IRON AND NUTRITIONAL STATUS OF CHILDREN 12-59 MONTHS IN MIGWANI DIVISION, MWINGI DISTRICT - KENYA

BY

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Declaration

I hereby declare that this dissertation is my original work and to the best of my knowledge it has not been presented for a degree in any other University or institution.

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Dedication

I feel great to dedicate this work to my late dad Mr. Zephaniah Mwai. The confidence that he had in me has pushed me this far. May Almighty God rest his soul in eternal peace.

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Acronyms and Abbreviations

ACT:	α-1-Antichymotrypsin
AGP:	α-1 Acid Glycoprotein
ASAL:	Arid and Semi-Arid Land
CBC:	Complete Blood Count
CBS:	Central Bureau of Statistics
CDC:	Centre for Disease Control
CF:	Correction Factor
CI:	Confidence Interval
CRP:	C-reactive protein
DDS:	Dietary Diversity Score
DHMT:	District Health Management Team
DMT1:	Divalent Metal Ion Transporter 1
ENA:	Emergency Nutrition Assessment
EPI:	Expanded Programme for Immunization
ESR:	Erythrocyte Sedimentation Rate
EU:	Egerton University
FAO:	Food and Agriculture Organization
GAM:	Global Acute Malnutrition
GOK:	Government of Kenya
HAZ:	Height-for-Age Z-scores
HCP1:	Heme Carrier Protein 1
ID:	Iron Deficiency
IDA:	Iron Deficiency Anaemia
IDD:	Iodine Deficiency Disorder
IDE:	Iron Deficiency Erythropoiesis
INACG:	International Nutritional Anaemia Consultative Group

IOM:	Institute of Medicine
KDHS:	Kenya Demographic and Health Survey
KEMRI:	Kenya Medical Research Institute
KNH:	Kenyatta National Hospital
MAM:	Moderate Acute Malnutrition
MOPHS:	Ministry of Public Health and Sanitation
MSPND:	Ministry of State Planning and National Development
NHANES:	National Health and Nutrition Examination Survey
PEM:	Protein Energy Malnutrition
RBC:	Red Blood Cell
RDW:	Red Blood Cell Distribution Width
SAM:	Severe Acute Malnutrition
SD:	Standard Deviation
SF:	Serum Ferritin
SMART:	Standardized Monitoring and Assessment of Relief and Transitions
SPSS:	Statistical Package for Social Sciences
UNICEF:	United Nations Children's Fund
VAD:	Vitamin A Deficiency
WAZ:	Weight-for-Age Z-scores
WHZ:	Weight-for-Height Z-scores
WFP:	World Food Programme
WHO:	World Health Organisation

Operational Definition of Terms

Anaemia: Haemoglobin (Hb) concentration below established cut-off levels depending on age, sex and physiological status. In this study, anaemia is defined as Hb concentration <110g/L.

Anthropometric indices: These are calculated from anthropometric measurements and include weight-for-age, height-for-age and weight-for-height in this study.

Inflammation: C-reactive proteins >5 mg/L.

Iron deficiency anaemia (IDA): An advanced stage of iron depletion defined as iron deficiency (serum ferritin < 12 µg/L) and low haemoglobin (Hb <110g/L) hence is defined as concurrent anaemia and iron deficiency.

Iron deficiency (ID): A state of insufficient iron to maintain normal physiological functions of tissues. Iron deficiency is defined as serum ferritin concentrations < 12µg/L.

Nutritional status: The result of complex interaction between food composition and the overall status of health and care practises. The nutritional health of an individual is determined by anthropometric measurements, biochemical measurements of nutrients in blood (iron status), clinical (physical) examination, dietary analysis and economic evaluation.

Stunting: A condition of young children having a low height for their age (Z score <-2SD height-for-age).

Underweight: A condition of young children being too light for their age (Z score <-2SD weight-for-age).

Wasting: A condition of young children having a low weight for their height (Z score <-2SD weight-for-height).

Abstract

Poor nutritional status, anaemia, iron deficiency and iron deficiency anaemia among children in many parts of Kenya continues to be public health issues especially in arid and semi-arid lands which are generally food insecure. Available nutritional status monitoring methods in Kenya do not capture adequate data for decision making. The general objective of this study was to determine iron and nutritional status and associated factors among children 12-59 months old in Migwani Division, Mwingi, a district within arid and semi-arid lands of Kenya.

A cross-sectional study was conducted among 293 children (147 boys and 146 girls) aged 12-59 months in January/ February 2010 in Migwani division, Mwingi district. Nutritional status of the children was assessed using anthropometric indices and the WHO 2005 child growth reference standards. Haemoglobin concentration was determined using a haematological analyzer and anaemia defined as haemoglobin concentration <110g/L. Hb concentration and anaemia was adjusted for altitude and ethnicity. Serum ferritin concentration was determined using enzyme linked fluorescent immune assay- ALFA and iron deficiency was defined as serum ferritin concentration <12 µg/l. Iron deficiency anaemia was defined as concurrent anaemia and iron deficiency. Serum ferritin and iron deficiency was corrected for infection using C-reactive protein which was determined using nyco card reader. SPSS version 16 and EPI info-ENA were used for data analysis. Multiple logistic regressions were done to determine independent factors. Stepwise backward elimination method was used to develop the best final models. Research was approved by Kenyatta National Hospital Ethical Review committee.

Over half (54.1%) of the subjects (48.0 – 60.1 C.I.) were stunted while 35.8% (30.7 – 41.4 C.I.) were underweight. These rates were higher than the national average as

reported in the 2008/09 Kenya Demographic and Health Survey. The prevalence of Global Acute Malnutrition was 10.3% (6.3 – 16.3 C.I.). Prevalence of anaemia before and after adjusting for altitude and ethnicity was 34.5% and 16.7% respectively. The prevalence of iron deficiency before and after correcting for infection was 23.0% and 29.5% respectively. Factors found to be independently associated with anaemia were: birth order (OR=0.77; p=.001), age (OR=1.04; p=.0323), dietary diversity (OR=1.71; p=.001), stunting (OR=4.28; p=.0007) and iron deficiency (OR=4.23; p=.0006). Age (OR=1.06; p=.000) was independently associated with iron deficiency while factors independently associated with iron deficiency anaemia were age (OR=1.05; p=.024) and birth order (OR=0.79; p=0.006). Breastfeeding status (OR=0.35; P=.012), stunting (OR=49.47; p=.000) and wasting (OR=152.17; p=.000) were independently associated with Underweight. Underweight (OR=14.67; p=.000) was independently associated with stunting while factors independently associated with wasting were age (OR=1.04; p=.036) and underweight (OR=25.51; p=.000).

We conclude that anaemia status among children in Migwani is of mild public health significance (5.0-19.9%) while global acute malnutrition is a serious public health issue (10-14%) according to World Health Organization classification. Low birth order, young age, low dietary diversity, stunting and iron deficiency are risk factors to anaemia. Young age is risk to iron deficiency. Young age is a risk factor while low birth order is a protective factor to iron deficiency anaemia. Underweight is associated with stunting while young age and underweight are risk factors to wasting. Breastfeeding children were protected from underweight while stunting and wasting are risk factors to underweight.

The households and community members should improve care and support of children while the government and NGOs should put/improve mechanisms in place

to prevent and correct the problem of stunting, anaemia and iron deficiency such as promotion of exclusive breastfeeding and dietary diversification. There is need to strengthen nutrition status monitoring in the area in order to implement timely and evidence based interventions.

Key words: anaemia, iron deficiency, nutritional status, children, Kenya.

CHAPTER ONE

1.0 Background

1.1 Introduction

Nutritional status is the result of complex interaction between dietary intake and the overall status of health and care practises. The body nutritional health is determined by the sum of its nutritional status with respect to each needed nutrient. One of these nutrients is iron. Iron depletion in the body results in iron deficiency. The nutritional health of an individual is assessed by anthropometric measurements, biochemical measurements of nutrients or their by-products in blood, clinical (physical) examination, dietary analysis and economic evaluation (DiSilvestro et al, 2004). Poor nutritional and iron conditions are some of the major public health challenges in Kenya especially among children (CBS, 2004 and Mwaniki et al, 1999).

Malnutrition refers to failing health that result from long-standing dietary practices that do not coincide with nutritional needs resulting in either under nutrition or over nutrition (DiSilvestro et al, 2004). It can also be defined as a state in which an individual's physiological and physical functions are impaired as a result of inadequate food intake, lack of appetite and body's inability to digest and utilize food properly as a consequence of illness (MOPHS and MSPND, 2008). Protein energy malnutrition (PEM), iron deficiency (ID) and iron deficiency anaemia (IDA), zinc deficiency, vitamin A deficiency (VAD) and iodine deficiency disorders are among the major forms of malnutrition in Kenya (CBS, 2004).

In 2005, global wasting was estimated at 10% with South-Central Asia estimated to have the highest prevalence of 16%. At the same time, 20% of children younger than

five years in low and middle income countries were underweight. The highest prevalence of underweight was reported in South-Central Asia and East Africa of 33% and 28% respectively. For all developing countries, an estimated 32% of children younger than five years are stunted (Lancet, 2008).

In Kenya, about 35% of children under five years are stunted, 7% are wasted and 16% are underweight (KNBS and ICF Macro, 2010). The prevalence of these problems is most critical in Eastern and North Eastern provinces of Kenya.

Iron is one of the most abundant minerals on the earth of which the human body requires only minute quantities (Hallberg, 2001). 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 haemoglobin and 12 percent in the storage complexes ferritin and hemosiderin. A very important 15 percent, however, is incorporated into a variety of other iron-containing compounds essential to cell function (IOM, 1998). ID is a state of insufficient iron to maintain normal physiological functions of tissues. It can exist with or without anaemia. 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 1 billion people affected (DiSilvestro et al, 2004).

It is also the most prevalent nutritional deficiency in the world with approximately one billion people affected (WHO and UNICEF, 2004a). Global rates for iron deficiency anaemia in developing countries as 51 percent for children 0—4 years of age, 46 percent for school-age children, 42 percent for women, and 26 percent for men. Even in the United States, the NHANES II survey found an overall 7 percent

prevalence of actual anaemia in women 15–44 years old, but with the highest burden in minority and poverty groups (IOM, 1998). Global prevalence of anaemia in preschool aged children is 47.4%. Africa and Asia are the most affected and as these regions are also the poorest, it may reflect the link between anaemia and development (WHO, 2001).

Nearly half (43.2%-46%) of the preschool children in Kenya have been estimated to be iron deficient (Mwaniki et al, 1999; Verhoef et al, 2001).

1.1 Problem Statement

Poor nutritional and iron status occur in children in many parts of Kenya especially in arid and semi-arid areas where, due to shortage of rains, these is are often food insecurity. The levels of micronutrient deficiency, especially iron, may also be high. From the 1999 Kenya National Survey on Micronutrients, it was estimated that seven out of every ten children under five years old were likely to be anaemic at Hb<110g/L[1] while nearly half of preschool children (43.2%) were iron deficient in Kenya (Mwaniki et al, 1999). The semi arid North Eastern districts and dry humid semi-arid midlands were found to have a relatively high prevalence of anaemia among children 6-72 months (Mwaniki et al, 1999). However, there is no information on the prevalence of iron deficiency and anaemia in Mwingi district. Malnutrition in children remains high in Kenya where about 35% of children under five are stunted, 7% are wasted and 16% are underweight. The prevalence of these problems is most critical in North Eastern and Eastern provinces (KNBS and ICF Macro, 2010) underscoring the need for more mitigation efforts. However, to recommend feasible

[1] The Hb levels were adjusted for attitude and age at2.5g/L per 1000m above sea level and 0.41g/L per month for 6 months old and over

long-term strategies of reducing malnutrition and iron deficiency in these specific areas, baseline information on nutritional and iron status is a pre-requisite.

1.2 Aim of the Study

This study aimed at contributing towards the improvement of nutritional and iron status of children 12-59 months in arid and semi arid lands (ASAL) of Kenya.

1.3 Purpose of the Study

The purpose of the study was to provide baseline information on the current situation on malnutrition, anaemia, ID and IDA in children 12-59 months in Migwani Division, Mwingi District. This information would be used by policy makers and as reference by subsequent studies and interventions including a proposed food-based intervention study; Improving Iron Status of Children in a Semi-Arid Area in Kenya: The Potential of Amaranth Grain Flour.

1.4 Study Justification

In most countries, national policies have been implemented to provide iron supplements to pregnant women, and to a lesser extent to young children, as the primary strategy for preventing iron deficiency and anaemia (WHO, 2006). An infant's risk of developing iron deficiency begins in utero, because premature delivery deprives the baby of the accumulation of iron near the end of pregnancy and smaller babies generally have less body iron. Unfortunately, iron in breast milk cannot prevent the exhaustion of iron reserves in the first 4–6 months brought about by rapid growth. Poor weaning practices and inadequate feeding during childhood contribute further to the persistence or development of iron deficiency (IOM, 1998).

Despite advances in scientific knowledge regarding multiple aetiology, treatment and potential strategies for combating iron deficiency, iron deficiency anaemia remains a significant public health challenge especially for growing children in developing countries (Mwaniki et al, 1999; WHO and UNICEF, 2004b). Its prevention therefore is of global concern especially because of its association with brain development in early years of life (WHO and UNICEF, 2004b; Oken and Duggan, 2002).

A large community based trial in Zanzibar found that though there is marked reduction of iron deficiency and anaemia in iron deficient children; iron and folic acid supplementation may be associated with adverse effects including increased risk of hospitalization and mortality raising concerns about safety of iron supplementation in malaria endemic areas at population level (Sazawal et al, 2006). Based on this study, the WHO has advised that iron supplementation should only be targeted to those who are anaemic and at risk of iron deficiency in malaria endemic areas such as Kenya (WHO, 2006). Food based approaches therefore offer a large and safer opportunity to improve lives and address the widespread micronutrient deficiency in malaria endemic areas in Sub-Saharan Africa as they are more sustainable and safer (WFP, 2006). To determine effect of such food based strategies, baseline status are necessary. Hence this study was designed to assess the nutritional and iron status of children 12-59 months in Migwani Division, Mwingi District Kenya so as to provide baseline information for a proposed food based intervention study using amaranth flour with a focus on iron status.

1.5 Objectives of the Study

The general objective of this study was to determine iron and nutritional status and associated factors among children 12-59 months old in Migwani Division, Mwingi District.

The specific objectives were:

1. To determine the socio-demographic and economic characteristics of the study households.
2. To determine the prevalence of anaemia, iron deficiency, iron deficiency anaemia, stunting, underweight and wasting among children 12-59 months old.
3. To determine the food consumption patterns among children 12-59 months old with a focus on iron intake.
4. To determine the presence of infection (CRP) and prevalence of malaria in children 12-59 months old.
5. To determine factors associated with anaemia, iron deficiency, iron deficiency anaemia, stunting, underweight and wasting among children 12-59 months old.

1.6 Study Hypotheses

1. There is no association of demographic and socio-economic factors, food consumption patterns and health conditions with outcomes including anaemia, iron deficiency, iron deficiency anaemia, underweight, stunting and wasting among children 12-59 months old in Migwani Division, Mwingi District.
2. The prevalence of anaemia in Migwani Division, Mwingi District among children 12-59 months is of public health significance ($\geq$ 20%).

1.7 Study Questions

1. What is the distribution of socio-demographic and economic characteristics of households in Migwani Division, Mwingi district?
2. What is the prevalence of anaemia, iron deficiency, iron deficiency anaemia, underweight, stunting and wasting among children 12-59 months in Migwani Division, Mwingi district?
3. What are the levels of infection in children 12-59 months in Migwani division, Mwingi District?
4. What is the prevalence of malaria in children 12-59 months in Migwani division, Mwingi District?
5. What are the food consumption patterns of the children 12 to 59 months in Migwani division, Mwingi district?
6. Which factors are associated with anaemia, iron deficiency, iron deficiency anaemia, underweight, stunting and wasting among children 12-59 months in Migwani division, Mwingi District?

1.8 Limitation of the Study

Although we targeted to assess 300 children, only 261 children provided adequate blood for the required analysis for serum ferritin and CRP. Nevertheless, this sample was still representative because it was equal to the study's calculated minimum sample size.

CHAPTER TWO

2.0 Literature Review

2.1 Introduction

Body composition is much influenced by nutrition. The human body needs a lot more food to support growth and development than it does to maintain its size once growth ceases. Hence infants and children need more nutrients than adults to support their tremendous growth and development (DiSilvestro et al, 2004). Overall, eating a poor diet as an infant or a child hamper the cell division that occurs at that critical stage. Disturbances of growth resulting from nutritional deficiencies influence body composition, including the eventual size of the body and of body organs. As with the foetus, the long term effects of nutritional problems in the infancy and childhood depend on the severity, timing and duration of the nutritional insult to cell processes. Consuming an adequate diet later usually won't compensate for lost growth as the hormonal and other conditions needed for growth will not likely be present (DiSilvestro et al, 2004).

2.2 Nutritional Status

Under-nutrition encompasses stunting, wasting, underweight and deficiencies of essential vitamins and minerals. The effects of under-nutrition span into future generations, with a mother's nutritional status affecting the health of her future grandchildren. Conditions such as stunting, severe wasting and intrauterine growth restriction (IUGR) in the first two years of life cause irreparable harm by impeding physical growth (Lancet, 2008). Under-nutrition can lead to protein energy malnutrition (PEM) in form of kwashiorkor or marasmus. Kwashiorkor results primarily from inadequate energy and protein intake in comparison with body needs

which often increases with concurrent disease and infection. Marasmus results primarily from extreme starvation as a result of negligible intake of both protein and energy (DiSilvestro et al, 2004).

