicken	13.1	2.8	-	-	-	-	0.5	51.4	32.2
Fish	31.5	17.8	8.9	4.7	0.9	0.9	10.8	10.3	14.1
Fruits	10.8	11.8	19.1	18.6	7.4	7.8	4.4	1.5	18.6
Legumes	8.2	10.0	45.9	29.1	2.7	0.9	1.8	-	1.4
Green vegetables	1.5	2.5	22.5	43.1	10.8	4.9	10.8	1.0	2.9
Cereal porridge	0.9	0.5	3.7	12.6	10.3	0.9	65.4	-	5.6
Black tea	0.5	1.9	5.3	8.2	1.4	1.0	61.5	1.4	18.8
Cassava *asida*	0.7	-	-	0.7	-	-	90.3	-	8.2
Maize *asida*	0.5	-	0.5	1.1	-	-	93.6	-	4.3
Sorghum *asida*	-	-	-	-	-	-	87.1	1.6	11.3
Millet *asida*	-	-	10.0	5.0	-	-	50.0	-	35.0
Rice	12.7	13.2	43.9	22.9	1.5	0.5	2.9	0.5	2.0
Bread	3.0	9.4	35.5	30.0	4.4	0.5	12.8	-	12.8

4.5 Immunization and morbidity experience among the children

4.5.1 Immunization

In this study, about 97% of the children had received the full immunization recommended for their ages. The likelihood of a child receiving a given specific vaccine seemed to decrease with the age of the child with about 98.8% had received the BCG vaccine at birth compared to the 91.8% who received the measles vaccine at 9 months of age. The figure below describes the trend in immunization coverage.

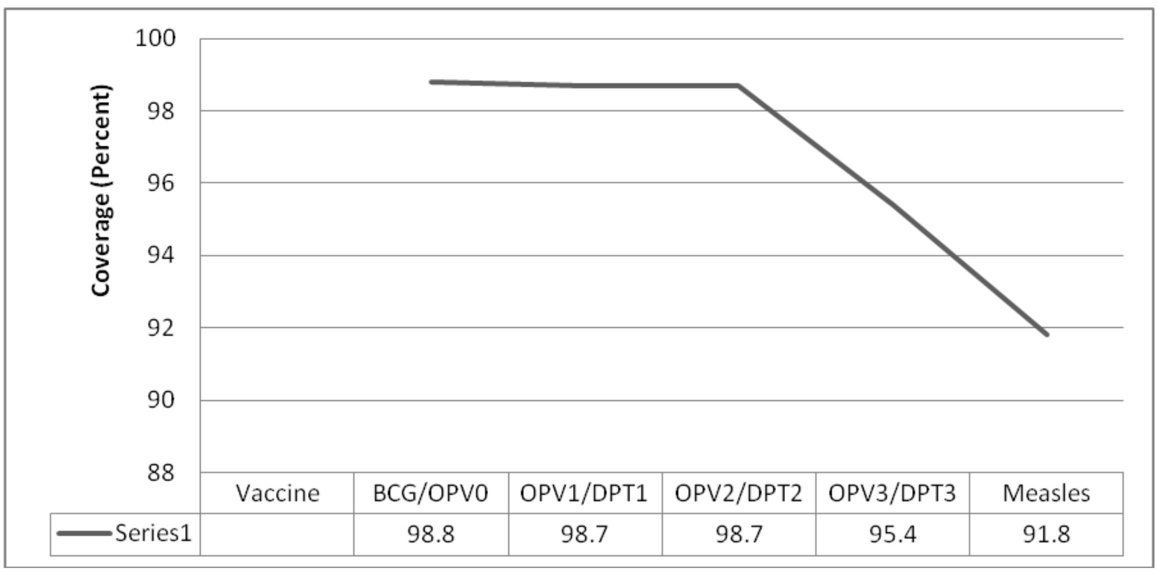


Figure 5: Trends in immunization coverage of children

4.5.2 Morbidity Patterns

The study showed that 57.3% of the children surveyed reported to have experienced one or more signs of illness in the past two weeks preceding the study. Diarrhea and cough ranked the highest with a prevalence of 22.7% respectively. 26.9% of the children had suffered malaria in the past two weeks preceding the study and 19.1% reported to have had no appetite for food. Of these, 16.2% did not seek medical care anywhere. Majority (50.4%) of the children were taken to private clinics/pharmacy, followed by public health facility (35.5%), own medication (11.4%) and traditional healer (1.7%).

The table 9 shows the distribution of the children by the different ailments they had suffered two weeks preceding the study.

Table 9: Prevalence of illnesses among the study children

Illness	**Percent**
Diarrhea	22.7
Cough	22.7
Malaria	26.9
Vomiting	.3
Poor appetite	19.1
Pale eyes and hard palms	5.0
Brittle finger nails	3.3

A bivariate analysis to test the correlation between immunization status and illness found a significant negative correlation between a child's immunization status and diarrhea incidence (Pearson Correlation = -.176, p =0.041).

4.6 Prevalence of Anemia

Anemia in children was measured using the Hemoglobin (Hb) levels. A cut off of Hb below 11g/dL (WHO, 2011) was used to define anemia. The mean Hb for the children was 9.6±1.7 g/dL which was below the normal range. Overall, 79.7% of the children were anemic and only 20.3% of the children had normal Hb levels. The prevalence of severe anemia was 4.1%, moderate anemia 51.2% and mild anemia 24.4%. About 53% of the boys were anemic compared to 45% of the girls. However, a comparison of the mean Hb of the two gender using a student independent T-test found no significant difference in the means (p=.400, LCL =-.928, UCL=.302). The table 10 shows the mean Hb and standard deviations.

Table 10: The mean Hbs and standard deviations of study children by gender

Sex	**Mean Hb (g/dl)**	**Standard Deviation**
Male	9.45	1.8
Female	9.76	1.6
All	9.6	1.7

4.7 Relationships between nutritional status of the children and other variables

4.7.1 Nutritional status of the children by breastfeeding status

A Pearson Chi-square test found no significant difference in the prevalence of malnutrition (stunting, wasting and underweight) between children who were still breastfeeding and those who had stopped breastfeeding at the time of the survey. Table 11 presents the results of the nutritional status of the children by breastfeeding status

Table 11 shows that 9.1% of the children still breastfeeding were severely stunted, 15.9% moderately stunted and majority, (75%) normal. On the other hand, 7.4% of the children who stopped breastfeeding were severely stunted, with 12.2% moderately stunted and 78.4% normal.

The prevalence of severe wasting however was 5.6%, moderate wasting was found to be 8.9%, and those who were normal were found to be 85.6% among breastfeeding children. Among non-breastfeeding children, 0.7% were severely wasted, 7.4% moderate and 91.9% normal.

Underweight was reported to be 7.6% severe, 13.0% moderate and 79.3% normal among breastfed children. Those who were not breastfed however reported to have 2.7% severe underweight, 9.4% moderate and 87.9% normal.