There are three categories of malnutrition which include acute malnutrition (low weight-for-height) manifested as wasting, chronic malnutrition (low height-for-age) manifested as stunting and under-weight (low weight-for-age).

Acute malnutrition (determined by patient's degree of wasting) is categorized into Moderate Acute Malnutrition (MAM) for subjects with weight for height being < -2 z-scores to ≥ - 3 z-scores, Severe Acute Malnutrition (SAM) for subjects having < -3 z-scores with or without oedema or > -3 z-scores with oedema. Global Acute Malnutrition (GAM) refers to both MAM and SAM for subjects having < -2 z-scores with or without oedema. All cases of bilateral oedema are classified as SAM. Wasting (low Weight-for-height) is a measure of how thin the child is. It is the result of recent rapid weight loss or a failure to gain weight. It can be reversed when conditions improve. An advantage of using weight-for-height to assess the nutritional state is that it does not involve age; in many poor populations age is not known and is difficult to estimate reliably (MOPHS and MSPNDV, 2008).

Chronic malnutrition is determined by the individual's degree of stunting (MOPHS and MSPNDV, 2008). Stunting (low Height-for-age) is the index of linear growth. Stunted children are too short for their age. It develops over a long period as a result of inadequate dietary intake and/or repeated infections. Growth is a relatively slow process, and if a child of normal height stops growing it takes a long time for that

child to fall below the cut off point for stunting. For this reason, height-for-age is often used to indicate long-standing or chronic malnutrition. If the problem that led to stunting is in the past, it is possible that the current growth rate is actually normal, although this is unusual without a change in the family circumstances. Stunting may also be due to intra-uterine growth retardation followed by normal post-natal growth. A child who is 100% of normal growth who falters to 70% of normal growth will take up to half his life to fall below the usual cut-off point and be labeled as moderately stunted. Thus, a one year old child gaining height at 70% of normal will not be designated as stunted for 6 months (MOPHS and MSPNDV, 2008).

Underweight children are too light for their age. Weight-for-age is a composite index, which reflects both wasting and stunting, or any combination of both. It therefore reflects acute or chronic malnutrition, or both. Neither stunted nor wasted children weigh as much as normal children of the same age (MOPHS and MSPNDV, 2008). The classification of underweight and stunting indices in terms of severe, moderate and global follows the same criteria as those of wasting.

2.3 Iron

Iron is one of the most abundant minerals on the earth of which the human body requires only in minute quantities (Hallberg, 2001). 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 haemoglobin and 12 percent in the storage complexes ferritin and hemosiderin. A very important 15 percent, however, is incorporated into a variety of other iron-containing compounds essential to cell function (IOM, 1998). Iron plays a major role

in the immune system. Iron deficiency leads to impaired immune function, anaemia and delayed psychomotor development among young children while in adults it leads to anaemia, reduced work capacity and decreased resistance to fatigue (Dallman, 1986). In food it 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 (Zimmermann et al, 2005).

2.3.1 Iron Absorption

Iron absorption refers to amount of dietary iron that the body obtains and uses from food (Annibale et al, 2001). 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 dietary iron consumed, individual iron status, presence of inhibitors such as phytates and enhancers such as ascorbic acid (Annibale et al, 2001; Hunt et al, 1994; Hallberg and Hulthen, 2000). 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 improves its bio-availability (Zimmermann et al, 2005). Calcium is the only nutrient that negatively influences the absorption of heme and non heme iron (Cook, 1990b).

The body levels of iron are regulated at the point of absorption in the proximal small intestines as humans do not actively excrete iron. Absorption is via specific transporters namely heme carrier protein 1 (HCP1) and divalent metal transporter 1(DMT1) for heme and non heme iron respectively (Shayeghi et al, 2005; Andrews, 1999). Movement of iron across the basolateral membrane into the blood is mediated by the protein transport ferroportin 1. These transporters are up-regulated by hypoxia

and iron deficiency thereby increasing iron absorption. Hepcidin hormone which is secreted by the liver inhibits iron absorption and so in deficiency, its release is reduced (Ganz, 2005). Several algorithms to predict non-heme iron bioavailability have been developed such as those by Hallberg and Hulthen, (2000), Tseng et al, (1997) and Conway et al, (2007). These algorithms are used to estimate the bioavailability of the dietary content of meals, to estimate effects expected by dietary modification and to translate physiologic into dietary requirements from different types of diets (Hallberg and Hulthen, 2000; Shayeghi et al, 2005; Conway et al, 2007).

2.3.2 Iron Deficiency

ID is a state of insufficient iron to maintain normal physiological functions of tissues. It can exist with or without anaemia. Nutritional ID develops gradually and usually begins with a negative iron balance (iron depletion), when iron intake does not meet the daily need for dietary iron (Zimmermann et al, 2005). The stages in the development of iron deficiency are the depletion of iron stores, as indicated by low plasma ferritin; interference with biochemical processes, indicated by low transferrin saturation and elevated free erythrocyte protoporphyrin and serum transferrin receptors; and, finally, anaemia, as indicated by low haemoglobin (IOM, 1998).

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 1 billion people affected (DiSilvestro et al, 2004). Nearly half (43.2%-46%) of the preschool children in Kenya have been estimated to be iron deficient (Mwaniki et al, 1999; Verhoef et al, 2001). Iron deficiency is considered to be about 2 to 2.5 times the rate of anemia. This estimate applies when malaria is not endemic

in the region and there are no reasons to suspect widespread hemoglobinopathies. IDA is an advanced stage of iron depletion defined as ID and low haemoglobin. 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 (WHO and UNICEF, 2004b).

2.4 Anaemia

Anaemia, defined as haemoglobin or haematocrit concentration below established cut-off levels depending on age, sex and physiological status is a wide spread public health problem with major consequences for human health as well as social and economic development (DiSilvestro et al, 2004). Anaemia status depends on ethnicity and altitude (Nestel and INACG, 2002).

Ethnicity

Data from the United States show that healthy people of African extraction of all age groups at all times, except during the perinatal period, have hemoglobin concentrations 5 to 10 g/L below those of whites and this difference is independent of iron deficiency and in some cases hemoglobinopathies and socio-economic factors (Johnson-Spear and Yip, 1994). Based on the US data for healthy people of African extraction, and to achieve adequate sensitivity and specificity for screening purposes, WHO indicates that haemoglobin concentrations be adjusted downward by 10 g/L in people of African extraction irrespective of age (WHO, 2001).

Altitude

At elevations above 1000 m, haemoglobin concentrations increase as an adaptive response to the lower partial pressure of oxygen and reduced oxygen saturation of blood. Centre for Disease Control (CDC) (1995), Dirren et al (1994) and Dallman et al (1980) provide some of the methods which are suggested to be used to adjust the

haemoglobin measurements based on altitude for estimating the prevalence of anaemia. The CDC's Paediatric Nutrition Surveillance System used data from 2- to 5-year-old children with little or no iron deficiency from clinics at 1200 to 3000 m elevation to develop a curve that describes haemoglobin changes with altitude. Their work resulted in the following equation.

"Hb = –0.32 × (altitude in meters × .0033) + 0.22 × (altitude in meters × .0033)^2".

Although in most populations the prevalence of anaemia determined by using haematocrit or haemoglobin concentration (using the cut-off values given in Table 2.1), will be similar, results may not be identical. This difference in anaemia prevalence, obtained by using these two methods, may add to the complexity of a survey report and make the results more difficult for decision-makers to interpret (WHO, 2001). Accordingly, there is little advantage in determining haematocrit as well as haemoglobin during surveys.

Table 2.1: Haemoglobin and Haematocrit Levels below which Anaemia is Present in a Population[2]

Age or gender group	Haemoglobin	Haematocrit	
	g/l	mmol/l	l/l
Children 6 months to 59 months	110	6.83	0.33
Children 5–11 years	115	7.13	0.34
Children 12–14 years	120	7.45	0.36
Non-pregnant women (above 15 years of age)	120	7.45	0.36
Pregnant women	110	6.83	0.33
Men (above 15 years of age)	130	8.07	0.39

(WHO, 2001)

[2] Conventional conversion factors: 100 g haemoglobin = 6.2 mmol haemoglobin = 0.30 l/l haematocrit.

Iron deficiency anaemia is assumed to account for about 50% of anaemia cases (WHO, 2007). Other causes of anaemia include acute and chronic infections that cause inflammation, micronutrient deficiencies such as folate, Vitamin B12, Vitamin A and genetically inherent traits such as thalassaemia (WHO, 2007).

In Kenya, like most developing countries, the burden of anaemia continues to be a major public health problem according to WHO classification as indicated in Table 2.2. The largest burden is among preschool children where seven out of ten are likely to be anaemic (Hb concentration adjusted for altitude and age) (Mwaniki et al, 1999). Between 57% and 72% of the preschool children in dry humid and semi arid midlands of Kenya are anaemic. This compares with the findings by Verhoef et al, (2001) in Kibwezi which indicated that 69% of the children 2-36 months had anaemia. Similar levels of anaemia prevalence have been reported in other developing countries such as Tanzania (45%) for children under 5 years and South Africa (48%) for children 6-11 months (Mamiro et al, 2004; Faber et al, 2005).

Table 2.2: Proposed Classification of Public Health Significance of Anaemia in Populations on the Basis of Prevalence Estimated from Blood Levels of Haemoglobin or Haematocrit[3]

Category of public health significance	Prevalence of anaemia (%)
Severe	> or = 40
Moderate	20.0 – 39.9
Mild	5.0 – 19.9
Normal	< or = 4.9

(WHO, 2001)

[3] Based on cut-off levels of haemoglobin and haematocrit given in Table 2.2

2.5 Assessment of Nutritional Status

2.5.1 Dietary Intake of Nutrients

Dietary intake estimates are obtained primarily as a proxy for more fundamental biological variables such as tissue or blood concentration of nutrients. Among the methods used to estimate dietary intake at individual level include food frequency, 24-hour dietary recall, food accounts, food records, dietary diversity scores among others.

The Food Frequency Questionnaire (FFQ) is the most common dietary assessment tool used in large epidemiologic studies of diet and health. Investigator asks participants to report the frequency of consumption of different types of foods.

Dietary diversity is a qualitative measure of food consumption that reflects household access to a wide variety of foods, and is also a proxy of the nutrient adequacy of the diet for individuals. This is in terms of access to food, intake of energy and macronutrients and intake of micronutrients. Dietary diversity is a key element of high quality diets. Increasing dietary diversity helps ensure adequate intake of essential nutrients (WHO, 1998).

The quantitative 24-hour dietary recall method is used to estimate daily adequacy of nutrient intake and is more appropriate for assessing the intake of large populations than of individuals. Usual intake of an individual cannot be captured by a one-day recall. If applying the method to a large population, the sample population should be representative of the population that is being studied and interviews should take place on different days of the week in order to reflect both weekday and weekend eating patterns (WHO, 1998).

For a rapid assessment of food intake, a qualitative 24-hour recall can be used to identify family and individual intakes. This method has been used in many countries, particularly in Africa for assessing infant and family feeding practices, and can be implemented by personnel with minimal training. The foods consumed the preceding day by the infant, young child and mother or family are analysed according to the age of the young child (e.g. 0-2, 3-5, 6-8, 9-11, 12-17, 18-23 and 24-35 months).

The services of a statistician to plan the study are recommended. The number of times each major food and food-group are consumed per day is calculated. From this, one can deduce what are the main staples and other components in the common family diet, and whether all such components (e.g. foods of animal origin, legumes, dark-green leafy vegetables, etc.) are consumed by the young children as well, or only by older children and adults. The age of introduction of various foods can also be derived (WHO, 1998).

2.5.2 Clinical Assessment of Anaemia

The signs and symptoms of anaemia-pallor of the skin and of the conjunctiva, fatigue, shortness of breath, lack of appetite-are nonspecific and difficult to detect. The clinical detection of anaemia is influenced by so many variables, such as skin thickness and pigmentation, that it is unreliable unless the anaemia is very severe. The clinical assessment of anaemia lacks sensitivity and, therefore, a prevalence of 2%-3% of cases clinically detected represents a severe problem (WHO, 1989).

2.5.3 Anthropometric Assessment

Anthropometric measurements such as height, weight, body skin folds, body circumferences and oedema assessments are excellent indicators of nutritional status.

They are easy to obtain and generally reliable (DiSilvestro et al, 2004). They are commonly done in children between 6-59 months of age. Nutritional status among children aged 6-59 months is used as a proxy indicator for the general health and wellbeing of the entire community. This age group is chosen to give an indication of the severity of the situation in the whole population. If children are badly affected, other individuals are likely to be affected as well. Children aged 6-59 months are used because they are in a growth period, are particularly vulnerable to disease and food shortage, face a higher risk of mortality than the rest of the population in cases of crises and are considered to be the most sensitive to nutritional stress (Save the Children, 2004).

Nutritional assessments are designed with respect to three indices: height-for-age (HFA), weight-for-height (WFH) and weight-for-age (WFA). These combinations make sense only when compared to a normal value, derived from a reference population. Reference population represents healthy children with normal growth and shows how much a child of a given height/age should weigh and how tall a child of a given age be. There are some reference values drawn from international growth standards. These are assumed to reflect normal individual growth under optimal environmental conditions, and can be applied to individuals everywhere, regardless of ethnicity, socio-economic status and type of feeding (MOPHS and MSPNDV, 2008). Anthropometric indices are usually expressed in two ways: as the percentage of the median value of the reference standard, or as z-scores derived from the reference standard. These two are equivalent ways to express how far an individual's nutritional status deviates from the reference population.

Percentage of the median: The median is a type of "average". It is used instead of the mean when the standard population is not normally distributed. The median is

simply the middle value which has half the population above and half below the given median value. The percentage of the median is calculated as follows: for example, if the child's weight is 9.4 kg, and the reference value is 11 kg, the percentage of the median is (9.4kg/11kg)*100 = 85%.

Z-score: The normal range for growth is assumed to lie between –2 and +2 standard deviations, which include 95% of the reference population. Z-scores are expressed in multiples of the standard deviation: a Z-score of 0 is equivalent to the median while a Z-score of –2 lies two standard deviations below the median (MOPHS and MSPNDV, 2008).

2.5.4 Biochemical Assessment of Iron Deficiency and Anaemia

Individuals begin to suffer from the adverse effects of iron deficiency well before they become frankly anaemic and hence detectable by biochemical tests. Special laboratory tests have therefore been developed for the detection of iron deficiency. Such tests can also serve to show whether the anaemia present in a given population is due to iron deficiency or to another cause, such as parasitic infection, which would require completely different therapeutic or preventive measures. Tests of iron deficiency are thus suitable for monitoring the iron status of population groups. They should not be used routinely for diagnostic purposes in primary health care. Laboratory tests should also be used to diagnose anaemia and determine its severity. Such tests are useful in individuals in whom anaemia is suspected, especially those from known high-risk groups; they can be repeated over time to monitor the effectiveness of treatment. Laboratory tests can also be used to determine the prevalence and severity of anaemia in a population as well as to single out the groups that are most affected (WHO, 1989). Biochemical methods are used to assess nutrient

levels in the body. Blood, urine, saliva and breast milk are among the body tissues used for biochemical assessment.

2.5.4.1 Serum Ferritin

Serum ferritin is a measure of the amount of iron in body stores if there is no concurrent infection. Serum ferritin is considered as the best indicator of the impact of an iron intervention as well as being a useful indicator of depleted iron stores. However serum ferritin is also an acute phase protein, which means that its concentration rises during inflammation. When the concentration is ≥12-15 μg/l iron stores are present. Higher concentrations reflect the size of the iron store. When the concentration is low (<12–15 μg/l) then iron stores are depleted (WHO, 2007).

The World Health Organization recommends that a serum ferritin concentration <12 μg/l indicates depleted iron stores in children <5 years of age, while a concentration <15 μg/l indicates depleted iron stores in those >5 years of age. However, both thresholds may be too low during an acute phase response or when there is chronic disease, and a serum ferritin concentration between 30 and 100 μg/l may better indicate depleted iron stores in such circumstances (WHO, 2007). When infection is present the concentration of ferritin may increase even if iron stores are low. This means that it can be difficult to interpret the concentration of ferritin in situations in which infectious diseases are common.

At the moment the reliable assessment of iron status is not possible in the presence of inflammation or infection, and it is necessary to exclude such subjects. Markers of inflammation or infection should be included. The measurement of the concentration of C-reactive protein (CRP) provides indicator of acute disease whereas other

proteins, such as alpha-1-acid glycoprotein (AGP), may provide a marker of chronic infection. An alternative is to measure the erythrocyte sedimentation rate (ESR). However none of these will identify minor infections that may increase the ferritin concentration for long periods and a health questionnaire should be completed for each subject to identify possible infection. The use of highly sensitive assays for CRP may be valuable to detect sub-clinical infections (WHO, 2007).

A ferritin concentration of <15 μg/l indicates the absence of storage iron while concentrations >100 μg/l indicate the presence of storage iron. Concentrations in the range of 15–100 μg/l serum ferritin is difficult to interpret. The customary thresholds to indicate an iron deficiency of <12–15 μg/l may not apply during inflammation. One way of dealing with this issue is to set the threshold higher, and a threshold of <30 μg/l has been recommended in the presence of infection, but only for children <5 years old (WHO, 2001). It would seem logical to combine the assay of serum ferritin with a measure of disease severity such as the erythrocyte sedimentation rate (ESR) or the concentration of CRP. This lack of success in "correcting" serum ferritin concentrations for the effect of inflammation or infection is probably due to the different responses to acute disease shown by ferritin and CRP. Although other acute phase proteins may show similar responses in time, the small changes in concentration reduce the value of the marker as an indicator of disease. Minor infections in children, without changes in other markers of infection, may cause long-term increases in serum ferritin concentration (WHO, 2007).

The consultation proposed that the measurement of acute phase protein could help to interpret data on serum ferritin. If the concentration of the additional acute phase protein is higher than the normal threshold it could indicate underlying inflammation

and explain a higher serum ferritin concentration in the presence of ID. Several acute phase proteins could be used for this purpose including C-reactive protein (CRP), α-1-antichymotrypsin (ACT), α-1 acid glycoprotein (AGP), serum amyloid A, fibrinogen and haptoglobin.

The most frequently used acute phase proteins are CRP, which responds quickly to inflammation but also subsides quickly in concentration; ACT which also rises quickly but remains at a high concentration longer than CRP; and AGP which is slower to respond than CRP or ACT but remains at a high concentration for longer than either. The concentration of AGP maybe a better indicator than CRP or ACT of the presence of chronic, sub-clinical infection, and may better reflect the changes in the concentration of ferritin during infections (WHO, 2007). In the initial phase of infection the change in concentration of CRP may predict the behaviour of ferritin, and in the later stages AGP may control for the confounding effects of the acute phase response. Measurement of both these APPs may help to interpret the changes in serum ferritin concentration: if only the CRP concentration is elevated then the infection is in the initial stages; if both CRP and AGP are elevated in concentration then the infection is in the acute stage; and if only AGP is elevated then the infection is in the chronic stage and a correction factor to interpret ferritin in each stage could be calculated according to Christine, A. and Northrop-Clewes (WHO, 2007).

2.5.4.2 C-Reactive Protein

The most frequently used acute phase proteins to determine severity of disease/infection/inflammation are CRP, which responds quickly to inflammation but also subsides quickly in concentration. α-1-antichymotrypsin (ACT) which also rises quickly but remains at a high concentration longer than CRP and α-1 acid

glycoprotein (AGP) which is slower to respond than CRP or ACT but remains at a high concentration for longer than either can also be used. Suitable methods for determining the CRP concentration include nepholometry and turbidimetry, and they should be able to detect the protein at concentration as low as 5 mg/l. Normal concentrations of CRP is <5 mg/l. An international reference standard is available (WHO, 2007).

2.6 Gaps in Knowledge

In most countries, national policies have been implemented to provide iron supplements to pregnant women and to a lesser extent to young children as the primary strategy for preventing iron deficiency and anaemia (WHO, 2006). Though much has been done in relation to surveys on malnutrition levels in ASAL areas, the levels keep on changing depending on food security and rainfall patterns. The available nutrition surveillance mechanisms are also not able to capture adequate data for decision making. There is no surveillance system in place for iron status in children in Kenya while the latest micronutrient survey was conducted over eleven years ago in 1999. This study wishes to address these gaps.

CHAPTER THREE

3.0 Methodology

3.1 Study Area and Study Site

This study was conducted in Migwani division[4] of Mwingi district in Eastern Province of Kenya. Mwingi district borders Kitui to the south, Machakos district to the west, Mbere and Meru South district to the north and Tana River district to the east. The district lies between latitude 0^0 03' and 1^0 12' south and longitude 38^0 47' east and covers an area of 10,300 km^2. Most of the district is within the ASAL with two rainy seasons occurring in March-May (long rains) and October-December (short rains). The amount of rainfall in the district, which is erratic ranges between 400 mm and 800 mm per year. The short rains are more reliable than the long rains (GOK, 2008).

Mwingi district has a total population of 303,828 of which about 60% lives in poverty[5]. Frequent droughts have aggravated the poverty situation in the district thus depleting any surplus food. More than a third of the under five year olds are stunted (FAO, December 2008). The study was conducted in selected locations in Migwani division, Mwingi District because the dimension falls within ASAL and within an agro-ecological zone.

[4] See appendix 5 for map of study area.

[5] The poor are defined as those who cannot afford basic food and non food items. The national overall poverty is considered to be less than 1USD per day.

3.2 Study Design

The survey adopted a cross-sectional study design. The study assessed simultaneously the exposure (cause) and anaemia, iron deficiency, iron deficiency anaemia and malnutrition (effect) in the study population. This provided information about the frequency and characteristics of the outcome by furnishing a snapshot of the health experience of the population.

3.3 Subjects and Sampling Frame

3.3.1 Study Population

The study population comprised children 12-59 months. This age group was estimated to be 35,747 children constituting 13.94% of the total population in Mwingi district. The study population was of African origin.

3.3.2 Sample Size Determination

Since 43.2% of children 6-72 months in Kenya are iron deficient (Mwaniki et al, 1999), to measure the prevalence of iron deficiency within 6 percentage points with 95% confidence (expected prevalence of 43% within a 95% CI between 37% and 49%) using Cochran's formula (Israel, 1992) a sample size of 261 was sufficient.

$$z^2pq/d^2$$

$z = 1.96$ $\quad p = 0.43$

$q = 0.57$ $\quad d = 0.06$

$$(1.96^2 * 0.43 * 0.57) / (0.06^2) = 261$$

Added ≈ 15% to cater for attrition, then a sample of 300 children was to be selected.

3.3.3 Sampling Procedure

The sample was selected randomly using a multi-stage sampling procedure. The sampling frame consisted of households in selected sub-locations in Migwani division of Mwingi District which had been selected as it falls within ASAL and within an agro-ecological zone. Cluster sampling strategy was used to select three sub-locations in Migwani and three sub-locations in Nzauni locations while EPI method[6] of sampling was used to select households with children 12-59 months (MOPHS and MSPNDV, 2008). When the team arrived at the cluster (sub-location), the following procedure was followed after discussions with the village leaders:

The team located (as much as possible) the centre of the selected sub-location and randomly chose a direction by spinning a bottle, pencil, or pen on the ground and noting the direction it pointed when it stopped. The team walked in the direction indicated, to the edge of the cluster. At the edge of the cluster, it spined the bottle again until it pointed into the body of the cluster area. The team walked along this second line counting each house on the way. Using a random number list, the team selected the first house to be visited by drawing a random number between 1 and the number of households counted when walking. For example, if the number of households counted was 27, then they selected a random number between one and 27. If the number 5 was chosen, they went back to the fifth household counted along the walking line. This was the first house which was visited. The subsequent households were chosen by proximity meaning the next closest household to the

[6] Over time, the World Health Organization Expanded Program on Immunization (EPI) cluster survey design has become the default choice in the field to measure vaccination coverage and other indicators, even when a sampling frame is available. The cluster method was developed in the 1970s for immunization coverage in the USA and expanded for the smallpox eradication campaign later that decade. It has now been accept as a method of sampling in nutrition surveys.

right. The team continued in this direction until the required number of children was selected. In each household, one child aged 12-59 months was selected. In a household with more than two children aged 12-59 months, one child was selected randomly by allocating them numbers and choosing one. The clusters were mapped with a view to select only those accessible by road and proximal to public health facility (1-5 km). The children were selected by the mobilizing team which visited the households.

3.3.4 Inclusion and Exclusion Criteria

Inclusion:

- Children 12-59 months of age living in the selected household and whose parent or guardian gives consent or assent.

Exclusion:

- Children 12 to 59 months of age whose parent or guardian did not give consent or assent.
- Obviously ill children

3.4 Data Collection Tools and Equipments

The data collection tools used in the study included questionnaires, pens, pencils, sharpeners, rubbers, clipboard, box files and data entry forms. The equipments used in the study included children weighing scale (Salter scale), weighing pants, scale hanging rope, height board, thermometer, blood pressure machine, stethoscope, syringes, gloves, aluminium foil, blood collection tubes, cool box, ice packs, slides, microscope, haematological analyzer for Hb analysis, Nyco card reader for CRP

analysis and Enzyme linked fluorescent immune assay – ALFA for serum ferritin analysis.

3.5 Recruitment and Training of Research Assistants

The enumerators who were recruited for data collection on demographic and social economic characteristics and anthropometric measurement were required to have a minimum of secondary level of education. They were trained[7] for two days on questionnaire administration, method of interaction, data collection techniques and recording and on basic field ethics. The enumerators were given supportive supervision during the actual data collection to ensure quality of data.

The clinical assessment was done by either a nurse or clinical officer who was sensitized on what to assess while blood samples were only collected by trained laboratory personnel.

3.6 Pretesting of the Tools

The study tools were pretested in an area similar to the area selected for study. This was done in the second day of the training. Challenges met in the field during pretesting were addressed during the feedback session. The required adjustments were made on the questionnaire. The enumerators also did practicals on anthropometric measurements. During this time, the enumerators were shown how to take height and weight measurements and reading of child health cards or estimation of age using calendar of events. The data collected during pretesting of the questionnaire was used to test the data entry and analysis matrix.

[7] See appendix 4 for training agenda.

3.7 Data Collection Procedures

3.7.1 Community Mobilization

The mobilization team composed of a graduate nutritionist research assistant, public health officer and a community leader visited the selected households to mobilize the mothers or principal care giver to bring the selected children to the nearest public health facility where interviews were conducted, blood samples collected and measurements done. The mother's appointments to come to the selected facilities were booked different dates. The mothers were requested to provide their mobile telephone numbers during mobilization for follow up.

3.7.2 Household Demographic and Socio-economic Data

A semi-structured questionnaire[8] was used to collect household demographic and socio economic data of the selected household from the mother or principal caretaker. This was done at the health facility when the caregivers brought the children. Collected data included: marital status, education and occupation of members of households, marital type, health of the selected child, water and hygiene status in the household.

3.7.3 Food Consumption Patterns

A qualitative 24hr dietary questionnaire[9] was used to collect information on types of foods and number of meals consumed by the index child in the preceding 24 hours.

[8] see appendix 2 for the questionnaire

[9] See a sample of qualitative 24hr dietary recall form in section F of appendix 2.

The enumerators used probing questions to get information on the number of meals and types of foods/ingredients in each meal as well as type of snacks used.

3.7.4 Anthropometric Measurements

Age and sex determination: Age was calculated from the birth date based on clinic cards, birth certificates or mothers recall. The sex of the child was also determined during data collection.

Weight and height measurement: Weight was measured to the nearest 0.1 kg while height/length measurement was taken to the nearest 0.1cm using spring Salter scale and height/length board respectively. The procedure was standardized through training of enumerators using Standardised Monitoring and Assessment of Relief and Transitions (SMART) methodology. The subject was in minimum clothing which did not require to be corrected during analysis.

3.7.5 Clinical Assessment

Clinical assessment was carried out by clinicians according to a laid down criteria[10]. The clinical assessment was based on signs and symptoms related to anaemia and iron deficiency.

3.7.6 Blood Sample Collection and Laboratory Analysis

Blood collection: Venous blood samples (5ml) were collected by venipuncture. The blood was collected in tubes containing EDTA and transported to the Migwani Sub-district Hospital laboratory in a cool box with ice packs at about 8-10^{0}C. Hb

[10] See attached clinical assessment form as section G in appendix 2.

concentration was assessed using a Sysmex haematological analyser. The remaining blood sample was centrifuged within 12 hours after collection at 3000 rpm for 10 minutes and clear serum sample separated into sterile cryovials. The serum was then stored at -8°C until the subsequent biochemical analysis in the KEMRI laboratory.

Laboratory analysis: A microscopic test for current or recent malaria infection was done in the laboratory. In KEMRI, further biochemical analysis[11] was done. These included serum ferritin using Enzyme linked fluorescent immune assay- ALFA and CRP using Nyco card reader.

3.8 Data Quality Control

The questionnaire was pretested in an area similar to the area selected for study purposes. The weight measuring scales were calibrated and standardized daily before use. All the measurements (weight and Height) were recorded twice and average calculated. All the laboratory equipments were calibrated before use. These included enzyme linked fluorescent immune assay – ALFA and nyco card reader. Field data was checked daily for consistencies and completeness. Any challenge was addressed during daily debriefing with the field assistants. The outliers in the anthropometric data using SMART flags[12] were excluded in the final data analysis while skewed data especially serum ferritin results was log transformed before data analysis.

[11] The rationale of these tests is as described in appendix I

[12] SMART flags use the observed mean to determine the outliers in a data set.

Table 3.1: Quality of Anthropometric Data

Indicator	N	Mean z-scores ± SD***	Design Effect (z-score < -2)	z-scores not available*	z-scores out of range**	Shapiro-Wilk test[1]	Skewness[2]	Kurtosis[3]
WHZ	290	-0.71±0.95	1.30	0	3	P=.501	0.05	0.11
WAZ	293	-1.65±0.99	1.00	0	0	P=.456	0.16	-0.08
HAZ	290	-2.12±1.04	1.00	0	3	P=.567	0.06	-0.39

* contains WHZ and WAZ for the children with oedema

** SMART flags

***The standard deviation (SD) should be between 0.8 and 1.2 z-score units for WFH in all well conducted surveys. This survey was well conducted.

[1] If $p < 0.05$ then the data are not normally distributed. If $p > 0.05$ data can be considered to be normally distributed. The data is normally distributed.

[2] If the value is between minus 1 and plus 1, the distribution can be considered as symmetrical. This data is symmetrical.

[3] If the value is less than an absolute value of 1 the distribution can be considered as normal.

3.9 Data Management and Analysis

Data was analyzed using the Statistical Package for Social sciences (SPSS) version 16 and Epi-info ENA version 3.5.1 Computer packages. Microsoft excel was used to draw graphs. Descriptive summary statistics such as frequencies, means, medians and standard deviations were used to describe the characteristics of study population, food consumption pattern of children, main childhood illnesses, prevalence of malnutrition, anaemia, iron deficiency and iron deficiency anaemia. Inferential statistics; Odds ratio, Confidence Interval, and P-value were used to determine association between various dependent and independent variables, for example, to establish the factors influencing the nutritional and iron status of children under five years of age.

The children's nutritional status was analysed using EPI.INFO-ENA version 3.5.1 computer software to convert anthropometric measurements to indices; weight-for – age, height –for-age and weight-for-height Z-scores. The World Health Organisation (WHO) growth standards 2005 were used as reference data for the nutritional indices. Stunting, underweight or wasting was defined by Z score <-2SD for anthropometric indices (de Onis et al, 2007). Those with Z-scores below -3SD were considered to be at severe level of malnutrition.

Means ± SD of all iron status indicators including Hb and serum ferritin concentrations were determined. Hb was adjusted for both altitude and ethnicity while serum ferritin was adjusted for infection using CRP results. Hb and anaemia were adjusted for altitude using the CDC formula {ΔHb=-0.32*(Alt*.0033) +0.22*(Alt*.0033)^2} (Nestel and INACG, 2002) and an altitude of 1244 metres above sea level (Google earth) was used. A value of 0.239g/dl was used to adjust individual Hb values, 0.239g was subtracted from each individual Hb value (g/dl). To adjust for ethnicity, a value of 1.0g was added to individual Hb value as recommended by WHO (2001). Anaemia was defined as Hb concentration <110g/L (11mg/dl).

Iron deficiency was defined as serum ferritin concentrations < 12µg/L. Iron deficiency anaemia was defined as concurrent anaemia and iron deficiency. Infection was defined as C-reactive proteins ≥ 5mg/L. CRP was used in calculating the correction factor for iron deficiency (WHO, 2007; Skikne et al, 1990; Cook et al., 2003).

To adjust the serum ferritin for infection, the C-reactive protein was used to account for infections. The children 12-59 months tested for infection were grouped into two categories. Those with CRP < 5mg/L were classified as normal while those with CRP ≥ 5mg/L were classified as infected. To get the correction factor, the geometric mean serum ferritin of normal children was divided by geometric mean serum ferritin for those who were classified as infected. A geometric mean concentration was used because, as noted by Beard et al (2006), distributions of serum ferritin were skewed (skewed moment=5.18). Geometric mean was calculated after log transformation. Those with infection had their serum ferritin levels adjusted by multiplying the individual readings of serum ferritin with correction factor to take care of high levels resulting from effect of infection.

Data coding, entry and validation was carried out using appropriate software mainly SPSS/PC version 16 and EPi Info version 3.5.1 statistical package. Data was assessed for normality by visual examination of distribution plots, determining of skewness and kurtosis. Associations between dependent/outcome variables such as anaemia, ID, IDA, stunting, wasting and underweight with independent variables such as age, sex, socio-economic characteristics and morbidity experience was determined through Bivariate analysis (Odds ratio) and multiple logistic regression (odds ratio), confidence interval and P-value. Multivariate analysis was done after bivariate analysis where factors that had a p value ≤0.25 were entered in logistic regression model building process. A stepwise backward elimination procedure was performed to obtain the "final best models" which gave factors that were independently associated with the outcome variables. The final equations have binary outcome variables.

3.10 Ethical Consideration

This study was conducted under the umbrella of the main study; Improving Iron Status of Children in a Semi-Arid Area in Kenya: The Potential of Amaranth Grain Flour. The main study had both ethical approvals[13] from Kenyatta National Hospital (KNH)/ University of Nairobi Ethical Review Committee and Research Clearance permit[14] from the Ministry of Higher Education, Science and Technology in Kenya.