Table 11: The distribution of Iron Deficiency by the nutritional status of children by breastfeeding status

		child still breastfeeding			Significance
		Yes (%)	No (%)	Total (%)	
Stunting	Severe Stunting	9.1	7.4	8.1	χ = .966, df =2,
	Moderate Stunting	15.9	12.2	13.6	p=.617
	Normal	75.0	80.4	78.4	
Wasting	Severe wasting	5.6	0.7	2.5	χ = 5.686, df =2,
	Moderate wasting	8.9	7.4	8.0	p =.058
	Normal	85.6	91.9	89.5	
Underweight	Severe underweight	7.6	2.7	4.6	χ = 4.217, df = 2,
	Moderate underweight	13.0	9.4	10.8	p =.121
	Normal	79.3	87.9	84.6	

The table 12 shows that only 7.9% of households with high HDDS were severely stunted, 13.5% moderately stunted and 68.5% normal, but with no significant difference

The prevalence of wasting among households with HDDS was found to be only 1.1% severe, 5.6% moderate and 83.3% found to be normal. There was significant difference between wasting and HDDS as well as underweight as indicated in the table above.

Table 12: Nutritional status of the children by the household dietary diversity score

		Dietary Diversity Score (HDDS) of the children				
		Low (%)	**Medium (%)**	**High (%)**	**Total (%)**	**Significance**
Stunting	Severe Stunting	0	1.7	7.9	9.6	χ = 4.949,
	Moderate Stunting	0.6	0.6	13.5	14.6	df=4,
	Normal	3.4	3.9	68.5	75.8	p= .293
Wasting	Severe wasting	0	1.1	1.1	2.2	χ=21.439,
	Moderate wasting	0.6	1.7	5.6	7.8	df=4,
	Normal	3.3	3.3	83.3	90	p =**.000**
Underweight	Severe underweight	0	2.2	3.3	5.5	χ=22.849,
	Moderate underweight	0	0.6	11.6	12.2	df=4,
	Normal	4.4	3.3	74.6	82.3	p = **.000**

4.7.2 Relation between Nutrition and Immunization

Amongst the three anthropometric indices, only the prevalence of underweight was significantly different between children who were fully immunized and those that had received partial immunization (χ = 9.883, df = 2, p =.007). The study found no significant difference between stunting and wasting among those who were immunized and those that were not.

Table 13: Nutritional status of the children by their immunization status

		Fully immunized			Significance
		Yes (%)	No (%)	Total (%)	
Stunting	Severe Stunting	7.7	0.4	8.2	χ = 1.896, df =2,
	Moderate Stunting	12.9	0.9	13.7	p=.388
	Normal	76.4	1.7	78.1	
Wasting	Severe wasting	2.1	0.4	2.6	χ = 5.719, df =2,
	Moderate wasting	7.7	0.4	8.1	p =.057
	Normal	87.7	1.7	89.4	
Underweight	Severe underweight	3.8	0.8	4.6	χ = 9.883, df = 2,
	Moderate underweight	10.9	0	10.9	p =**.007**
	Normal	82.4	2.1	84.5	

4.7.3 Relation between Iron Status and Nutritional Status

The prevalence of malnutrition among children with severe anemia, moderate anemia, mild anemia and no anemia was significantly different for all the three anthropometric indicators. In all the three indicators, there was a significant relationship between the presence of anemia and the nutritional status of the child (Table 14).

Table 14: Distribution of anemia by the type of nutritional status

		Anemia status				
		Severe (%)	**Moderate (%)**	**Mild (%)**	**No anemia (%)**	**Significance**
Stunting	Severe Stunting	1.7	5.0	3.3	0	χ = 14.629,
	Moderate Stunting	0.8	9.2	0.8	0.8	df=6,
	Normal	1.7	37.5	20.0	19.2	p= **.023**
Wasting	Severe wasting	1.6	1.6	0	0	χ=30.825,
	Moderate wasting	0.8	4.1	0.8	4.9	df=6,
	Normal	1.6	45.1	23.8	15.6	p =**.000**
Underweight	Severe underweight	1.6	3.3	1.6	99.2	χ=15.046,
	Moderate underweight	1.6	7.4	4.9	0.8	df=6,
	Normal	0.8	41.0	18.0	77.9	p = **.020**

4.7.4 Anemia by socio-demographic and socio economic status of households

The study showed that 91.7% of the children whose parents were in a monogamous family had no anemia while 76.1% had anemia as indicated in the figure below. On the other hand, 23.9% of those children whose parents were in a polygamous marriage were anemic, with only 8.3% normal. Table 15 below shows the distribution of anemia by the type of occupation of the Household head, the marital status of the household head and the education level of the household head.

Table 15: Anemia distribution by socio-demographic and socio economic status of households.

Variable		Anemia (%)	No anemia (%)	Total (%)	Significance (χ^2)
	Monogamous	76.1	91.7	79.3	
Marital type	Polygamous	23.9	8.3	20.7	0.235
	Salaried	78.6	80	78.8	
	Self employed	10.7	15	11.5	
Occupation of HH	Casual labor	10.7	5	9.6	0.667
	Married	94.2	95	94.3	
Marital status of	Separated	1.2	0	0.9	
mother	Single	4.7	5	4.7	0.888
	College	19	50	25	
	Secondary	50	30	46.2	
	Primary (completed)	14.3	0	11.5	
Education level of	Primary (Dropped)	9.5	5	8.7	
HH	None	7.1	15	8.7	0.017

4.7.5 Association between anemia, HDDS, immunization and morbidity status of the children

As shown in table 16, there was no significant association between the child's anemia status and the household's diet diversification. Similar results were also seen in the case of anemia and immunization and morbidity status of the children.

Table 16: Distribution of anemia by household dietary diversity scores (HDDS), immunization and morbidity status of the children.

Variable		Anemia (%)	No anemia (%)	Total (%)	Significance (χ^2)
	Low	3.5	0	2.9	
	Medium	3.5	11.1	4.9	
HDDS	High	92.9	88.9	92.2	0.298
	Yes	92.7	100	94.1	
Fully Immunized	No	7.3	0	5.9	0.182
	Yes	64.3	54.2	62.3	
Sick in last 2 weeks	No	35.7	45.8	37.7	0.359

CHAPTER FIVE: DISCUSSIONS

This study assessed the iron and nutritional status of children aged 6 to 59 months and the associated factors.

5.1 Socio-demographic and economic characteristics

The average house hold size in Juba County was found to be 8.5, slightly higher than the 8 persons per household as reported by WFP 2010. The difference in this household size may be attributed to extended families, movement of people from place to place as they try to settle after the war, loss of property after the war, and dependency due to loss of either one parent or both. No data exists on age dependency ration for South Sudan, however, it is obvious that a big number of people younger than 15 and older are dependants compared to the working population, i.e. those aged between ages 15 – 64 years. This is typical of developing countries, and south Sudan is not an exception. High dependency ratios are associated with poor household food security. Although this is not clear in South Sudan, it is evident that it is true and is one of the reasons why food consumption scores are generally low.

Polygamous families are poorer than monogamous families. Families with a polygamous marriage face economic challenges in the distribution and management of resources within the household, and this has a negative impact in the nutritional status of the family, especially that of 6-59 months within that household. In this study however, most of the households were monogamous marriage (78.2%), with 21.8% polygamous marriage.

The educational level of the mothers and the caregivers plays a major role in the well being of children and the family as a whole. In this study, although (43.4%) of the mothers had completed secondary school, (11.2%) of the mothers were illiterate. Although a good percentage of the household heads earned their income from employment (80.1%), it was also true that the amount of salary they earned was not enough to meet the nutritional needs of the family because the income was too low. The composition of the household is an important characteristic because it is also associated with the well being of the family. When the number of people exceeds the income of the household head, food consumption is either reduced or the quality as well as quantity of food consumed is compromised, when this happens, the most affected are the under five children who need adequate nutrition at this age to meet their nutritional requirements for growth and development. To make matters even worse for children, south Sudanese have a culture of communal eating where everyone in the family eat from the same plate, including children. The little ones will end up not having enough since they cannot manage to struggle to feed to satisfaction. Before they are satisfied or have had enough, the food is either finished or they give up and have to wait for another meal which may not be any time soon. This results in inadequate intake leading to poor health and nutritional status.

5.2 Nutritional status

Adequate nutrition is critical to the development of the child. The nutritional status of infants and children under five years of age is of particular concern since the early years of life are crucial for optimal growth and development. Nutritional status is considered as an outcome of immediate, underlying, and basic causes (UNICEF, 1990).

Stunting, wasting, and underweight

As stunting is a physical manifestation of chronic malnutrition, the natural growth patterns of these children have been impeded by a variety of aspects during the twenty-four month window of opportunity, including their weight at birth, quality of diet, mother's nutritional intake and health during pregnancy, bouts of infectious disease, and proper sanitation and hygiene of their environment. There are also larger factors in consideration, including education about proper nutritional practices, chronic poverty, lack of agricultural biodiversity, and climate change, all of which negatively affect a mother's ability to properly nourish both her child and herself.

The prevalence of wasting in this study (10.5%) was a bit higher than the levels reported in Central Equatoria State of 10% by FAO (FAO, 2011). Wasting represents the failure to receive adequate nutrition in the period immediately preceding the survey. This could explained in the case of this study by the fact that the intake of food may have been compromised due to illness causing loss of appetite and therefore inadequate food intake during the period preceding the study. Another contributing factor could be the fact the young children depend on their caretakers or mothers for feeding. As some mothers go to work, the children are either left home in the care of caretakers or relatives who do not care enough to give these children adequate food the way the mother would have done.

The prevalence of underweight was found to be 15.4% in Juba. This prevalence of may be attributed to both stunting and wasting in the study area. This is because weight for age is a composite index of height-for-age and weight-for-height. It takes into account both acute and chronic malnutrition.

5.3 Breastfeeding and weaning practices

Breast milk comprises all the energy and nutrients necessary for newborn children as well as important maternal antibodies that enhance the child's natural immune defenses. According to the Global Strategy for Infant and Young Child Feeding (a joint WHO/UNICEF publication), breast milk contains all of the nutrients necessary for the proper growth and development in the first six months of life. A meta-analysis of existing evidence by WHO indicates that complimentary foods and liquids introduced prior to 6 months of age serve only to increase the risk of diarrheal disease, while having no beneficial impact on growth. According to WHO, breast milk continues to be an integral part of a child's diet even after 6 months of age.

Unlike the period of exclusive breastfeeding (where children are generally protected from infectious disease), the introduction of complimentary foods enhances the vulnerability of the child, potentially exposing them to natural pathogens. This is contrary to the situation in the study children in south Sudan where complementary foods are introduced as early as 4 months of age with Exclusive breastfeeding practiced by only 22.3% of the mothers interviewed during the study period. In as much as 92.1% of the mothers in the study reported to have given their babies the first milk (colostrum), the introduction of complementary food as early as 4 months exposes these children to infections and diarrheal diseases because most of the baby foods are prepared in an unhygienic manner and there is always risk of food contamination either from the preparation methods or from the environment itself which is not always good sanitation wise. Repeated diarrhea leads to loss appetite, weight and eventually to a compromised immune system either due to the diarrhea or any other illnesses

It is advised that foods should only be introduced when the energy requirements of the child can no longer by met by breast milk alone and the foods given should be adequate to provide the required nutrients for proper growth and development of the child.

The food should also be hygienic and clean to avoid food contamination and subsequent diarrhea.

In this study, it was found that 57.7% of the complementary food used was cereal porridge, followed by (21.6%) milk, (15.8%) soup, (2.1%) juice, and 2.1%) used water as the first food introduced to their babies. As poor sanitation and water is believed to be one of the primary culprits of Malnutrition and childhood morbidity in Sudan (and particularly in southern Sudan), the introduction of these foods at such young age could therefore have a particularly devastating impact on health and nutritional status of children under five. Cereal is known to interfere with the absorption of iron in the body, and for these little ones whose iron status at four months is already at risk, the impact can be even worse especially when coupled with the presence of malaria, diarrhea, and other illnesses that affect appetite and normal intake of food. Although there was not any significance in the analysis about this, it is evident from the high rate of cereal consumption both as porridge for this children and as the main staple food as being one of the factors for the low HB levels in the children studied.

5.4 Food consumption patterns

Twelve food groups were considered as per FAO (2011) guidelines. The mean HDDS was 9.9 food groups. The maximum number of food groups consumed was 12 while the minimum was 1 food group. Majority of the households surveyed had high HDDS of 8 food groups.

97.8% of the households consumed cereals as the main food with fruits being the least consumed.

High consumption of more than 8 food groups is reported to have an effect on anemia status where children with high DDs are protected from anemia. Those taking less than or equal to three food groups are found to be at risk of anemia. The findings here show that cereals are the most consumed in most households, and cereals are reported to inhibit iron absorption due to the presence of phytates in them. This would have a direct effect on the anemia status of the children. It was also noted in this study that fruits were less consumed, yet fruits, especially vitamin C rich fruits are known to enhance the absorption of iron in the body.

Animal source foods are an important component of children's diets as a major source of protein and micronutrients. According to Lancet series (2008), low intake of these foods is a risk factor for stunting. As evidenced from this study, stunting is a risk factor for iron deficiency. This study also found that animal source foods are less consumed by the children surveyed, and this would have a negative impact on the nutritional and anemia status of children.

5.5 Iron status

Anemia, often due to iron deficiency, is one of the most widespread causes of mortality and morbidity in South Sudan, which probably has the highest rates in the world (SOUTH SUDAN MEDICAL JOURNAL, 2010-2012). There is no more recent survey in south Sudan conducted on anemia, but there is a legislation regarding IDA in place that is still being developed (www.tulane.edu/-internut/countries/sudan/sudaniron.html).

In this study, findings showed that 79.7% of the children surveyed in Juba had anemia with a mean Hb of 9.6g/dl lower the recommended normal levels of WHO. The prevalence of severe anemia was 4.1%, moderate 51.2% and mild anemia 24.4%. The study also found a significant relationship between the presence of anemia and the nutritional status of children. There was significant relationship between anemia and stunting, underweight, and wasting. Factors that attribute to this low prevalence of hemoglobin include inadequate food and nutrients intake by the children, early introduction of weaning foods, as early as 4 months of age, lack of knowledge by mothers and caregivers on child feeding practices, repeated malaria infections, helminthes infections and other child illnesses with diarrhea being the leading one.

Another factor could be attributed to low education level of mothers and caregivers, low income, high number of dependents per household compared to the income of the household head (extended family) and polygamy which is becoming a common practice among South Sudanese families.

CHAPTER SIX

6.0 Conclusions and Recommendations

6.1 Conclusions

The main objective of this study was to determine the prevalence Iron Deficiency and the associated factors among children 6-59 months in Central Equatoria State, Juba. The prevalence of iron deficiency which was 9.6g/dl was found to be lower than the recommended levels by WHO of 11.0g/dl for children aged 6- 59 months, meaning the prevalence of iron deficiency among the children studied was high (79.7%) and this may be associated with a number of factors.