Local and district authorities were involved in the implementation of the study and community informed extensively about the aim and procedures of the study. The participant's informed consent[15] was solicited before enrolment into the study. The participant's confidentiality was enlisted by ensuring that information on their identification was omitted from study related materials and all conversations and information provided to the researchers was regarded as confidential. Strict procedures were followed during blood collection and only trained laboratory personnel were involved. Apart from pain and discomfort during blood collection, no other distress was expected and experienced from this study. Children with signs of severe disease and Hb levels below 70g/L were referred for appropriate care.

[13] See appendices 6 and 7 for ethical approval

[14] See appendix 8 for research authorization

[15] See appendix 3 for the informed consent form.

CHAPTER FOUR

4.0 Results

4.1 Demographic Characteristics of the Study Population

4.1.1 Demographic Profile

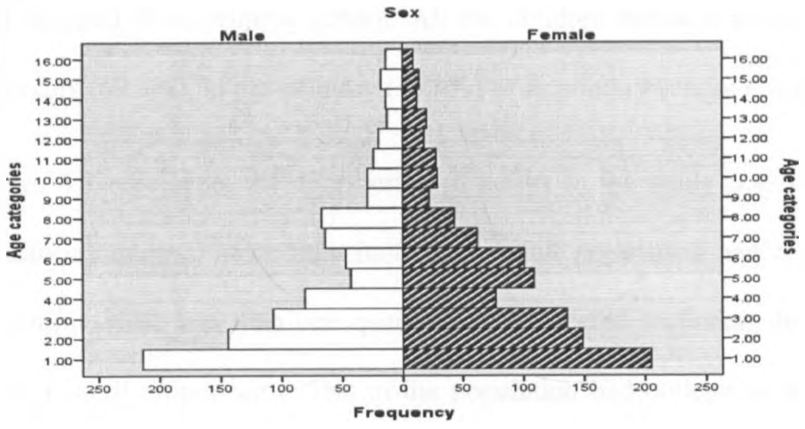
Table 4.1 shows the distribution of selected demographic characteristic of the study households. A total of 293 households were visited with a population of 1967 people. The mean household size was 6.7±2.3 members ranging from 2-17 members. The dependency ratio was 1.12 with labour force making up slightly less than half the total population. Of the dependent population, the elderly composed of 4.1% while children under fifteen years were made up of almost half the total population. Children under five years represented about a quarter of the total population. Women of the reproductive age were also about a quarter of the total population. The female population was higher than the male population in that for every 10 males, there were 11 females.

Table 4.1: Selected Demographic Characteristics of the Study Population

Variable	N=1967
Sex ratio (M:F)	1:1.1
Infant under 1 year (%)	1.3
Children under five years (%)	21.4
Children under 15 years (%)	48.7
Women of reproductive age (%)	22.6
Labour force '15-64 years old' (%)	47.2
Elderly population (%)	4.1

4.1.2 Population Age and Sex Characteristics

The household age-sex structure was wide at the base as depicted by the population pyramid in figure 4.1. The male to female ratio in the age groups ranged from 0.4 in 21-25 years age group to 1.6 in 36-40 and >75 years age group. Most of the other age groups had male to female ratio of 0.9-1.1. There were significant differences between the proportion of males and females in 21-25 years age group (χ^2=28.7; p=.0000), 26-30 years age group (χ^2=19.7; p=.000) and 36-40 years age group (χ^2=5.24; p=.022). Males and females in all the other age groups were equally represented.



Age categories in years

1=0-5	9=41-45
2=6-10	10=46-50
3=11-15	11=51-55
4=16-20	12=56-60
5=21-25	13=61-65
6=26-30	14=66-70
7=31-35	15=71-75
8=36-40	16=75+

Figure 4.1: Population age and sex pyramid

4.1.3 Religion and Marital Status of the Study Population

Almost all (99.9%) of the population were Christians while only 0.1% reported to be traditionalists'.

Figure 4.2 shows the distribution of study population by marital status. More than two thirds of the adults in the study population were married while slightly less than a quarter were single. Widows and separated couples represented 6% and 2% respectively.

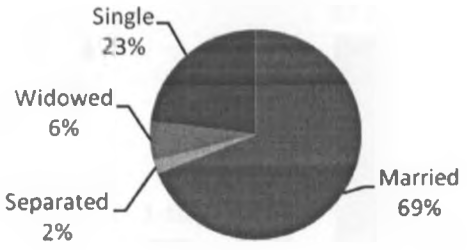


Figure 4.2 Marital status of the study population

4.1.4 Education in the Study Population

School enrolment for children 6-17 years was 93% where about 87% were in primary school while less than 6% were in secondary school. Only two children 6-17 years had dropped from primary school. All the children below 6 years were either pre-schoolers (69.3%), in pre-primary (15.9%) or in primary school (14.8%).

Figure 4.3 represents the distribution of adults in the study population by level of education attained. More than half of the adult population had completed primary education while less than one quarter had completed secondary level of education. Only a small proportion (<5%) of the population had college or university level of education. The ratio of males to females at different levels of education varied.

Overall, there were significant differences between males and females with college/university (χ^2=5.45; p=.02), completed secondary (χ^2=5.92; p=.015), completed primary (χ^2=10.45; p=.001) and uncompleted primary (χ^2=5.14; p=.023) levels of education. Those with pre-primary level, incomplete primary level and secondary levels and those with adult education had both males and females equally represented.

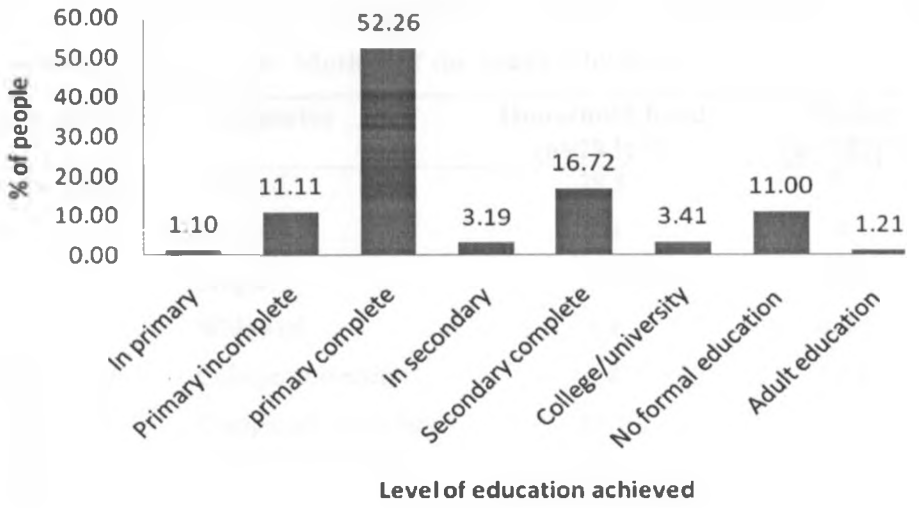


Figure 4.3: Education level of the adults in the study population

4.2 Demographic and Socio-economic Characteristics of Household Head and Mothers of the Study Children

Table 4.2 shows the demographic and socio-economic characteristics of the household heads and the mothers of the study children. The vast majority of the households were male headed (82.3%) and in monogamous marital status (94.5%). The majority (about 80%) of household heads and mothers of index child were married while minority were separated. About half (46.1%) of the household heads had complete primary education while slightly over two thirds (67.4%) of mothers of index child had complete primary education. None of the mothers had adult education. More than one quarter (27.3%) of household heads were farmers while majority (62.4%) of the mothers of index child were housewives.

Table 4.2: Selected Demographic and Socio-economic Characteristics of the Household Head and the Mother of the Study Children

Characteristic	Categories	Household head (n=293) %	Mother (n=282) %
Marital status	Married	78.8	81.2
	Separated	1.0	3.5
	Single	15.7	1.8
	Widowed	4.4	13.5
Education	College/university	4.8	1.8
	Completed secondary	19.1	12.8
	Primary complete	46.1	67.4
	Primary incomplete	9.9	16.7
	Adult education	1.7	-
	No formal education	18.4	1.4
Occupation	Salaried	19.1	2.1
	Farmer	27.3	15.6
	Self employed	20.1	10.3
	Casual labour	24.9	8.9
	Housewife	8.5	62.4
	Student	-	0.7

4.3 Distribution of Households by their Water Sources

Table 4.3 shows the distribution of households by their water source and method of water treatment. The majority (39.2%) of the households were using borehole as the main source of domestic water while one quarter of the households were using water well. More than half (55.6%) of the households were treating their drinking water of which boiling was the major treatment method.

Table 4.3: Distribution of Study Households by Water Source and Method of Water Treatment

Characteristic	N=293	%
Main source of water	River	23.9
	Tap	2.0
	Borehole	39.2
	Well	25.9
	Dam	2.7
	Tanker	6.1
Water treatment	Yes	55.6
	No	44.4
Method of water treatment	Boiling	54.4
	Chemical treatment	33.5
	Both treatment methods	12.1

4.4 Demographic Characteristics of the Study Children

A total of 293 children aged 12-59 months were assessed for their nutritional status where both boys and girls were equally represented (χ^2=0.003; p=.953). Table 4.4 shows the age and sex distribution of the children. There was no significant difference in overall age/sex distribution in the study children (Pearsons χ^2_{3df}=3.11; p = .375). There was a significant difference in the size of age groups (χ^2=48.99; p=.000). The largest group (38.6%) was 24-35 months old.

Table 4.4: Distribution of Study Children by Age and Sex

Categories	Boys n=147 %	Girls n=146 %	Total n=293 %	Ratio Boy: girl
12-23 months	49.4	50.6	30.4	1.0
24-35 months	46.0	54.0	38.6	0.9
36-47 months	51.8	48.2	19.1	1.1
48-59 months	62.9	37.1	11.9	1.7
Total	50.2	49.8	100.0	1.0

Half of the children in the study population were of first or second birth order. Third and fourth birth orders composed of more than one quarter while 5th born and more was composed of less than one quarter of the study children (Figure 4.4).

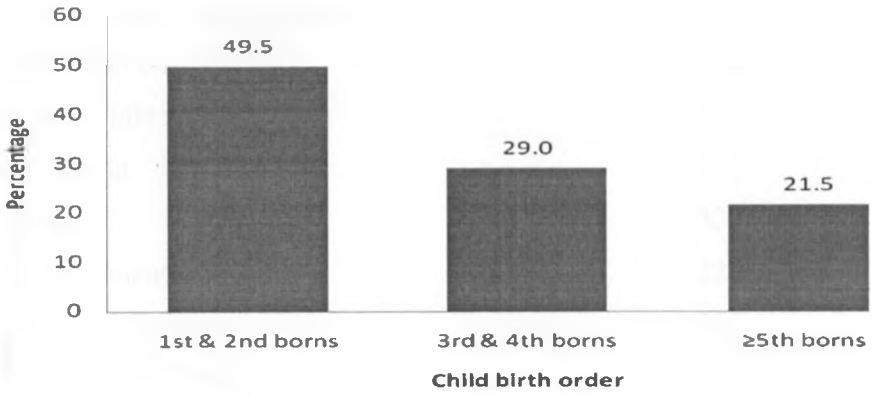


Figure 4.4: Distribution of study children by birth orders

4.5 Morbidity Experience and Health Seeking Behaviour of Study Children

Table 4.5 shows the morbidity experience and health seeking behaviour of the study children. Three quarters of the children had experienced sickness in the previous two weeks prior to the day of interview. Majority were suffering from respiratory infections such as coughs/cold followed by fever/malaria and diarrhoea. More than three quarters of those who were sick sought treatment of which about three quarters visited a GOK health facility. Less than a quarter used over the counter drugs with only 3.5% visiting private clinic. About a third of children were infected according to CRP test analysis while only 6.25% were infected with malaria. There was no significant difference between boys and girls in either those who were sick in the previous two weeks, those who had infection according to CRP and those who had malaria infection (χ^2=0.69; p=.41), (χ^2=0.294; p=.59) and (χ^2=0.89; p=.35).

Table 4.5: Morbidity Experience and Health Seeking Behaviour of the Study Children

Characteristics	N	%
Sick in the last 2 weeks	291	75.8
Infection as per C-reactive protein	261	32.6
Malaria infection	288	6.25
Respiratory infections	222	41.4
Fever/malaria	222	34.2
Diarrhoea	222	12.2
Sought treatment	222	77.9
Visited GOK facility	173	74.0
Over the counter drugs	173	22.5

4.6 Immunization, Vitamin A Supplementation and De-worming Status in Children 12-59 Months

Table 4.6 shows immunization, vitamin A supplementation and de-worming status of the study children. Over two thirds of the children had received vitamin A supplement in the last six months while only a third were de-wormed in the same period. There was no significant difference between boys and girls in vitamin A supplementation and de-worming status (χ^2=0.32; p=.57) and (χ^2=1.33; p=.249) respectively. Coverage for all the vaccines was high (above 95%) except for Oral Polio Vaccine given at birth (OPV0) whose coverage was low (65.8%). Excluding polio vaccine given at birth, the immunization coverage was still high (88.7%). There was no significant difference in vaccination coverage between boys and girls (Pearson χ^2_{1df}=1.47; p=.225). Minority, 10.6% (31/293) of the study children did not have immunization card.

Table 4.6: Vitamin A Supplementation, De-worming and Immunization Status in Study Children

	Vit A (n=293)	Deworming (n=293)	BCG (n=292)	OPV0 (n=292)	OPV1 (n=292)	OPV2 (n=292)	OPV3 (n=292)	PV1 (n=292)	PV2 (n=292)	PV3 (n=292)	Measles (n=292)	All basic vaccines* (n=292)
Yes	200	91	286	192	288	286	285	289	287	287	280	259
%	68.3	31.1	97.9	65.8	98.6	97.9	97.6	99.0	98.3	98.3	95.9	88.7

*BCG, measles and three doses each of Pentavalent (PV) and polio vaccine (excluding OPV0)

4.7 Food Consumption Patterns in Study Children

Table 4.7 shows selected indicators of food consumption patterns among the study children. More than half (56.2%) of the households obtain their food stuffs from the market as their main source while 43.8% obtained their food stuffs from the farm. Most children (53.4%) consumed three meals in a day with the mean (SD) number of meals being 3.38 (0.73) and 40.1% consuming 4-6 meals per day. A small proportion of children consumed less than three meals per day.

Over two-thirds of children had a high dietary diversity score (≥6 food groups per day). Over one quarter had a medium DDS (4-5 food groups/day) while a small proportion had a low DDS (<4 food groups/day).

About one quarter of the study children were breastfeeding of which they were breastfed between 12-35 months. Only one child above 36 months old was still breastfeeding.

Table 4.7 Distribution of Study Children by Food Consumption Patterns

Characteristic	%(N=292)
Meals per day 1-2	6.5
3-4	88.0
5-6	5.5
24hr individual dietary diversity score:-	
Low (≤3food group)	2.7
Medium (4-5 food group)	27.4
High (≥6 food group)	69.9
Consuming in previous 24hrs:-	
Heme iron source	6.5
Non heme iron source	72.9
Vitamin C rich food	76.0
Either heme or non heme iron source	75.3
Breast feeding at the time of study	23.29

4.8 Nutritional Status of Children 12-59 Months

4.8.1 Acute Malnutrition (Wasting) in Study Children

Distribution of study children by acute malnutrition is shown in table 4.8. The prevalence of global acute malnutrition (GAM) in the children 12-59 months was 10.3%. There was no significant difference in the prevalence of wasting between boys and girls (χ^2=0.302; p=.58). Severe wasting was only 0.3% found only among boys.

Table 4.8: Prevalence of Acute Malnutrition in Children 12-59 Months

	GAM % (C.I)	MAM % (C.I)	SAM % (C.I)
All (n=290)	10.3 (6.3, 16.5)	10.0 (6.2, 15.8)	0.3 (0.0, 4.2)
Boys (n=145)	11.0 (5.1, 22.3)	10.3 (5.2, 19.5)	0.7 (0.0, 8.9)
Girls (n=145)	9.7 (4.6, 19.2)	9.7 (4.6, 19.2)	0.0 (0.0, 0.0)

The mean±SD of WHZ (n=290) was -0.71±0.95. The WHZ scores for both boys and girls were normally distributed (Shapiro-Wilk test, p=.501). The observations were also symmetrical (skewness=0.05 and kurtosis=0.11). Comparing the WHZ distribution curves together with the mean WHZ scores of the study population with the WHO standards curve, the proportion of wasted study children was higher than a standard normal population (Figure 4.5).