Large household size is one factor, with the least household having at least 3 children age below five years. In this large households, there is normally only one person capable of earning a salary to cater for all household needs and yet the salary is too small compared to the number of dependents under their care. In addition to this, this salary is not consistent such that sometimes it takes two to three months for salaries to be paid for government staff. This has impact on the nutritional status of the household especially where the bread winner is a government employee. This would mean that the amount of food consumed would not be enough to meet the nutritional needs of every family member and especially of children under five years who need extra calories to meet their need for growth and development. The number of meals consumed per day is reduced to one meal per day. Although different food groups are consumed by most of these households, this does not automatically translate into adequate nutrient intake since the quality of food consumed is questionable in terms of nutrients and the amount of iron available in it. High dietary diversity does not result in improved micronutrient levels in the body especially iron whose absorption is affected by many factors such as the presence of phytates in cereals, repeated illnesses and infections and the low or no consumption of foods rich in vitamin C that enhances the absorption of iron. Vitamin C is found in fruits, and from the study, the consumption of vitamin C rich fruits is very low.

Another factor is parasitic infections. South Sudan is a malaria endemic zone with high prevalence of malaria infections. Malaria causes anemia through hemolysis and increased splenic clearance of infected and uninfected red blood cells. A single overwhelming episode of malaria, or repeated episodes due to re-infection or failure to adequately clear parasitemia as a result of antimalarial drug resistance may result in life-threatening anemia, metabolic acidosis, and, if untreated, death. In this study, 26.9% of the children had been sick from malaria two weeks preceding the study. This has as well contributed to the low Haemoglobin levels among the children under study.

The introduction of complementary foods to babies at the age of 4 months is a risk factor for diarrhea which leads to loss of nutrients. The unhygienic preparation of food for these babies also leads to food contamination and eventually to diarrhea and other infections. Poor hygiene and sanitation is a major problem in most households in Juba. Most of the families drink and use untreated water which is either directly from the river or from boreholes which are not well stored.

Intestinal helminthes is another factor that remains a challenge in south Sudan. There is increasing evidence that very young children may benefit from de-worming. In a re-cent study from Zanzibar, the prevalence of moderate anemia (hemoglobin level < 9 g/dL) and wasting (weight-for-height <-1 Z-score and mid upper arm circumference < 5th centile) was significantly reduced in children less than 24 months old with light worm infections who had been treated with mebendazole every three months for a year. In this study however, most of the children did not deworm in the past three months preceding the study. First-time helminthes infections at this age may induce pro-inflammatory mediators that are detrimental to protein metabolism, appetite, and erythropoiesis. Mebendazole and albendazole can be safely used in young children, and WHO now recommends that in areas with a high prevalence of intestinal helminthes, de-worming three times per year should start from the age of 12 months.

In conclusion, most of the children studied had low hemoglobin levels with a mean of 9.6g/dl which is below the recommended cut off level by WHO. The prevalence of Iron Deficiency was therefore very high which is not good and something need to be done to prevent anemia.

6.2 Recommendations

Following the following results of this study, below are recommendations.

Encouragement of good breastfeeding and weaning practices. This can be done through awareness at health facilities and at the community level through different channels of communication.

Food diversification through kitchen gardens to ensure adequate intake of micronutrients. The government should encourage farming and discourage the use of relief food which causes a lot of dependency on free food. Moreover, most relief food is made of dry rations which does not usually meet the need for growth and development for children.

De-worming and Vitamin A supplementation programs to be improved

Most importantly, a multi – sectorial approach to address the issue of Iron deficiency to be encouraged through the involvement of relevant ministries e.g. the Ministry of Agriculture by encouraging farming, Ministry of Education by integrating Nutrition Education in schools, with the MOH as the lead in all these activities.

Growth monitoring should be intensified at health facilities by the Ministry of Health in order to detect the cases of stunting early enough to allow for correcting the problem in the first two years of life that provide for a window of opportunity to catch up with growth if good feeding is resumed.

Most studies in South Sudan are based on general nutritional status of children, particularly to detect malnutrition, but no studies have focused on micronutrient malnutrition/ deficiency like Iron deficiency and anemia. I would recommend that more studies be carried out on iron deficiency on a yearly basis to establish the root causes of Anemia in children under five so that best ways to address the problem can be identified and adopted.

REFERENCES

ACC/SCN, (2000). Fourth Report on the World Nutrition Situation. Administrative Committee on Coordination/Sub-Committee on Nutrition. Geneva:

Adam I, Khamis, A . H. and Elbashir, M. I. (2005). Prevalence and risk factors for anemia in pregnant women of Eastern Sudan. *Trans R Soc Trop Med Hyg*. 99(10): 739-743.

Andrews NC. Disorders of iron metabolism. N Engl J Med.1999; **341:1986**–95. Hallberg L,

Annibale B, Capurso G, Matino G, Grossi C, Delle Fave G. Iron Deficiency Anemia and Helicobacter pylori infection. Antimicrob agents 2000; 16: 515 -9

Black, R. (2003). Micronutrient deficiency and underlying cause of morbidity and mortality.

Bowman, B.A., R.M. Russel, (2001). Present Knowledge in Nutrition. 8th edition, International Institute, ILS Press, D.C. Washington.

Brune M, Rossander L. Iron absorption in man: ascorbic acid and dose-dependent inhibition by phytate. Am J Clin Nutr 1989; **49:140**–4.

Carpenter, C.E & Mahoney, A.W (1992). Contributions of Heme and non heme Iron to human nutrition. Critical Review: In Food Science Nutrition. 31:333-367

Caulfield L. (2006). Stunting, Wasting, and Micronutrient Deficiency Disorders; In: Disease Control Priorities in Developing Countries (pp551-567). New York: Oxford University Press.1

CDC & WFP, 2004. Emergency Nutrition Assessment of Crises affected Populations in Darfur region. Sudan. United States Centers for Disease Control and Prevention, and World Food Programme of the United Nations, Rome.

Cook JD, Dasenko SA, Whitaker P. Calcium Supplementation: Effect on Iron absorption. AMJ Clinical Nutr 1991; 53: 106-11

DiSilvestro, R.A., Hamph, J.S and Wardlaw, G M. (2004). Perspective in Nutrition, 6th Edition. McGraw Hill companies. New York, USA.

Domellof, M.R.J. Cohen, K.G Dewey, O. Hernell, L.L. Rivera and B. Lonnerda (2001). Iron Supplementation of breast-fed Honduran and Swedish Infants from 4 to 9 months of age. J. pediatrics. 138: 679-687.

Egli I, Davidson L, Zedor C, Walczyk T, Hurrel R. Dephytinization of a complementary food based on wheat and soy increases zinc, but not copper, apparent absorption in adults. J Nutrition 2004; 134: 1077-87

FAO, (2005). Sudan Nutrition Profile. Food and Agricultural Organization of the United Nations.

Fischer, A.A., Laing, J.E., Stockel, J.E. & Townsend, J.W. (1991) Handbook for Family

Gatchell et al, (2004). The sustainability of community –based Therapeutic care in non-emergency contexts, Food and Nutrition Bulletin, vol 27. No.3.