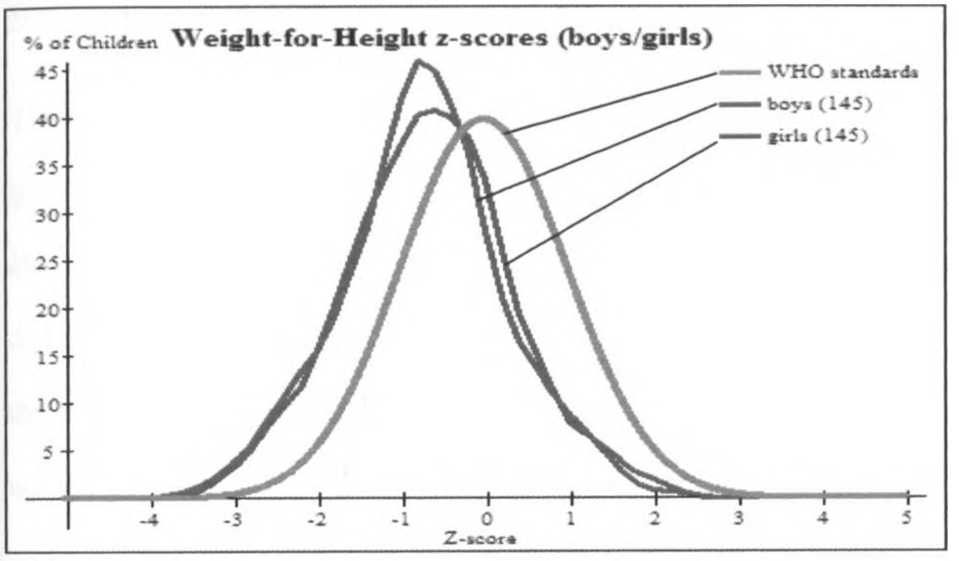


Figure 4.5: Distribution of children 12-59 months by WHZ scores

Further analysis, showed significant mean difference in WHZ scores between underweight children and Non-underweight children (t=12.58; p=.000); children who had experienced sickness in the previous two weeks and those who were well (t=2.28; p=.02) as well as children from households whose heads were in different categories of occupation (F_{4df}=3.81; P=0.005) (See appendix 17).

4.8.2 Underweight in Study Children

Over one-third of the study children were underweight (Table 4.9). More boys were underweight than girls though the difference was not significant (Pearson χ^2_{1df}=0.32;

p=.57). On the contrary, more girls were severely underweight than boys but the difference was also not significant (χ^2=1.96; p=.16).

Table 4.9: Prevalence of Underweight in Children 12-29 Months

	Global underweight % (CI)	Moderate underweight % (CI)	Severe underweight % (CI)
All (293)	35.8 (30.7, 41.4)	27.6 (25.6, 29.8)	8.2 (3.2, 19.3)
Boys (147)	37.4 (36.3, 38.5)	31.3 (22.8, 41.3)	6.1 (1.1, 28.5)
Girls (146)	34.2 (25.1, 44.7)	24.0 (18.7, 30.2)	10.3 (6.8, 15.2)

The mean±SD of WAZ (n=293) was -1.65±0.99. The WAZ scores for both boys and girls were normally distributed (Shapiro-Wilk test, p=.456). The observations were also symmetrical (skewdness=0.16 and kurtosis=-0.08). Comparing the WAZ distribution curves together with the mean WAZ scores of the study population with the WHO standards curve, the study children were more underweight than a standard normal population (Figure 4.6).

Figure 4.6: Distribution of children 12-59 months by WAZ scores.

Further analysis, showed significant mean difference in WAZ scores between stunted and non-stunted children (t=12.83; p=.0000); wasted and non-wasted children (t=8.15; p=.0000); children from household whose heads were in different categories of occupation (F_{4df}=2.9; p=.02) and children whose mothers were in different categories of occupation (F_{4df}=2.58; p=0.04) (See appendix 15).

4.8.3 Stunting in Study Children

Table 4.10 shows the distribution of children by stunting. More than half of the study children were stunted. In relation to gender, fewer boys than girls were stunted though the difference was not significant (Pearson χ^2_{1df}=0.004; p=.95). One third of the study children had moderate stunting while less than one quarter had severe stunting.

Table 4.10: Prevalence of Stunting in Children 12-59 Months

	Global stunting % (C.I.)	Moderate stunting % (C.I.)	Severe stunting % (C.I.)
All (n=290)	54.1 (48.0, 60.1)	33.8 (30.8, 36.9)	20.3 (15.3, 26.5)
Boys (n=145)	53.8 (42.5, 64.7)	34.5 (24.9, 45.5)	19.3 (12.3, 29.1)
Girls (n=145)	54.5 (46.5, 62.2)	33.1 (28.0, 38.7)	21.4 (16.5, 27.2)

The mean±SD of HAZ (n=290) was -2.12±1.04. The HAZ scores for both boys and girls were normally distributed (Shapiro-Wilk test, p=.567). The observations were also symmetrical (skewness = 0.06 and kurtosis = -0.39). Comparing the HAZ distribution curves together with the mean HAZ scores of the study population with the WHO standards curve, study children were more stunted than a standard normal population (Figure 4.7).

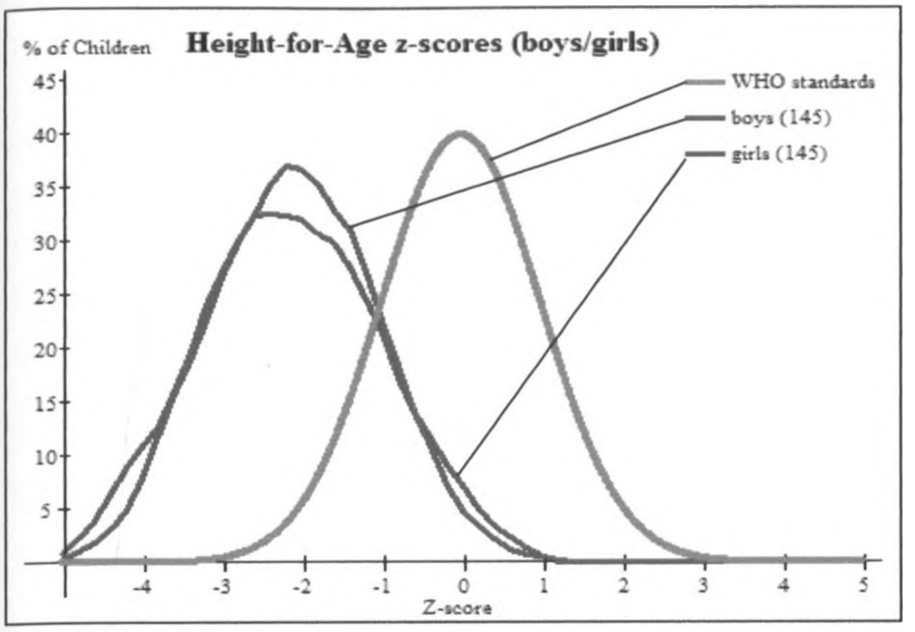


Figure 4.7: Distribution of children 12-59 months by HAZ scores

Further analysis showed significant mean difference in HAZ score between underweight and non underweight children (t=10.49; p=.0000); children in different birth order groups (F=5.53; p=.004) and children in different household size groups (F=2.64; P=0.03) (See appendix 13).

4.9 Haemoglobin Concentration and Anaemia

Table 4.11 shows Hb concentration and prevalence of anaemia before and after adjusting for altitude and ethnicity. The mean±SD Hb before adjusting for altitude and ethnicity was 11.24±1.10 g/dl compared to 12.00±1.10 g/dl after adjustment. Over one third of the study children showed presence of anaemia before adjusting for altitude and ethnicity compared to 16.7% after adjusting for both altitude and ethnicity. There was no difference between boys and girls in relation to anaemia prevalence both before (χ^2=0.01; .92) and after (χ^2=0.02; p=.89) adjusting for altitude and ethnicity. About one third (32.42%) of the children in the sample had mild anaemia while 1.71% had moderate anaemia before adjusting for altitude and

ethnicity. Only one case had severe anaemia (0.34%). After adjusting for both altitude and ethnicity, 15.7% had mild anaemia. Only 1% had moderate anaemia while there was no case of severe anaemia.

Table 4.11: Haemoglobin Concentration and Prevalence of Anaemia in Study Children

	Hb, g/dl (mean±SD)	95% C.I	Anaemia % (n=293)	95% C.I
Un-adjusted	11.24±1.10	11.14 – 11.35	34.47	29.0 – 40.2
Adjusted	12.00±1.10	11.90 – 12.11	16.7	12.6 – 21.5

Further analysis showed significant mean difference in Hb concentration between age groups (F_{3df}=5.86; P=.0007); stunted and non-stunted children (t=2.75; P=.006); birth order groups (F_{2df}=3.55; P=.03); breastfeeding and non-breastfeeding groups (t=2.34; P=.02); iron deficient and non iron deficient children (t=4.92; P=.00001). The mean concentration of Hb was not significantly different in relation to other factors which were analyzed for association with anaemia (See appendix 9).

4.10 Serum Ferritin Concentration and Iron Deficiency (ID)

Before correcting for infection, geometric mean±SD of serum ferritin was 21.45±2.37 µg/L while the prevalence of Iron Deficiency was 23% (60/261). There was no difference between boys and girls in relation to prevalence of Iron Deficiency before adjusting for infection (χ^2=0.27; p=.61).

To correct for infection, a correction factor (C.F) for high serum ferritin in the infected group as indicated by CRP was calculated by dividing the mean serum

ferritin of normal group of 176 children with the mean serum ferritin for infected group of 85 children as shown below:

Geometric Mean ± SD of Serum Ferritin in Reference (Normal) children was 18.66±2.07 µg/L while that in infected children was 28.60±2.43 µg/L. Hence the C.F was calculated as follows = 18.66/28.60 = 0.652.

After correcting for infection, the geometric mean±SD of serum ferritin concentration for the total sample was 18.67±2.31 µg/L. while the prevalence of ID was 29.5%. There was no difference between boys and girls in relation to Iron Deficiency (χ^2=0.33; p=.57). Table 4.12 shows serum ferritin concentration before and after correcting for infection.

Table 4.12: Serum Ferritin Concentration and Prevalence of ID

	SF*, µg/L (mean±SD)	95% C.I.	ID % (n=261)	95% C.I.
Un-corrected	21.45±2.37	19.31 - 23.82	23.0	18.0 - 28.6
Corrected	18.67±2.31	16.86 - 20.67	29.5	24.0 - 35.4

*Serum Ferritin

There was significant mean difference in serum ferritin concentration between different age groups (F_{3df}=8.22; p=.0000); as well as between breastfeeding and non breastfeeding children (t=2.74; p=.0007). The mean differences of serum ferritin concentration in factors assessed for association with ID are shown in Appendix 11.

4.11 Iron Deficiency, Anaemia and Iron Deficiency Anaemia

Children, who had either iron deficiency or anaemia, were found to be in three categories. Those with iron deficiency and anaemia composed 8.4%, those with iron

deficiency without anaemia were 21.1% while those with anaemia and no iron deficiency were 7.3% (N=261).

After correcting serum ferritin for infection, the prevalence of iron deficiency increased by 6.5% while after adjusting Hb for both altitude and race, anaemia prevalence dropped by about half (figure 4.8). IDA also dropped to 8.4% from 10.7%.

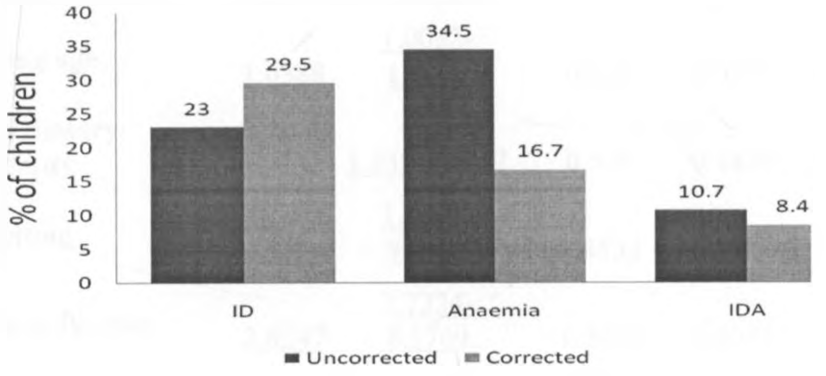


Figure 4.8: Comparison of uncorrected and corrected prevalence of anaemia, iron deficiency and iron deficiency anaemia.

4.12 Factors Associated with Anaemia

After bivariate analysis, the factors which were found as possible risk factors to anaemia in study children included; Iron deficiency (OR=3.47, C.I.=1.75-6.89; P=.004), young age (OR=1.04, C.I.=1.01-1.07; P=.004), intake of low dietary diversity (OR=1.32, C.I.=1.01-1.69; P=.04), stunting (OR=3.57, C.I.=3.57; P=.005), underweight (OR=1.93, C.I.=1.04-3.59; P=.037), partial immunization (OR=2.45, C.I.=1.08-5.55; P=.03) and breastfeeding status (OR=2.8, C.I.=1.46-5.37; P=.002). Taking of non heme iron foods (OR=0.52, C.I. =0.27-0.99; P=.045), either heme or non heme iron food (OR=0.44, C.I. =0.23-0.84; P=.014) and low birth order (OR=0.83, C.I. =0.73-0.94; P=.004) were found as protective factors against anaemia. These and other results of non significant factors are shown in appendix 10.

Further analysis showed factors independently associated with anaemia as indicated in table 4.13 to include; child birth order, age, dietary diversity, stunting and iron deficiency.

Table 4.13: Factors Independently Associated with Anaemia

Predictor variable	Odds Ratio	95% C.I.	Coefficient (β)	S. E.	Z-Statistic	P-Value
Low birth order	0.7719	0.661-0.9013	-0.259	0.0791	-3.2743	0.0011
Young age	1.0388	1.0032-1.0756	0.038	0.0178	2.1408	0.0323
Low dietary diversity	1.7142	1.239-2.3717	0.539	0.1656	3.2538	0.0011
Stunting	4.2774	1.8374-9.9577	1.4533	0.4311	3.371	0.0007
Iron deficiency	3.8547	1.7324-8.5769	1.3493	0.4081	3.3065	0.0009
CONSTANT	*	* *	-3.0575	1.1286	-2.7091	0.0067

-2*Log-Likelihood=177.5; $\chi 2$=49.1, D.F. =5, p=.000

Equation: Anaemia = -3.0575 + -0.259birth order + 0.038 age + 0.539 dietary diversity + 1.453 stunting + 1.35 ID.

4.13 Factors Associated with Iron Deficiency

After bivariate analysis, young age (OR=1.08, C.I. =1.03-1.09; P=.000) and breastfeeding (OR=2.22, C.I. =1.20-4.12; P=.01) were found as the possible risk factors to iron deficiency. None of the analysed factors was found to be protective. (See appendix 12).

Further analysis showed child age as the only factor independently associated with iron deficiency as indicated in table 4.14.

Table 4.14: Factors Independently Associated with Iron Deficiency (ID)

Predictor variable	Odds Ratio	95% C.I.	Coefficient	S. E.	Z-Statistic	P-Value
Young age	1.06	1.03-1.09	0.06	0.01	4.32	0.0000
CONSTANT	*	* *	-0.88	0.41	-2.16	0.0311

-2*Log-Likelihood=294.9; $\chi 2$=21.7, D.F. =1, p=.0000

Equation: Iron Deficiency = -0.8827 + 0.0572 age.

4.14 Factors Associated with Stunting

After bivariate analysis, underweight was found to be a possible risk factor to stunting where underweight children were more likely to be stunted than non underweight children (OR=14.67, C.I.=7.49-28.72; p=.000). Other factors were found to be non significantly associated with stunting (See appendix 14).

On further analysis, underweight remained as an independent factor significantly associated with stunting (Table 4.15). Underweight children were 14.67 times as likely to be stunted than non underweight children.

Table 4.15: Factors Independently Associated with Stunting

Predictor variable	Odds Ratio	95% C.I.	Coefficient (β)	S. E.	Z-Statistic	P-Value
Underweight	14.67	7.49-28.72	2.69	0.34	7.83	0.0000
CONSTANT	*	* *	-2.05	0.31	-6.68	0.0000

-2*Log-Likelihood=317.1; $\chi 2$=87.3, D.F. =1, p=.0000

Equation: Stunting = -2.0477 + 2.6855 underweight.

4.15 Factors Associated with Underweight

After bivariate analysis, stunting (OR=14.67, C.I. =7.49-28.72; P=.000), wasting (OR=22.42, C.I. =6.63, 75.89; P=.000) and occupation of household heads as a

farmer, casual worker or housewife (OR=1.69, C.I. =1.02, 2.79; P=.04) were found as possible risk factors to underweight while breastfeeding (OR=0.52, C.I.=0.28-0.95; P=0.3) was found as a protective factor to underweight. Other factors were found to be non significantly associated with underweight (See appendix 16).

Further analysis showed breastfeeding, stunting and wasting as factors independently associated with underweight as indicated in table 4.16.

Table 4.16: Factors Independently Associated with Underweight

Predictive factor	Odds Ratio	95% C.I.	Coefficient (β)	S. E.	Z-Statistic	P-Value
Breastfeeding	0.35	0.15-0.79	-1.05	0.42	-2.51	0.012
Stunting	49.47	14.98-163.36	3.90	0.61	6.40	0.0000
Wasting	152.17	27.44-843.96	5.03	0.87	5.75	0.0000
CONSTANT	*	* *	-4.32	0.91	-4.73	0.0000

-2*Log-Likelihood=225.8; $\chi 2$=155.6, D.F. =3, p=.0000

Equation: Underweight = -4.3235 + -1.0544 breastfeeding + 3.9014 stunting + 5.025 wasting.

4.16 Factors Associated with Wasting

After bivariate analysis, underweight children were more likely to be wasted than non-underweight children (OR=22.42, C.I. =6.63-75.89; P=.000) while children from households where the head was either a farmer, casual worker or housewife were found to be more likely to be wasted than children from households where household heads were salaried or self employed (OR=2.4, C.I. =1.00-5.78; P=.0499). Other factors were found to be non significantly associated with wasting (See appendix 18).

Further analysis showed age and underweight as factors independently associated with wasting as indicated in table 4.17.

Table 4.17: Factors Independently Associated with Wasting

Predictor variables	Odds Ratio	95% C.I.	Coefficient (β)	S. E.	Z-Statistic	P-Value
Young age	1.04	1.00-1.08	0.04	0.02	2.09	0.0364
Underweight	25.51	7.44-87.47	3.24	0.63	5.15	0.0000
CONSTANT	*	* *	-0.20	0.60	-0.33	0.7417

-2*Log-Likelihood=147.8; $\chi 2$=50.0, D.F. =2, p=.0000

Equation: Wasting = -0.197 + 0.0376 age + 3.239 underweight.

4.17 Factors Associated with Iron Deficiency Anaemia

After bivariate analysis, young age was found to be a risk factor to iron deficiency anaemia (OR=1.06, C.I.=1.03-1.09; P=.000) while low birth order was found to be a protective factor (OR=0.8, C.I.=0.68-0.95; P=0.1). Other factors were found to be non significantly associated with IDA are shown in appendix 19.

Further analysis showed child birth order and age as factors independently associated with iron deficiency anaemia (Table 4.18).

Table 4.18: Factors Independently Associated with Iron Deficiency Anaemia

Predictor variables	Odds Ratio	95%	C.I.	Coefficient	S. E.	Z-Statistic	P-Value
Low birth order	0.79	0.66	0.93	-0.24	0.09	-2.74	0.0062
Young age	1.05	1.01	1.10	0.05	0.02	2.25	0.0244
CONSTANT	*	*	*	1.76	0.70	2.52	0.0117

-2*Log-Likelihood=139.1; $\chi 2$=11.8, D.F. =2, p=.0000

Equation: IDA= 1.7632 + -0.2399 birth order +0.0495 age.

CHAPTER FIVE

5.0 Discussion

This study assessed iron and nutritional status of children 6-59 months and associated factors.

5.1 Socio-demography Characteristics

The mean household size in Migwani division of 6.7 persons is slightly higher than 6.0 persons for Mwingi district reported in the Mwingi district development plan of 2008-2012 (GOK, 2008). It is also much higher than the national average of 4.2 persons (KNBS and ICF Macro, 2010). The large household size may be attributed to the extended families living and eating together in the study area. The age dependency ratio in Migwani division of 1.12 is higher than the dependency ratio in the larger Mwingi district of 1.0 (GOK, 2008) and the national age dependency ratio of 0.96 reported in the year 2008-2009 (KNBS, 2010). The male to female ratio in Migwani division compares well with the Mwingi district sex ratio of 0.89 (KNBS, 2010) but is lower than the national figure of 0.96 (KNBS and ICF Macro, 2010).

The household age-sex structure is wide at its base which is typical of developing countries with more young and few elderly people and compares well with the population pyramid of the Kenyan population (KNBS and ICF Macro, 2010). The labour force aged between 15-64 years composed of 47.2% in Migwani is slightly lower than that of Mwingi district of 49.9% (GOK, 2008) and that of national level of 51%. This may be as a result of people in this age group moving to the urban areas.

The composition of the households including size and sex of the household head are important characteristics because they are associated with the welfare of the households. Households headed by females are typically poorer than those headed by

males. Economic resources are also often more limited in large households than in small households (KNBS and ICF Macro, 2010). The was a low proportion of female headed households in study area (17.7%) compared to the national figure (34.0%) and that of Mwingi district (45.2%) (GOK, 2008) implying that, few households have problems of limited resources which is a common characteristic of female headed households (KNBS and ICF Macro, 2010).

Education is a key determinant of the life style and status an individual enjoys in the society. Studies have consistently shown that educational attainment has a strong effect on health behaviours and attitudes (KNBS and ICF Macro, 2010). In the study population, adult men are more educated than women since more men than women have college/university education or completed secondary education. This compares well with the national level where more men have attained secondary education than females (KNBS and ICF Macro, 2010). The low level of education in women may result in poor life style. This may have an effect on child care practices since this role is majorly carried out by women. Low education in women may also result in lack of employment, hence limited control of economic resources by women.

5.2 Morbidity Experience

The high morbidity levels reported by the caretakers in the study area is comparable to the findings reported by Kanyuira (2010) in Kirinyaga South district of which 64% of the children had experienced sickness in the previous two weeks. Generally the high incidence of childhood illnesses such as respiratory infection (44.9%), fever (24%) and diarrhoea (17%) found in study children is likely to impact negatively on long term nutritional status of under fives. These diseases have been reported as the most important childhood illnesses which contribute to child mortality and poor

nutritional status. The findings on fever and diarrhoea experience in study children are similar to those reported in Kenya at the national levels (KNBS and ICF Macro, 2010).

5.3 Immunization, Vitamin A Supplementation and De-worming Status of Study Children

According to the World Health Organisation, a child is considered fully vaccinated if he or she has received a BCG vaccination against tuberculosis; three doses of DPT vaccine to prevent diphtheria, pertussis, and tetanus (or three doses of pentavalent which includes two additional vaccines, Hepatitis B and Himophilus influenza); at least three doses of polio vaccine (OPV); and one dose of measles vaccine (WHO, 2002). These vaccinations should be received during the first year of life. BCG is given at birth or first clinic contact, DPT-HipB-Hib and polio require three doses each given at 6, 10 and 14 weeks of age. Measles is given at or soon after reaching 9 months of age (WHO, 2002; KNBS and ICF Macro, 2010). In Kenya, all children who are taken for immunizations are given child welfare card when antigens given are indicated. In the study group, 10.6% of the children reported as lacking immunization card was as a result of misplacement by the caregiver or the person responsible for the card was not in during the day of interview. The overall vaccination coverage in the study children is higher than that reported in Eastern province (84.2%) as well as the national coverage (77.4%). Coverage of all individual antigens is also found to be higher than the coverage at national level. Coverage of OPV0 (given at birth) in Migwani division is lower than that reported in Eastern province of 76.2% though higher than the national coverage of 59.3%. The low coverage of OPV0 may be as a result of mothers not giving birth at health

facilities hence children not given. Another possibility is where OPV0 is given but not indicated on the card.

Vitamin A is an essential micronutrient for the immune system and plays an important role in maintaining the epithelial tissue in the body. Severe vitamin A deficiency (VAD) can cause eye damage. VAD can also increase severity of infections such as measles and diarrhoeal diseases in children and slow recovery from illness (KNBS and ICF Macro, 2010). In Migwani, 68.3% of children 12-59 months are reported to have received vitamin A supplement in the last six months, a vitamin A coverage that is higher than for both Eastern Province (25.5%) and national levels (30.0%) (KNBS and ICF Macro, 2010). The poor coverage at provincial and national level may be attributed to low reporting or averaging.

The coverage of de-worming in Migwani of 31.1% is lower compared to the coverage in Eastern province of 33.2% and at the national level of 40.0% (KNBS and ICF Macro, 2010). The poor coverage in de-worming status may be attributed to low community sensitization on the importance of this service. The health workers may also be missing the opportunity of deworming the children when brought to health facilities. Certain types of intestinal parasites can cause anaemia. Periodic de-worming for organisms like helminthes and schistosomiasis (bilharzia) can improve children's micronutrient status.

5.4 Food Consumption Patterns

Dietary diversity scores have been positively correlated with increased mean micronutrient density adequacy of complementary foods (FANTA, 2006). The high consumption (69.9%) of more than five food groups reported as high dietary diversity

score is found to have an effect on anaemia status where children with high DDS are protected from anaemia. The protective effect is noted in children taking more than three food groups. Those taking less than or equal to three food groups are found to be at risk of anaemia. In terms of other nutritional status, DDs did not have an effect. This finding agrees with those of Kanyuira (2010) in Kirinyaga South district who found no significant relationship between high dietary diversity and nutritional status. The recommended feeding of children is exclusive breastfeeding for the first 6 months of life and continued breastfeeding through the second year of life. Even with optimum breastfeeding, children will become stunted if they do not receive an adequate quantity and quality of complementary foods after 6 months of age. Most incident stunting (and wasting outside of famine situations) happens in the first 2 years of life when children have a high demand for nutrients and there are limitations in the quality and quantity of their diets, especially after the period of exclusive breastfeeding (Lancet, 2008). In this study, breast feeding children are found to be protected from underweight.

Animal-source foods are an important component of child 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. It is also the major cause of iron deficiency anaemia especially in poor people. In young children the peak prevalence of iron deficiency anaemia occurs around 18 months of age and then falls as iron requirements decline and iron intake is increased through complementary foods (Lancet, 2008). According to this study, intake of heme or non heme iron rich food are possible protective factors against anaemia but on further analysis, they are not independently associated with anaemia status.

5.5 Nutritional Status

Adequate nutrition is critical to child development. 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).

5.5.1 Wasting

The prevalence of wasting or low weight for height found in this study (10.3%) is higher than levels reported in Eastern province (7.3%) and at national level (7%) (KNBS and ICF Macro, 2010) as well as 7% reported in Kwale district (Adeladza, 2009). High levels of wasting are as expected in an ASAL. Wasting represents the failure to receive adequate nutrition in the period immediately preceding the survey and may be the result of inadequate food intake or a recent episode of illness causing loss of weight and the onset of malnutrition. Prior to the survey, Migwani had experienced a drought which might have accounted for the high levels of wasting. In this study, younger children are more likely to be wasted than older ones. This may be explained by the fact that young children rely majorly on their care giver while the older children can visit and have a bite from the neighbour's house. This agrees with the findings by Macharia et al (2005) in Kathonzweni division of Makueni district who found significant relationship between children's age and nutritional status based on the prevalence of wasting and of underweight. Another factor found to be independently associated with wasting is underweight. It has been established that, in practice about 20% variation in underweight is related to wasting (MOPHS and MSPNDV, 2008).

5.5.2 Underweight

The prevalence of underweight or low weight for age found in this study (35.8%) is much higher than levels reported in Eastern province (19.8%) and the national level of 16% (KNBS and ICF Macro, 2010). The high prevalence of underweight may be attributed to high levels of both wasting and stunting 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. Neither stunted nor wasted children weigh as much as normal children of the same age (MOPHS and MSPNDV, 2008). The prevalence of underweight compares well with that reported in Kwale district of 34% (Adeladza, 2009). Breastfeeding is found to be a protective factor against underweight. This finding agrees with that of Mahgoub et al (2006) who found a significant reduction in underweight among breastfed children. Breast feeding children may be protected from underweight because, in addition to food offered to all the children, breastfeeding children have an added advantage of taking breast milk. In case of low supply of food or low food intake, breastfeeding children in the household will be better off than non breastfeeding counter parts. The fact that stunting and wasting were found to be risk factors to underweight is not a surprise since in practice, about 80% and 20% variation in underweight is related to stunting and wasting respectively (MOPHS and MSPNDV, 2008).

5.5.3 Stunting

Stunting or low height for age in this study is very high compared the rest of the Eastern province (41.9%) and the national level of 35% (KNBS and ICF Macro, 2010). However, stunting in this study also compares with that reported in Kwale district of 51% (Adeladza, 2009). The height-for-age index is an indicator of linear

growth retardation and cumulative growth deficits. Stunting develops over a long period as a result of inadequate dietary intake and/or repeated infections. The high levels of stunting in Migwani may be attributed to inadequate dietary intake as a result of prolonged drought experienced in ASAL. The fact that underweight was found to be a risk factor to stunting is no surprise. In practice, about 80% variation in underweight is related to stunting (MOPHS and MSPNDV, 2008).

5.6 Anaemia

The prevalence of anaemia in Migwani is much lower than the national prevalence reported by Mwaniki et al in 1999 of 70% and the findings by Verhoef et al, (2001) in Kibwezi which indicated that 69% of the children 2-36 months had anaemia. The status of anaemia even in these areas may have changed since the survey was done more than ten years ago. The factors found to be independently associated with anaemia include child birth order, age, dietary diversity, stunting and iron deficiency. Low birth order is a protective factor against anaemia. Young age, low dietary diversity, stunting and iron deficiency are found to be risk factors to anaemia. Low birth order may be protective because of the family set up. With low birth order, the family size is small and the parents may be young and energetic to provide for the family. The resources in the family may be enough to provide appropriate care to the children in terms of good and high quality protein foods rich in heme iron. Intake of few food groups is associated with poor food diversity and hence low intake of most essential nutrients. With low dietary diversity, most of the foods are found to be low in heme iron foods. Stunting which is a chronic form of malnutrition is an indication of prolonged food and nutrition insecurity. Nutrition has an important role in anaemia and of all the nutrients involved, iron is the most crucial. It has been established that,

iron deficiency accounts for almost 50% of anaemia in the population (WHO, 2001). Hence, the findings showing iron deficiency as a risk factor to anaemia is as expected.

5.7 Iron Deficiency (ID) and Iron Deficiency Anaemia (IDA)

The prevalence of iron deficiency in study children is lower than the national value of 43.2% reported by Mwaniki et al in1999. Children's age is independently associated with iron deficiency while both children's age and birth order are independently associated with iron deficiency anaemia. This may be attributed to fast depletion of iron stores as the children grow coupled by poor feeding practises (IOM, 1998). Children's food in most of ASAL areas is not adequate while majority of the foods are poor in heme iron. The low birth order which was found to be protective may be as a result of the parents being young and eager to care for the newborns. The resources in the family may also be plenty because of small family size (KNBS and ICF Macro, 2010) hence the family may afford heme iron rich foods.

CHAPTER SIX

6.0 Conclusions and Recommendations

6.1 Conclusions

The general objective of this study was to determine iron and nutritional status and associated factors among children 12-59 months old in Migwani Division. From the study findings, it is concluded that;

The populations in this community comprise large households. The labour force in these areas is lower than the dependents. Though there is high school enrolment, there are few people who have gone past primary level of education. Home deliveries may still be occurring in these areas. Although this community consumes different food groups, this does not necessarily translate into adequate nutrient intake particularly energy. Further still, high dietary diversity does not result in improved micronutrient levels in the body especially iron. Though a malaria endemic zone, prevalence of malaria is low though other types of infections are evident.

According to world health organisation (WHO), prevalence of anaemia is of mild (5.0 – 19.9%) public health significance while prevalence of global acute malnutrition is of serious (10 – 14 %) public health significance in this community. The prevalence of stunting, underweight and iron deficiency is high in this community with chronic malnutrition at serious levels.

Low birth order is protective against anaemia while young age, low dietary diversity, stunting and iron deficiency are risk factors. Young age is a risk factor to iron deficiency. Low birth order is protective while young age is a risk factor against iron deficiency anaemia. Underweight is a risk factor to stunting while both young age

and underweight are risk factors to wasting. Wasting and stunting are risk factors while breastfeeding is a protective factor against underweight.

6.2 Recommendations

Following the fore given results, the following are the recommendations;

The households and community members should be responsive enough to the nutritional needs of the children especially young children who were found to be at risk of anaemia, ID, IDA and wasting. The mothers should be encouraged to have fewer children because low birth order was found to be protective against anaemia and IDA.

The government and NGOs should put/improve mechanisms in place to prevent/correct the problem of malnutrition especially stunting and wasting whose prevalence has remained to be high. The same should apply to anaemia and iron deficiency whose prevalence could easily shift into severe levels of public health significance since it is of mild –moderate levels.

The mechanisms to be put in place may include; nutrition and health education with emphasis on the good nutritional and care practices such as importance of extended breastfeeding up to two years or more in children less than five years and diversification of food to ensure that children are able to get as many micronutrients as possible. Counselling on complementary feeding which has been found to be more effective at reducing stunting could be used. Although nutritional counselling concerning optimal complementary feeding is important everywhere, food insecure populations may also require improving food access by use of food and cash

transfers. There should be community sensitization on importance of de-worming so as to improve its coverage.

There should be improved agricultural practises such as irrigated agriculture to counter the prolonged drought in ASAL areas which result in food insecurity and hence chronic malnutrition coupled by a strong nutritional surveillance programme in ASAL areas for prompt reporting of malnutrition cases.

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Appendix 1: Rationale for Using Specified Tests in Blood Sample Analysis

Haemoglobin concentration

Measurement of haemoglobin concentration (haemoglobin ≤110g/L) has been used to identify lack of iron in nutrition surveys. About 3.4 grams of iron is equivalent to 1 gram of haemoglobin. It only identifies anaemia which could actually be caused by other factors and therefore it cannot be used in isolation as an indicator of iron status (Punnonen et al, 1997).

Serum Ferritin (SF)

Serum ferritin (SF) is an excellent indicator of the size of iron storage compartment. Determination of SF concentration is a simple method of for detecting early iron deficiency (SF ≤ 15 µg/L) in epidemiological studies (Punnonen et al, 1997). In healthy subjects, 1 µg ferritin/L corresponds to approximately 10mg storage iron. SF is a very sensitive acute phase reactant and is elevated by acute and chronic infections, inflammatory diseases, malignancies and liver disorders (Cook, 1990b).

C-reactive protein

C-reactive protein (CRP) is one of the plasma proteins known as acute-phase proteins: proteins whose plasma concentrations increases (or decreases) by 25% or more during inflammatory disorders. It responds quickly to inflammation but also subsides quickly in concentration thus a good indicator of acute inflammation (Gabay et al, 1999).

Complete Blood Count

The complete blood count (CBC) is an analysis of blood cells and coagulation. The basic examination of blood includes analysis of the concentration, structure and function of the different blood cells so as to determine general health status and to screen for and monitor a variety of disorders such as anaemia.