Gibney M. J, (2009). 2nd edition. Iron deficiency anemias in public health Nutrition. Blackwell carton: 227 – 235.

GOSS, (2006b). South Sudan Household Health Survey. Government of South Sudan.

GOSS, (2007a). Private Sector Development Strategy for South Sudan. Government of south Sudan.

Hallberg L, Hulthen L. Prediction of Dietary Iron absorption: an alogarithm for calculating absorption and bioavailability of dietary Iron. AMJ clinical Nutrition. 2000; 71:1147 – 1160

Hallberg, L. (2001). Perspectives on and Nutrition Iron Deficiency. Annual Review of Nutrition 21: 1- 25.

Hellberg L, Rossander – Hulthem L, Brunc M, Gleerup A. Calcium and Iron Absorption: Mechanism of action and nutritional Importance. Eur J Clin Nutr 1992; 46: 317-27

http://en.wikipedia.org/wiki/Iron_deficiency_anemia

http://www.food.gov.uk/healthiereating/folicfortification.

http://www.foodstandards.gov.au.

Hunt, J.R. (2002). Moving toward a plant based diet; Are iron and Zinc at risk? Nutrition Reviews 60: 127-134.

Hurrel RF, Hess SY. Role of Micronutrient Interactions in the Epidemiology of Micronutrient Deficiencies: Interactions of Iron, Iodine, and vitamin A. In: Peffifer JM, Zlotkin S, eds. Micronutrient Deficiencies during the weaning period and the first year of life. Vevey/Basel, Switzerland: Nestec Ltd and s karger AG, 2004: 1-19

IOM, (1998). Prevention of micronutrient deficiencies: Tools for policymakers ad public health workers. National Academy Press. Institute of Medicine: Washington, DC.

JICA (2009). Juba Urban Water Supply and Capacity Development Study.

LANCET. (2008). The lancet's series on maternal and child under nutrition. The lancet. Vol 371: 245-255.

Maziya –Dixon B; I.O. Alanyele, E.B. Oguntona, S. Nokoe, R.A. Sanusi, E. Harrison, (2004). Nigeria Food Consumption and Nutrition Survey 2001 -2003, Summary. International Institute of Tropical Agriculture (IITA), Ibadan.

MOH/WHO (1997). Comprehensive Nutrition Survey. Government of Sudan Federal Ministry of Health, National Nutrition Department, Sudan and World health Organization, Geneva.

MOPHS, (2008). Guidelines for Nutrition Assessments in Kenya. 1st edition. Ministry of Public Health and Sanitation and Ministry of State Planning and National Development and vision 2030 (MSPNDV); Government of Kenya (GOK): 20-25

Mwaniki, D., Omwega, A.M., Muniu, E.M., Mutunga, J.N., Akelola, R., Shako, B., Gotink, M.H. and Pertet, A.M. (1999). Anemia and Micronutrient Status of Iron, Vitamin A, and Zinc in Kenya, National Micronutrient Survey Report.

New Sudan Center for Statistics and Evaluation (NSCSE) series paper, "Toward a Baseline: Best Estimates of Social Indicators for Southern Sudan." In association with UNICEF (May 2004).

Oken, E. and Duggan, C. (2002). Updates on Micronutrients: Iron and Zinc. Current opinion in Paedriatrics 14: 350- 353

Osorio MM, Lira PIC, Batista-Filho M. (2001). Prevalence of anemia in children 6-59 months old in the state of Pernambuco, Brazil. Rev Panam Salud Pubication/Pan Am J Public Health 10(2): 101-7.

Planning Operations Research Design. Population Council New York. 45pp

Reddy MB, Hurrell RF, Cook JD. Meat consumption in a varied diet marginally influences non heme iron absorption in normal individuals. J Nutr2006; **136:576**–81.

Reeves JD, Yip R, Killey VA, Dallman PR. (1984). Iron deficiency in infants: The influence of mild antedecent infection. J Padiatrics 105(6): 874-879.

Sazawal S, Black RE, Ramsan M, Chwaya HM, et. al (2006). Effects of routine prophylactic iron and folic acid on admission to hospital and mortality in pre-school children in a high malaria transmission setting: community-based randomized placebo-controlled trial. Lancet: 367: 133-43,

Sigulem DM, Tudisco ES, Goldenberg P, Athaide MMM, Vaisman E. Anemia ferropriva em criancas do municipio de Sao Paulo. Rev Saude publication197; 12(2); 168- 170

Stoltzfus R., Dreyfuss M. (1998). Guidelines for the use of Iron Supplements to Prevent and Treat Iron Deficiency Anaemia. ILSI Press Washington.

Sudan's Starving Darfur Refugees. **(2004).** BBC News. Retrieved June 29, 2011 from http://news.bbc.co.uk/2/hi/africa/3692005.stm.

Sudanese Government of National Unity and Government of Southern Sudan. (2006). Sudan Household Health Survey, Sudan: Sudanese Central Bureau of Statistics/ Southern Sudan Commission for Census, Statistics and Evaluation.

UNICEF, (1990). Strategy for improved nutrition of children and women in developing countries: a UNICEF policy review (1990-1991). United Nations Children's Fund, New York.

UNICEF, (1998). Preventing Iron Deficiency in women and Children; Background and consensus on key Technical Issues and Resources for Advocacy, Planning and Implementing National Programmes; 4: 21-24

UNICEF, (2006). State of the world's children. United Nations Children's Fund, New York, USA.

UNICEF. (2009). Tracking progress on child and maternal nutrition: A survival and development priority. United Nations Children's Fund, New York (124 page PDF file)

Wardlaw G.M., J.S. Hampl, R.A. Disilvestro. (2004). Perspectives in Nutrition, 6th edition. McGraw Hill Co. Inc. NY.

WHO, (1983). Measuring Change in Nutritional Status; Guidelines for Assessing the Nutritional Impact of Supplementary Feeding Programmes for Vulnerable Groups 4:12-14.

WHO, (2005), Pocketbook of Hospital Care for Children*:* Guidelines For The Management Of Common Illnesses With Limited Resources (pages 276-77), World Health Organization, Geneva. http://Whqlibdoc.Who.Int/Publications/2005/9241546700.Pdf

WHO, (2006). Iron supplementation of Young children in Regions where Malaria transmission is Intense and Infectious Disease is Highly prevalent. Dallman, P. R. (1986). Biochemical basis for the manifestations of Iron Deficiency. Annual Review of Nutrition 6: 13- 40.

WHO/FAO. (2006). Guidelines on food fortification with micronutrients. World Health Organization/Food and Agriculture Organization. Geneva: WHO/FAO, 2006.

WHO/UNICEF, (2001). Iron deficiency anemia: Assessment, prevention and control; A guide for program managers. Geneva.

WHO/UNU/UNICEF. (2001). Iron deficiency anaemia, assessment, prevention and control: a guide for is programme managers. Geneva.

World Vision, (2006). Community Nutrition and Survival Project. Tonj, South.