Malaria Parasite Test

For nearly a hundred years, the direct microscopic visualization of the parasite on the thick and/or thin blood smears has been the accepted method for the diagnosis of malaria in most settings, from the clinical laboratory to the field surveys. The careful examination of a well-prepared and well-stained blood film currently remains the "gold standard" for malaria diagnosis. The microscopic tests involve staining and direct visualization of the parasite under the microscope.

Peripheral Smear Study for Malarial Parasites

Light microscopy of thick and thin stained blood smears remains the standard method for diagnosing malaria. It involves collection of a blood smear, its staining with Romanowsky stains and examination of the Red Blood Cells for intracellular malarial parasites. Thick smears are 20–40 times more sensitive than thin smears for screening of Plasmodium parasites, with a detection limit of 10–50 trophozoites/μl. Thin smears allow one to identify malaria species (including the diagnosis of mixed infections), quantify parasitemia, and assess for the presence of schizonts, gametocytes, and malarial pigment in neutrophils and monocytes.

The diagnostic accuracy relies on the quality of the blood smear and experience of laboratory personnel (Kakkilaya, 2006).

Appendix 2: Questionnaire

INDEX CHILD QUESTIONNAIRE

Iron Deficiency Anaemia remains a significant public health challenge especially for growing children in the developing countries. Its prevention is of global concern especially because of its association with brain development in the early years of life. Programmes that could help improve quality dietary intake will go a long way in fighting malnutrition and micronutrient deficiencies.

In response to the seriousness of this anaemia, it is believed that proper and continuous use of mineral rich foods can prevent iron deficiencies and in so doing reduce the risk of anaemia. It is for this reason that we wish to ask your child to participate in a study that is planned to determine the nutrition status, prevalence of iron deficiency and anaemia in this area of Migwani, Mwingi. Information gained from this study will be used for decision-making on promotion of the production of amaranth grain *(Terere)* for the health benefit of all people in your community and the country in general.

Several questions will be asked concerning the child and general household. The weight and height of your child will also be taken. 5 ml of blood to measure the levels of the minerals and adequacy of blood in your child will also be drawn.

A. General Information, Demographic And Social Economic

1. Identification

Location..... Sub-location.....

Name of Interviewer..... Date of interview...../...../2010

Respondent's name..... Sex.....

Name of the index child..... Sex.....

Marital type: 1=Monogamous 2=Polygamous

2. Information for all household[16] members.

S/No	Name	Relationship to HH head -codes-	Sex M=1 F=2	Age (years)	Marital status -codes-	Religion -codes-	Education -codes-	Occupation -codes-
1								
2								
3								
4								

Relationship to HHH
1=HHH 2=spouse or wife
3=son 4=daughter
5=grandson 6=granddaughter
7=relative 8=others
(specify)

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

Religion
1=Christian
2=Muslim
3=Traditionist
4=others
(specify)

Education
1=college/university
2=completed secondary
3=completed primary
4=Dropped from primary
5=in primary
6=in secondary
7=literate e.g. adult education
8=illiterate
9=others (specify)

Occupation
1=salaried employee
2=farmer
3=self employment/busine s
4=casual labourer
5=student
6=housewife

[16] A person or group of people living in the same compound (fenced or unfenced), answerable to the same head and sharing a common source of food and income during study period including unrelated servants, labourers and relatives

B. Morbidity

3. What is the common illness by rank in this community among children?

i. Diarrhoea..... ☐

ii. Marasmus/Kwasiokor..... ☐

iii. Malaria/fever..... ☐

iv. Intestinal worms..... ☐

v. Anaemia..... ☐

vi. Scabies..... ☐

vii. Coughing..... ☐

viii. Any others (specify).....

Note: please rank the answer(s) as given by the respondent.

4. Has (name of child) suffered from any kind of illness in the last two weeks?
1=Yes 2=No (**if no, go to question 8 part C**)

5. If yes in (4 above) which disease did (name) suffer from.....

6. Did (name) receive any treatment?
1=Yes 2=No

7. If yes, where did you get the treatment? .....
1=GOK facility 2=private clinic 3=over the counter drugs
4=traditional herbalist 5=others

C. Water and hygiene.

8. Which is the **main** source of water in your household for the household use?
1= river, 2=tap water, 3=borehole, 4=well, 5=dam,
6=tanker, 7=others (specify)

9. Do you do anything to water before drinking it? (Multiple answers possible)
1=boiling, 2=use traditional herbs, 3=use chemicals (water guard),
4=filters/sieves,

5=3 pot system, 6=nothing, 7= others (specify)

D. Supply and distribution of food in the household.

10. What is the **main** staple food in your family?
.....

11. Which is the **most** common alternative food in times of shortage? **(List them)**.....

12. Which is the **main** source of food in your family?

.....

1=Farm 2=Market 3=Food for work 4=Relief

5=from friends 6=Relatives 7=other sources (specify)

13. In what order is the food served in your family? (indicate 1, 2, 3 etc on the following according to order the food is served).

Husband ☐ Wife ☐ Sons ☐ Daughters ☐ Young children ☐

Visitors ☐ Others ☐

14. Do you serve (name) with tea during the **main** meal time?

1= Yes 2=No

15. If yes, when do you serve (name) tea?

1= with meals 2=soon after meals 3= two or more hours after meals

16. Has (name) received vitamin A supplement within the last 6 months? ***(Verify from Clinic card)***

1=Yes 2=No

17. If Yes, within what period did (name) received vitamin A.

1=Last one month 2=Last 2-3 months ago. 3=Over 3 months ago.

18. Has (name) been de-wormed within the last 6 months?

1=Yes 2=No

19. If Yes, when was (name) de-wormed?

1=Last one month 2=Last 2-3 months ago. 3=Over 3 months ago.

20. Is (name) on any food supplementary programme now or within the last one month?

1=Yes 2=No

21. If Yes, where is the programme based?

1=Hospital 2=School 3=Community 4=others (specify)

22. What kind of food is provided in this programme for feeding (name)?

.....

23. Has (name) been immunized for age? ***(Verify from Clinic card and indicate the date of immunization)***

1. BCG 1= Yes 2= No
   Date_____
2. Oral Polio 0 1= Yes 2= No
   Date_____

3. Oral Polio 1 1= Yes 2= No
   Date_____
4. Oral Polio 2 1= Yes 2= No
   Date_____
5. Oral Polio 3 1= Yes 2= No
   Date_____
6. Pentavalent (DPT, HepB & Hib)1 1= Yes 2= No
   Date_____
7. Pentavalent (DPT, HepB & Hib)2 1= Yes 2= No
   Date_____
8. Pentavalent (DPT, HepB & Hib)3 1= Yes 2= No
   Date_____
9. Measles 1= Yes 2= No
   Date_____

E. Anthropometric Data

Child Name..... Sex: ..... Date of interview:...../...../2010

S/ No	Child Birth order	Child's No	Sex M/F	Date of birth *(Verify from Clinic card)*	Weight (0.1 kg)	Weight (0.1 kg)	Height (0.1 cm)	Height (0.1 cm)	Bilateral oedema

F. Qualitative 24 Hr Recall Form Questionnaire

Individual Qualitative 24 HR Recall Form

I would like to ask you about the foods and drinks (Name) ate yesterday during the day and at night whether at home or outside the home. (Preferably start with the first food eaten in the morning) **[Note for the enumerator:** These questions apply only to the Index Child and **not** to any other person.**]**

Time	List of Food
Morning	
Afternoon	
Evening	

G. Clinical examination form

Name of child: ..... Sex..... ID No of Child: .....

Date of interview: ...../...../2010. DOB of index child: ...../...../2010

Vital signs

1. Temperature recording: .....
2. Blood pressure: ...../.....
3. Pulse: .....
4. Respiratory rate: .....
5. Pain (present): 1. Yes 2. No

Deficiency signs

Vitamin A:

Does the child have any of the following?

1. Night blindness: 1=Yes 2=No
2. Bitot spots: 1=Yes 2=No
3. Poor growth: 1=Yes 2=No

Iron

Does the child have any of the following?

1. Abnormal paleness or lack of colour of the skin: 1=Yes 2=No
2. Irritability: 1=Yes 2=No
3. Lack of energy or tiring easily (fatigue) 1=Yes 2=No
4. Increased heart rate (tachycardia) 1=Yes 2=No
5. Sore or swollen tongue 1=Yes 2=No
6. Enlarged spleen 1=Yes 2=No
7. A desire to eat peculiar substances such as dirt or ice (a condition called pica) 1=Yes 2=No
8. Blue sclera (sclera is a tough fibrous tissue that covers the white of the eye, blue sclera has an abnormal degree of blueness) 1=Yes 2=No
9. Immune system: reduced resistance to infection 1=Yes 2=No
10. Concave nails: 1=Yes 2=No
11. Hair loss: 1=Yes 2=No
12. Impaired wound healing: 1=Yes 2=No
13. Reduced resistance to cold: 1=Yes 2=No
14. Inability to regulate body temperature 1=Yes 2=No
15. Presence of bilateral oedema 1=Yes 2=No

H. **Blood analysis form.**

Child ID No:	Hb	SF	CRP	Malaria test

Appendix 3: Subject Consent Form

Introduction

Iron Deficiency Anaemia (IDA) remains a significant public health challenge especially for growing children in the developing countries. Its prevention is of global concern especially because of its association with brain development in early years of life. Programmes that could help improve quality dietary intake will go a long way in fighting malnutrition and micronutrient deficiencies.

In response to the seriousness of this anaemia, it is believed that proper and continuous use mineral rich foods such as amaranth grain can prevent iron and zinc deficiency and in so doing reduce the risk of anaemia. It is for this reason that we wish to recruit your child to participate in a project that is planned for children aged 1-5 years. Through this participation we intend to confirm the presence of anaemia and iron deficiency in this community. Information gained in this study will be used for decision making on promotion of the production of amaranth grain for the health benefit of all the people in your community and the country in general.

Procedures

If you grant consent for your child to participate in this study by signing the section at the end of this form, the following activities will be undertaken today.

A clinical and physical examination will be done by the study's medical personnel including 5 ml of blood to measure the levels of the minerals and adequacy of blood in your child.

Risks and Precautions

There is practically no risk associated with use of amaranth grain and the quantities that the children will consume are not expected to stop them from consuming other foods at home. In addition, since we shall regularly monitor the children, in the event

that you seek medical care for your child outside your local health facility, please show your cards and inform them that your child is participating in this study.

Blood collection usually causes or discomfort. We will take precaution to ensure minimum discomfort because only well trained and experienced staff will attend to your child. Blood collection from your child will be used only for the tests explained to you above and will be done in your presence.

Confidentiality

Any records relating to you and your child's participation will be strictly confidential. Your names and those of the child will not be used in any reports from the study and you will receive a copy of this consent form.

Circumstances that could lead to termination of your child's participation are:

Any overt and severe clinical signs of nutrient overload

If your child becomes unwell beyond the scope of the usefulness of the project

If you choose to revoke your decision

Participation information

Your child is being asked to participate in a medical research study.

Participation is entirely voluntary.

You may withdraw your child from participating in any part of the study or from the study entirely any time.

Refusal to participate will not result in the loss of benefits that you are otherwise entitled to.

No risks can be foreseen.

Please feel free to ask questions on anything that is not clear to you, after you have read and had the consent form explained to you.

In the event of further questions, please contact **Dr. A. Mwangi (0733826186)** or **Mrs. Catherine Mutie (0725363153)** or any project staff. Please clarify all issues with any of the above before undertaking to sign this document.

Parent Statement

I the undersigned have understood the above information, which has been fully explained to me by the investigator. I had the opportunity to ask questions, all of which were answered to my satisfaction. I understand that at any time, I may withdraw my child from this study without giving reasons. I agree to take part in this study.

Child's name: _____
(Index child)

Name of parent: _____

Parent's signature: _____ Date: _____

Investigators signatures
Name: _____

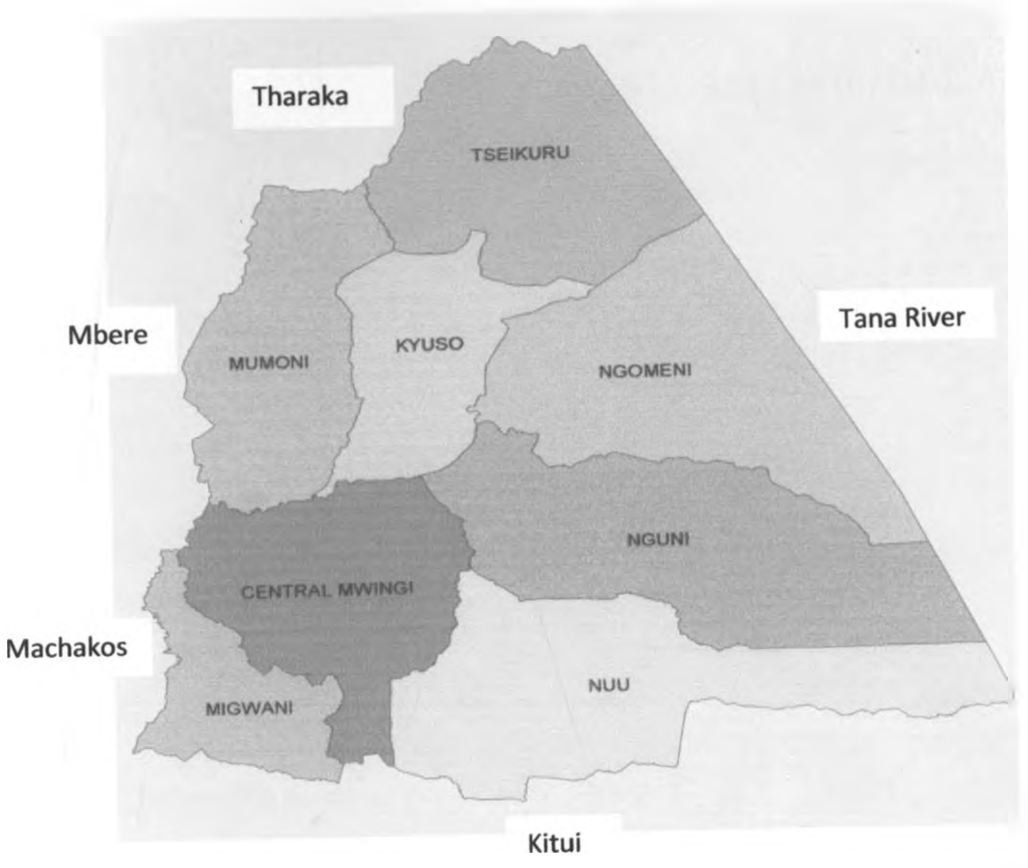
Signature: _____

Date: _____

Appendix 4: Field Assistants Training Program

Day 1				
Time	**Objective**	**Subject area**	**Learning method**	**Learning aids**
8.00-8.30	Introduction and climate setting	Self introduction of all	Discussion	Flip charts
8.30-9.00	Purpose and objectives of the study	Problem statement Purpose of study Specific objectives	Lecture, discussion	Power point, flip charts, handouts
9.00-10.00	Expected outputs of the survey	Anthropometric, clinical, biochemical, dietary assessment and filling of questionnaire.	Lecture, discussion, demonstration	Power point, flip chart, pictures, handouts
10.00-10.30	**B**	**R**	**E**	**A**	**K**
10.30-11.00	Anthropometric and clinical assessment	Measuring and recording weight, height/length, temperature, BP, pulse etc.	Lecture, demonstration, role play	Power point, flip chart, pictures, handouts
11.00-12.00	Administration of the questionnaire and dietary assessment	Demonstrate how to interpret and ask the questions and filling of questionnaire	Lecture, discussion, demonstration, role play	Power point, flip chart, handouts
12.00-1.00	Study ethics	Seeking consent from respondent Personal behavior	Lecture, discussion	Power point, flip chart, pictures, handouts
1.00-2.00	**L**	**U**	**N**	**C**	**H**
2.00-3.00	Study tools and equipments	Demonstration on the use and standardization of equipments.	Discussion, demonstration and role play	Power point, study equipments and flip charts.
3.00-4.00	Interpretation and familiarizing with the questionnaire	Study the questions Interpreting questions	Discussion	Study questionnaire, flip chart
Day 2				
8.00-9.00	Recap	Previous day work	Discussion, Teach back, role play	Flip charts, handouts
9.00-9.30	Using a checklist	Using inventory of equipments	Demonstration	Checklist
10.00-2.00	Pretesting questionnaire	Asking questions, recording, identify challenges	Practical work	Questionnaire
2.00-4.00	Feedback	Modification of questionnaire.	Discussion	Flip charts, questionnaire

Appendix 5: Map Showing Divisions of Mwingi District - Kenya



Appendix 6: Approval Letter from Kenyatta National Hospital (KNH) Ethical & Research Committee

KENYATTA NATIONAL HOSPITAL
Hospital Rd. along, Ngong Rd.
P.O. Box 20723, Nairobi.
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP", Nairobi.
Email: KNHplan@Ken.Healthnet.org

Ref: KNH-ERC/R/149

December 10, 2009

Catherine Macharia-Mutie
Division of Human Nutrition
Wageningen University
P O BOX 8129
6700 EV Wageningen

Dear Catherine

Re: Approval for annual study renewal titled "Improving iron status of children in a Semi-arid area in Kenya, The potential of Grain Amaranth flour" (P233/08/2007)

This is to grant you annual study extension for the approval of research Ref. No. P233/8/2007.

The renewal periods are 5th December 2009 - 4th December 2010.