Worthington MT, Cohn SM, Miller SK, Luo RQ, Bergycl. Characterization of a human plasma memberane heme transporter to intestinal and hepatocyte cell lines. AMJ Physical Intestinal Liver Physiology 2001; 280: G1172 – G1177

Yeung CK, Glahn RP, Welch RM, Miller DD. Prebiotics and Iron bioavailability – Is there a connection? J Food Science 2005; 70: 288-92

Zimmerman, M.B., Chaouki, N. and Hurrell, R. F. (2005). Iron Deficiency due to composition of a habitual diet low in bioavailable iron: A longitudinal cohort study in Moroccan children. Am J Clin Nutr 80: 115-121 Centers for Disease Control and Prevention. Iron deficiency – United States, 1999–2000. *MMWR* 2002; 51:897–899.

APPENDICES

Appendix 1: Activity and Data Analysis Matrix

	Data/ Variables (Quantitative/Qualitative)	Method	Tools	Analysis process/ statistical tests (SPSS v. 16).
SO 1	Determine the socio-demographic and economic characteristics of the study households. (Age, marital status, HH size, Education level, occupation)	interviews	Questionnaire	Mean, range (histogram, box plots and charts), X^2, t-test, ANOVA, Bivariate analysis and correlation
SO2	Determine the anthropometric status of children under five	Measurements	MUA C, height board, weighing scale	X^2, ANOVA, Mean,
SO 3	Determine the breastfeeding and weaning practices	Interviews	Questionnaire	Frequencies/percentages, correlation,
SO 4	Consumption of the different types of foods by 6-59 months	Interviews	DDQ	Percentages/ frequencies
	Frequency of consumption of iron rich foods	Interviews	FFQ	Percentages/frequencies
SO 5	Determine the anemia status of children under five	measure	Hemocue	Percentages/ frequencies, ANOVA, regression, correlation

Appendix 2: Questionnaire

General information on demographic and socioeconomic status

1. Identification

Questionnaire number ___________________

County __________________________ Payam_____________________

Name of interviewer ________________________date of interview ____/_____2012

Name of index child __________________________ sex ____________________________

Marital type 1= monogamous 2= polygamous

1. Information on household members

s/No	Name	Relationship HH head-codes	Sex M=1 F=2	Age (years)	Marital status codes	Religion codes	Education codes	Occupation codes
1								
2								
4								
4								
5								
6								

Relationship to HH
1=HHH 2= spouse
3= son 4= daughter.
5= grandson 6= grand daughter
7= relative 8= others (specify)

Marital status
1= married
2= separated
3= widowed
4=single
5= others (specify)

Education
1= college
2= completed secondary
3= complete primary
4= primary dropout
5= in primary
6= in secondary
7= adult education
8= illiterate
9= others

Occupation
1= salaried
2= farmer
3= self employed
4= casual labourer
5= student
6= housewife

2. Morbidity data

6. Has your child been sick in the last two weeks?
   Yes 2. No
7. Did you seek healthcare assistance when child was sick?
   Yes 2. No

9. If yes, where? _____________
   1. Own medication 2. Traditional healer 3. Private clinic/ Pharmacy
   4. Public health facility 5. Other (specify)................................

10. Did your child suffer from any of the following or have you noticed the following signs in your child of late?	Yes		No
If yes_________	No. of times	No. of days/occasion	
Diarrhea			
Cough			
Malaria			
Shortness of breath			
Headache			
Poor appetite			
sleepiness			
pale eyes, palm of the hands			
brittle finger nails			
problem of concentration or thinking			

3. Infant and Young Child Feeding practices (IYCF)

s/no	11. age of child	12. Did you give colostrum to your baby? 1= yes 2= no	13. When after birth did you put your baby to the breast? 1= immediately 2= within 1st day 3= within 1st 3 days 4= more than 3 days 5= others	14. Is ____ still breastfeeding? 1= yes 2= no	15. If yes, how often do you breastfeed 1= on demand 2= own choice 3= others	16. At what age did you start giving food to your child?	17.What foods did you start with? 1= juice 2= porridge 3= water 4= others
1							
2							

4. **Immunization**

18. Has (name) been immunized against the following (verify from card)

s/no		Yes=1	No =2
1	BCG		
2	Oral polio 0		
3	Oral polio 1		
4	Oral polio2		
5	Oral polio3		
6	Pentavalent (DPT1)		
7	Pentavalent (DPT2)		
8	Pentavalent (DPT3)		
9	Measles		

5. **Anthropometric and hemoglobin measurements**

Child ID	Name	19. Age (months)	20. Weight (*nearest 0.1 kg*)			21. Height (*nearest 0.1 cm*)			22. MUAC	23. Hb level
			1	2	Average	1	2	Average		

6. Dietary Diversity questionnaire

24 Question number	Food group	Examples	YES=1 NO=0	Main source: 1=own production 2=purchase 3=gift 4=Other (specify)
1	CEREALS	bread, noodles, biscuits, cookies or any other foods made from millet, sorghum, maize, rice, wheat + *local foods e.g. ugali, porridge or pastes or other locally available grains*		
2	VITAMIN A RICH VEGETABLES AND TUBERS	pumpkin, carrots, squash, or sweet potatoes that are orange inside + *other locally available vitamin-A rich vegetables(eg. sweet pepper)*		
3	WHITE TUBERS AND ROOTS	White potatoes, white yams, cassava, or foods made from roots.		
4	DARK GREEN LEAFY VEGETABLES	dark green/leafy vegetables, including wild ones + *locally available vitamin-A rich leaves such as cassava leaves etc.*		
5	OTHER VEGETABLES	other vegetables, including wild vegetables		
6	VITAMIN A RICH FRUITS	ripe mangoes, papayas + *other locally available vitamin A-rich fruits*		
7	Vitamin C FRUITS	Lemon, oranges, wild fruits etc		
8	ORGAN MEAT (IRON-RICH)	liver, kidney, heart or other organ meats or blood-based foods		
9	FLESH MEATS	beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds		
10	EGGS			
11	FISH	fresh or dried fish or shellfish		
12	LEGUMES, NUTS AND SEEDS	beans, peas, lentils, nuts, seeds or foods made from these		
13	MILK AND MILK PRODUCTS	milk, cheese, yogurt or other milk products		
14	OILS AND FATS	oil, fats or butter added to food or used for cooking		
15	SWEETS	sugar, honey, sweetened soda or sugary foods such as chocolates, sweets or candies		
16	SPICES, CONDIMENTS, BEVERAGES	spices(black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages OR *local examples*		

7. **Food Frequency Questionnaire**

25. FOOD EATEN	NUMBER OF TIMES EATEN									
	No. Of days consumed in a week							Once in two weeks	Once a month/ rare	Never consumed
Milk	1	2	3	4	5	6	7			
Eggs										
Beef										
Liver										
Chicken										
Fish										
Fruits										
Legumes, beans, lentils										
Green vegetables										
Cereal porridge										
Fermented porridge										
Tea										
Coffee										
Ugali/cassava										
Ugali/ maize										
Ugali/sorghum										
Ugali/ millet										
Rice										
Bread										

26. Has (child) dewormed in the last three months? 1= yes 2= No.

Appendix 3: Field Assistants Training Program

DAY	TIME	SUBJECT MATTER	LEARNING METHOD	LEARNING AIDS
1	9.00-10.30 am	**Introduction and Overview of the study** ○ General objectives ○ Specific objectives	○ Lecture	○ Flip charts ○ Marker pens ○ Note books ○ Pens/pencils
	10.30-11.00 am	Tea Break		
	11.00-1.00 pm	**Data collection techniques** ○ Questionnaire filling (all sections) and taking anthropometric measurements	○ Demonstration ○ Role play	○ Sample questionnaire
	1.00-2.00 pm	Lunch Break		
	2.00-4.00 pm	**Data collection techniques (cont')** ○ Anthropometry - Taking height - Taking weight - Recording measurements - Taking MUAC readings ○	○ Demonstration ○ Role play	○ Seca scales ○ Height boards ○ Salter scales ○ Flip charts ○ Marker pens ○ Data form ○ Muac tapes
	4.00-5.00 pm	**Ethics and conduct** ○ Professional conduct in the field ○ Confidentiality ○ Working hours ○ Allowances ○ Q & A	○ Lecture ○ Discussion	○ Flip charts ○ Marker pens
2	9.00-9.30 am	**Recap of the previous day**	○ Discussion	○ Flip charts ○ Marker pens
	9.30-1.30 pm	**Pre-test questionnaire**		○ Questionnaire
	2.30- 3.30 pm	Lunch Break		
	3.30-5.00 pm	Revision of the questionnaire based on the results of pretest Conclusions and closing	○ Discussion	○ Filled questionnaire

Annex 4: Activity and data matrix

Objective	**Data/variables**	**Method**	**Analysis process/ Statistical test**	**Reporting of results**
Socio demographic and economic data				
Describe demographic and socio-economic characteristics	❖ Age ❖ Sex ❖ Income ❖ Education ❖ Occupation ❖ Marital status ❖ Household size	❖ Ask ❖ Probe ❖ Observe	❖ **SPSS software** ❖ Percentages ❖ Range ❖ Means ❖ SDs ❖ Chi-square	❖ Tables ❖ Narratives
SO1: To determine the iron status of children under five				
Determine the iron status of children	❖ Number of food groups consumed ❖ Types of foods consumed ❖ Hb levels of children	❖ Ask ❖ Probe ❖ DDQ ❖ Blood test	**SPSS software** ❖ Percentages ❖ Range ❖ Means ❖ SDs ❖ Chi-square ❖ T-test	❖ Tables ❖ Histograms ❖ Narratives
SO2: To determine the breastfeeding and weaning practices of 6-59 months				
Determine the breastfeeding and weaning practices	❖ Exclusive breastfeeding ❖ Number of times child breastfeeds ❖ Number of meals child eats /day ❖ Types weaning foods used ❖ When weaning started ❖ How long child was breastfed	❖ Ask ❖ Probe ❖ FFQ	**SPSS software** ❖ Chi-square ❖ Regression ❖ Odds ratio ❖ Means ❖ SDs	❖ Tables ❖ Histograms ❖ Narratives
SO3: To determine the nutritional status of children under five				
Determine the nutritional status of children using anthropometric measurements	❖ Height ❖ Weight ❖ Sex ❖ Age	❖ Ask ❖ Probe ❖ Measure ❖ record	❖ EPI-Info software ❖ SPSS ❖ Z-scores ❖ Chi-square ❖ Means	❖ Tables ❖ Histograms ❖ Narratives

			❖ SDs	
SO4: To establish the nutritional knowledge of mothers about foods that are rich in iron.				
Establish the nutritional knowledge of mothers about foods rich in iron	❖ Frequently consumed foods ❖ Foods used for weaning ❖ Type of foods and fruits consumed each day ❖ Frequently consumed Drinks and juices	❖ Ask ❖ probe	**SPSS software** ❖ **Chi-square** ❖ **Regression** ❖ **Odds ratios**	❖ Tables ❖ Histograms ❖ Narratives

Appendix 5: Consent Form

Introduction

Iron deficiency Anemia is a significant public health problem especially for growing children. Its prevention is important because of its association with brain development in early years of life. Improving the quality of dietary intake would help fight malnutrition and micronutrient deficiencies in children under five years.

It is for this reason that we intend to check the iron status of your child to confirm the presence or absence of anemia in your child and others of the same age in this location. Information gained from this study will be used by decision makers in making good decisions for the promotion of good health and the improvement of health and the nutritional status of children in this community and the country at large.

Procedures

If you grant us consent, we will take a clinical and physical examination of your child which will be done by a medical personnel. This will help assess the iron status of your child. Blood collection from your child will be used only for the tests explained to you and is going to be done in your presence. No blood is going to be carried away for further tests. The results of the test will be given to you immediately.

Confidentiality

Any records relating to you and your child will be strictly confidential. Your names and those of your child will not be used in any reports from the study.

Parent statement

I the undersigned have understood the above information, which has been fully explained to me by the investigator. I agree to take part in this study.

Child's name: ____

Name of parent: ____

Parent's signature: ___________________________Date __________________

Investigator's signatures

Name: _________________________signature ____________ Date _________

Appendix 6: Budget

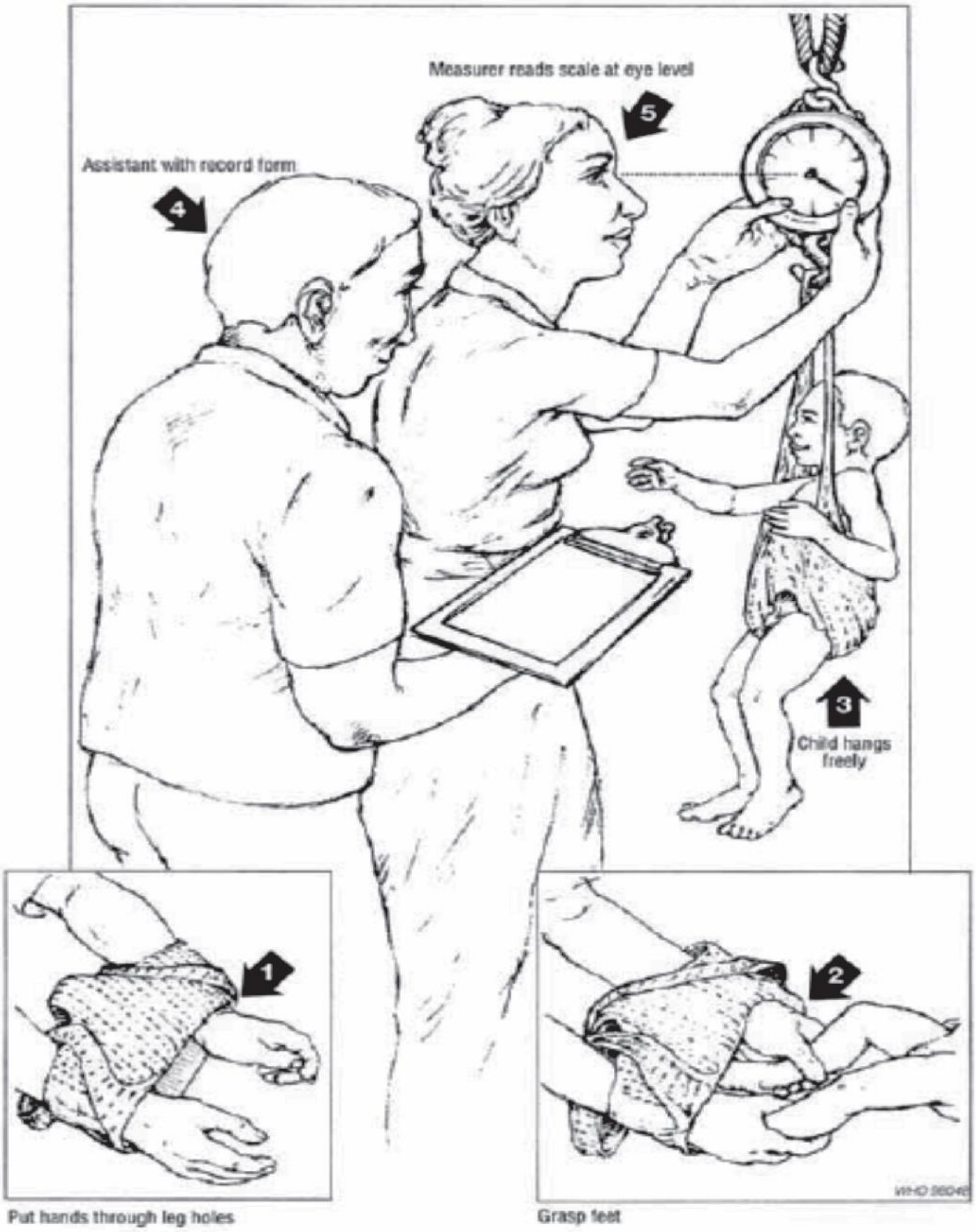
ITEM	NO. OF UNITS	UNIT COST (KSHS)	TOTAL COST (KSHS)
Transport to and from hospital	3	500	31,500
Nurse Allowance	1	500	15 000
Field Assistants Allowance	2	250	15 000
Haemocue			
Weighing Scale	1	5 000	5 000
Printing Paper	2	500	1 000
Photocopying Questionnaire	420	1.50	630
Stapler	1	200	200
Staples	1	100	100
Biro pens	8	10	80
Pencils	8	10	80
Erasers	3	25	75
Rulers	2	40	80
Note books	4	45	180
Cotton wool	1	250	250
Surgical Spirit	1	300	300
Surgical gloves	30	20	600
Supervisors Per Diem	2	8500	17 000
Supervisors Transport	1	25,000	50,000
Printing of Thesis	4	430	1 720
Binding of Thesis	4	500	2 000
TOTAL			140,295.00

Appendix 7: Work plan

THESIS	2012										2013					
ACTIVITY	MA	A	M	J	J	A	S	O	N	D	JA	F	M	A	M	J
PROPOSAL DEVELOPMENT																
PROPOSAL PRESENTATION																
ADJUSTMENT OF PROPOSAL																
SUBMITION OF PROPOSAL																
FIELD VISIT																
AQUIRE RESEARCH PERMIT																
PILOT TESTING																
TRAINNING ENUMERATORS																
PRE-TESTING																
ADJUST TOOLS																
DATA COLLECTION																
DATA MANAGEMENT AND ANALYSIS																
DATA ENTRY																
DATA ANALYSIS																
THESIS WRITE UP																
THESIS REPORT WRITING																
PRESENTATION OF THESIS																
CORRECTIONS																
DEFEND																

Appendix 8: Weight measurement.

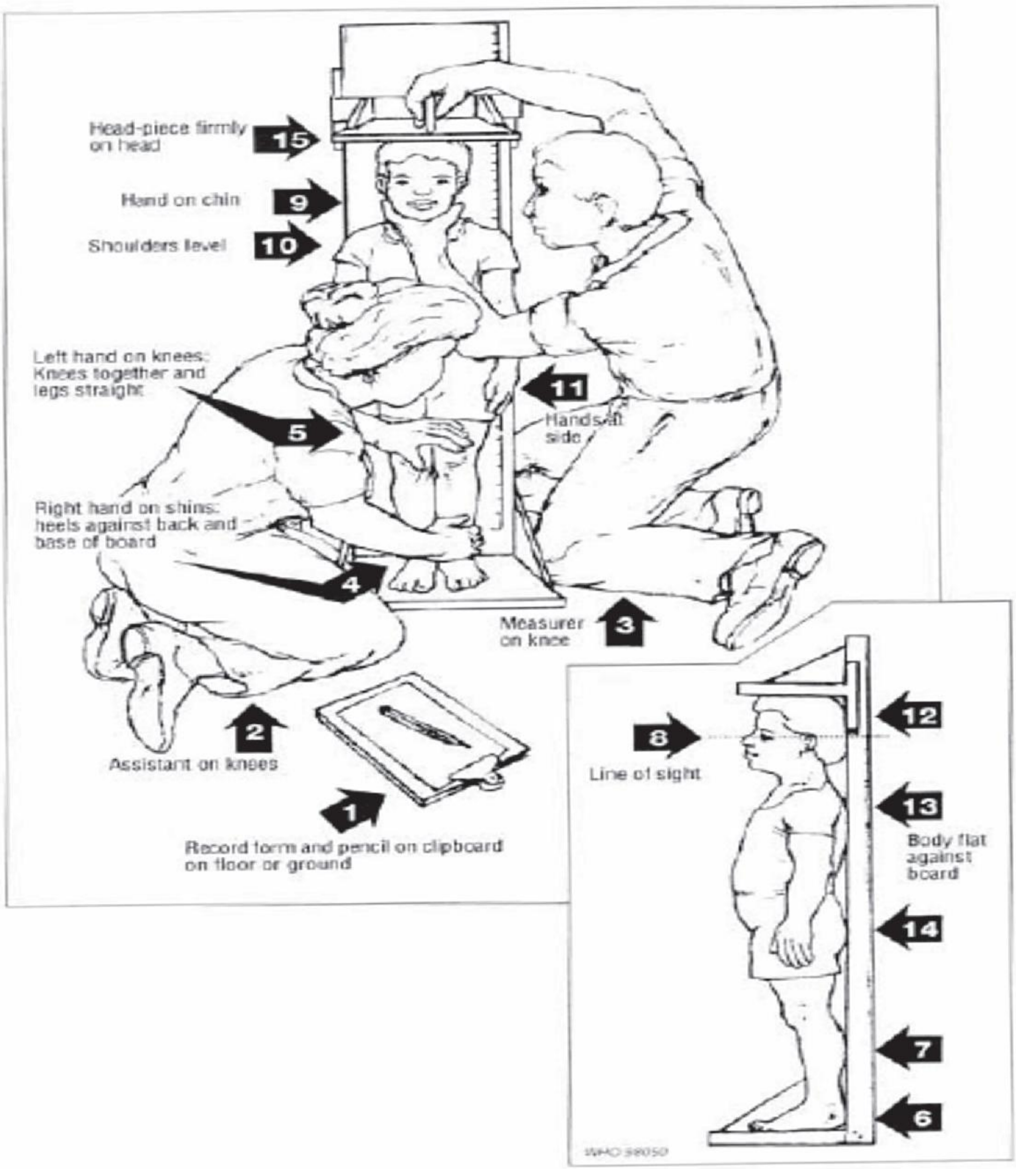
Fig. A3.1 Use of the hanging spring balance for weighing infants[1]



[1] Adapted, with permission, from *Assessing the nutritional status of young children: preliminary version.* New York, United Nations Department of Technical Co-operation for Development and Statistical Office, 1990.

Appendix 9: Height measurement

Fig. A3.3 Measuring a child's height[1]



[1] Adapted, with permission, from *Assessing the nutritional status of young children: preliminary version.* New York, United Nations Department of Technical Co-operation for Development and Statistical Office, 1990.