Yours sincerely

DR. L. MUCHIRI
AG. SECRETARY, KNH/UON-ERC

KENYATTA NATIONAL HOSPITAL
PROVED
10 DEC 2009
ETHICS & RESEARCH COMMITTEE

c.c. Prof. K.M. Bhatt, Chairperson, KNH/UON-ERC
The Deputy Director CS, KNH

Appendix 7: Approval Letter for Modification from Kenyatta National Hospital (KNH) Ethical & Research Committee

KENYATTA NATIONAL HOSPITAL
Hospital Rd. along, Ngong Rd.
P.O. Box 20723, Nairobi.
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP", Nairobi.
Email: KNHplan@Ken.Healthnet.org

March 8, 2010

Ref: KNH-ERC/ MOD/602

Catherine Macharia-Mutie
Division of Human Nutrition
Wageningen University
P O BOX 8129
6700 EV Wageningen

Dear Catherine

Re: Approval of modification study titled "Improving iron status of children in a semi-arid area in Kenya, the potential of Grain amaranth flour" (P233/8/2007)

Refer to your communication of February 17, 2010.

The KNH/UON-ERC has reviewed and approved your requested modification to analyze the samples for Serum Retinol instead of ZnPP.

The amendment to include children aged 12-59 months instead of 12 -23 months is also approved.

Yours sincerely

DR. L. MUCHIRI
AG. SECRETARY. KNH/UON-ERC

c.c. Prof. K.M. Bhatt, Chairperson, KNH/UON-ERC
The Deputy Director CS,KNH

Appendix 8: Research Authorization from National Council of Science and Technology

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telegrams: "SCIENCETECH", Nairobi
Telephone: 254-020-241349, 2213102
254-020-310571, 2213123.
Fax: 254-020-2213215, 318245, 318249
When replying please quote

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: NCST/BS/02/05

Date: 10th February 2010

Catherine Macharia Mutie
University of Nairobi
P. O. Box 442 - 00605
UTHIRU NAIROBI

Dear Madam,

RE: RESEARCH AUTHORIZATION

Following your application for extension of authority to carry out research on ***"Improving iron status of children in a semi-arid area in Kenya: The potential of grain Amaranth Flour"*** I am pleased to inform you that you have been authorized to undertake research in **Migwani – Mwingi District** for a period ending ***28th February 2011.***

You are advised to report **to the District Commissioners, the District Education Officers and the District Medical Officer of Health Migwani – Mwingi District** before embarking on the research project.

On completion of the research, you are expected to submit ~~four~~ two copies of the research report/thesis to our office.

PROF. S. A. ABDULRAZAK Ph.D, MBS
SECRETARY

Copy to:

The District Commissioner

Appendix 9: Hb Concentration and Mean Differences

Characteristics of the pre-school children	N (%)	Haemoglobin[$] (g/dl) Mean ±SD	95% CI)	Mean Difference *P* - value
Total	293	12.00±1.10	11.90, 12.11	
Iron Status				.0000*
ID	77 (29.5)	11.55±1.12	11.50, 11.61	
Normal	184 (70.5)	12.25±1.00	12.21, 12.28	
Age Group				.0007*
12 – 23	89 (30.4)	11.66±1.14	11.55, 11.77	
24 – 35	113 (38.6)	12.04±1.05	11.97, 12.13	
36 – 47	56 (19.1)	12.16±1.04	12.01, 12.32	
48 - 59	35 (11.9)	12.48±0.99	12.44, 12.52	
Sex				.4
Male	147 (50.6)	11.95±1.10	11.75, 12.15	
Female	146 (49.4)	12.06±1.10	11.65, 12.47	
DDS				.08
Low (≤3 food groups)	8 (2.7)	11.20±1.78	11.90, 11.50	
Medium (4-5 food groups)	80 (27.4)	11.94±0.94	11.83, 12.06	
High (≥6 food groups)	204 (69.9)	12.06±1.12	11.92, 12.20	
HAZ (WHO)				.006*
Stunted	158(53.9)	11.84±1.16	11.70, 11.99	
Not Stunted	135 (46.1)	12.19±0.99	11.86, 12.52	
WAZ (WHO)				.1
Underweight	105 (35.8)	11.87±1.12	11.85, 11.89	
Not Underweight	188 (64.2)	12.08±1.08	11.92, 12.25	
WHZ (WHO)				.1
Wasted	31 (10.6)	11.72±1.21	11.19, 12.25	
Not Wasted	262 (89.4)	12.04±1.08	11.96, 12.12	
Malaria infection				.9
Infected	18 (6.2)	12.02±0.87	11.65, 12.39	
Not Infected	270 (93.8)	11.99±1.12	11.84, 12.15	
Marital status of mother				.8
Married	229 (81.2)	12.00±1.11	11.92, 12.08	
Unmarried	53 (18.8)	11.95±1.07	11.73, 12.17	
Marital status of HHH				.14
Married	231 (78.8)	11.96±1.10	11.96, 12.16	
Unmarried	62 (21.2)	12.19±1.08	12.03, 12.34	
Marital type				.12
Monogamous	277 (94.5)	12.03±1.09	11.96, 12.10	
Polygamous	16 (5.5)	11.59±1.20	11.05, 12.13	
Infection (CRP)				.046*
Infected	176 (67.4)	12.13±1.13	12.06, 12.21	
Normal	85 (32.6)	11.85±0.97	11.76, 11.93	
Main source of food				.16
Farm	128 (43.8)	11.90±1.23	11.75, 12.06	
Market	164 (56.2)	12.09±0.98	11.97, 12.20	
Birth order				.03*
1st and 2nd	145 (49.5)	12.14±1.02	11.98, 12.31	
3rd and 4th	85 (29.0)	11.75±1.03	11.68, 11.82	
5th and above	63 (21.5)	12.03±1.30	11.98, 12.09	
Immunization				.18
partial immunized	33 (11.3)	11.76±1.20	11.55, 11.97	
Fully immunized	259 (88.7)	12.03±1.08	11.93, 12.14	
Morbidity experience				.76
Sick last 2wks	222 (78.8)	11.99±1.13	11.85, 12.13	
Well last 2wks	71 (24.2)	12.04±1.00	12.04, 12.05	
Occupation of Household Head				.1
Salaried	56 (19.1)	12.17±1.03	11.99, 12.35	
Farmer	80 (27.3)	12.15±0.98	11.89, 12.42	
Self employed	59 (20.1)	11.72±1.15	11.58, 11.85	
Casual labourer	73 (24.9)	11.90±1.13	11.89, 11.91	
Housewife	25 (8.5)	12.10±1.28	11.81, 12.48	

Occupation of the Mother				**.35**
Salaried	6 (2.1)	11.16±1.41		
Farmer	44 (15.7)	11.98±1.16	11.14, 12.83	
Self employed	29 (10.4)	12.20±0.98	11.93, 12.47	
Casual labourer	25 (8.9)	11.99±0.92	11.47, 12.52	
Housewife	176 (62.9)	11.99±1.12	11.91, 12.07	
Education of the HHH				**.5**
No education	59 (20.1)	12.08±1.10	12.07, 12.10	
Primary incomplete	135 (46.1)	11.91±1.15	11.80, 12.03	
Primary complete	29 (9.9)	12.22±1.08	12.08, 12.36	
Secondary education +	70 (23.9)	12.02±0.99	11.85, 12.19	
Education of the mother				**.75**
No education	4 (1.4)	11.58±1.11	10.51, 12.67	
Primary incomplete	47 (16.7)	11.88±1.18	11.64, 12.12	
Primary complete	190 (67.4)	12.01±1.09	11.96, 12.06	
Secondary education +	41 (14.5)	12.05±1.09	12.02, 12.08	
Household size				**.87**
2-3 members	17 (5.8)	12.58±0.95	11.87, 13.29	
4-5 members	76 (25.9)	11.95±1.02	11.81, 12.10	
6-7 members	104 (35.5)	11.93±1.09	11.75, 12.12	
8-9 members	63 (21.5)	12.09±1.14	12.07, 12.12	
10 and more	33 (11.3)	11.88±1.22	11.83, 11.94	
No of meals				**.19**
1-2 (low)	19 (6.5)	12.33±.098	11.95, 12.71	
3-4 (medium)	257 (88.0)	11.96±1.09	11.88, 12.04	
5-6 (high)	16 (5.5)	12.32±1.38	12.02, 12.61	
Vitamin A Supplementation				**.9**
Yes	200 (68.3)	12.01±1.12	11.78, 12.24	
No	93 (31.7)	11.99±1.05	11.83, 12.16	
De-worming				**.53**
Yes	91 (31.1)	11.94±1.28	11.65, 12.24	
No	202 (68.9)	12.03±1.01	11.99, 12.07	
Breastfeeding				**.02***
Yes	68 (23.3)	11.73±1.32	11.50, 11.97	
No	224 (76.7)	12.09±1.01	12.02, 12.16	
Non heme iron source				**.15**
Yes	213 (72.9)	12.06±1.07	12.03, 12.10	
No	79 (27.1)	11.85±1.17	11.51, 12.20	
Either heme or non heme iron source				**.21**
Yes	220 (75.3)	12.05±1.06	11.96, 12.14	
No	72 (24.7)	11.86±1.20	11.67, 12.06	

[§]Haemoglobin adjusted for altitude and ethnicity

*Significance difference in occurrence of anaemia

Appendix 10: Anaemia and Associated Factors

Characteristics of the pre-school children	N (%)	Anaemia[§] % (95% C.I.)	Bivariate Analysis	
			Odds Ratio (95%C.I.)	p-value
Total	293	16.7 (12.6, 21.5)		
Iron Status			3.47 (1.75, 6.89)	.0004*
ID	77 (29.5)	28.6 (18.8, 40.0)		
Normal	184 (70.5)	10.3 (6.3, 15.7)		
Age Group			1.04 (1.01, 1.07)	.004*
12 – 23	89 (30.4)	25.8 (17.1, 36.2)		
24 – 35	113 (38.6)	13.3 (7.6, 20.9)		
36 – 47	56 (19.1)	16.1 (7.6, 28.3)		
48 - 59	35 (11.9)	5.7 (0.7, 19.2)		
Sex			0.94 (0.51, 1.74)	.855
Male	147 (50.6)	16.3 (10.7, 23.3)		
Female	146 (49.4)	17.1 (11.4, 24.2)		
DDS			4.25 (1.10, 16.44)	.036*
Low (≤3 food groups)	8 (2.7)	50.0 (15.7, 84.3)		
Medium (4-5 food groups)	80 (27.4)	15 (8, 24.7)		
High (≥6 food groups)	204 (69.9)	16.2 (11.4, 22.0)		
HAZ Scores (WHO)			3.57 (1.74, 7.31)	.0005*
Stunted	158(53.9)	24.1 (17.6, 31.5)		
Not Stunted	135 (46.1)	8.1 (4.1, 14.1)		
WAZ Scores (WHO)			1.93 (1.04, 3.59)	.037*
Underweight	105 (35.8)	22.9 (15.2, 32.1)		
Not Underweight	188 (64.2)	13.3 (8.8, 19.0)		
WHZ Scores (WHO)			1.53 (0.62, 3.77)	0.358
Wasted	31 (10.6)	22.6 (9.6, 41.1)		
Not Wasted	262 (89.4)	16.0 (11.8, 21.0)		
Malaria infection			0.27 (0.04, 2.09)	.211
Infected	18 (6.2)	5.6 (0.1, 27.3)		
Not Infected	270 (93.8)	17.8 (13.4, 22.9)		
Marital status of mother			1.46 (0.64, 3.29)	.366
Married	229 (81.2)	17 (12.4, 22.5)		
Unmarried	53 (18.8)	17 (8.1, 29.8)		
Marital status of Household Head			1.00 (0.45, 2.22)	.99
Married	231 (78.8)	17.7 (13.0, 23.3)		
Unmarried	62 (21.2)	12.9 (5.7, 23.9)		
Marital type			1.72 (0.53, 5.57)	.367
Monogamous	277 (94.5)	16.2 (12.1, 21.1)		
Polygamous	16 (5.5)	25.0 (7.3, 52.4)		
Infection (CRP)			0.92 (0.45, 1.86)	.814
Infected	176 (67.4)	15.3 (10.4, 21.5)		
Normal	85 (32.6)	16.5 (9.3, 26.1)		
Main source of food			1.73 (0.93, 3.20)	.084
Farm	128 (43.8)	21.1 (14.4, 29.2)		
Market	164 (56.2)	13.4 (8.6, 19.6)		
Birth order			0.83 (0.73, 0.94)	.004*
1st and 2nd	145 (49.5)	7.6 (3.8, 13.2)		
3rd and 4th	85 (29.0)	25.9 (17.0, 36.5)		
5th and above	63 (21.5)	25.4 (15.3, 37.9)		
Immunization			2.45 (1.08, 5.55)	.03*
partial immunized	33 (11.3)	30.3 (15.6, 48.7)		
Fully immunized	259 (88.7)	15.1 (10.9, 20.0)		
Morbidity experience			0.98 (0.48, 2.01)	.963
Sick last 2wks	222 (78.8)	16.7 (12.0, 22.2)		
Well last 2wks	71 (24.2)	16.9 (9.0, 27.7)		
Occupation of Household Head			0.76 (0.41, 1.40)	.376
Salaried	56 (19.1)	12.5 (5.2, 24.1)		
Farmer	80 (27.3)	10.0 (4.4, 18.8)		
Self employed	59 (20.1)	25.4 (15.0, 38.4)		
Casual labourer	73 (24.9)	19.2 (10.9, 30.1)		

Housewife	25 (8.5)	20.0 (6.8, 40.7)		
Occupation of the Mother			**1.28 (0.47, 3.48)**	**.632**
Salaried	6 (2.1)	50.0 (18.8, 88.2)		
Farmer	44 (15.7)	13.6 (5.2, 27.4)		
Self employed	29 (10.4)	6.9 (0.8, 22.8)		
Casual labourer	25 (8.9)	12.0 (2.5, 31.2)		
Housewife	176 (62.9)	19.3 (13.8, 25.9)		
Education of the Household Head			**0.81 (0.42, 1.62)**	**.558**
No education	59 (20.1)	15.3 (7.2, 27.0)		
Primary incomplete	135 (46.1)	20.7 (14.2, 28.6)		
Primary complete	29 (9.9)	13.8 (3.9, 31.7)		
Secondary education +	70 (23.9)	11.4 (5.1, 21.3)		
Education of the mother			**1.42 (0.65, 3.10)**	**.38**
No education	4 (1.4)	25 (0.6, 80.6)		
Primary incomplete	47 (16.7)	21.3 (10.7, 35.7)		
Primary complete	190 (67.4)	16.3 (11.4, 22.4)		
Secondary education +	41 (14.5)	14.6 (5.6, 29.2)		
Household size			**0.89 (0.78, 1.01)**	**.668**
2-3 members	17 (5.8)	5.9 (0.1, 28.7)		
4-5 members	76 (25.9)	15.8 (8.4, 26.0)		
6-7 members	104 (35.5)	15.4 (9.1, 23.8)		
8-9 members	63 (21.5)	19.0 (10.2, 30.9)		
10 and more	33 (11.3)	24.2 (11.1, 42.3)		
No of meals			**1.04 (0.68, 1.58)**	**.864**
1-2 (low)	19 (6.5)	10.5 (1.3, 33.1)		
3-4 (medium)	257 (88.0)	17.1 (12.7, 22.3)		
5-6 (high)	16 (5.5)	18.8 (4.0, 45.6)		
Vitamin A supplementation			**0.76 (0.40, 1.45)**	**.411**
Yes	200 (68.3)	15.5 (10.8, 21.3)		
No	93 (31.7)	19.4 (11.9, 28.9)		
De-worming			**1.36 (0.72, 2.59)**	**.348**
Yes	91 (31.1)	19.8 (12.2, 29.4)		
No	202 (68.9)	15.3 (10.7, 21.1)		
Breastfeeding			**2.80 (1.46, 5.37)**	**.002***
Yes	68 (23.3)	29.4 (19.0, 41.7)		
No	224 (76.7)	12.9 (8.8, 18.1)		
Non heme iron source			**0.52 (0.27, 0.99)**	**.045***
Yes	213 (72.9)	14.1 (9.7, 19.5)		
No	79 (27.1)	24.1 (15.1, 35.0)		
Either heme or non heme iron source			**0.44(0.23, 0.84)**	**.014***
Yes	220 (75.3)	13.6 (9.4, 18.9)		
No	72 (24.7)	26.4 (16.7, 38.1)		

[§]Anaemia adjusted for altitude and ethnicity

*significance difference in Hb concentration

Appendix 11: Serum Ferritin Concentration and Mean difference

Characteristics of the pre-school children	N (%)	Serum Ferritin(µg/L)[$] Mean** ±SD	(95% CI)	Mean Difference (P-value)
Total	261	18.67±2.31	16.86, 20.67	
Age Group				.0000*
12 – 23	72 (27.6)	13.92±2.28	11.47, 16.90	
24 – 35	107 (41.0)	17.89±2.28	15.28, 20.95	
36 – 47	49 (18.8)	22.82±2.29	17.98, 28.97	
48 - 59	33 (12.6)	30.16±1.89	24.05, 37.82	
Sex				.37
Male	128 (49.0)	19.58±2.31	16.92, 22.67	
Female	133 (51.0)	17.83±2.31	15.44, 20.59	
DDS				.84
Low (≤3 food groups)	7 (2.7)	22.18±3.68	6.64, 74.10	
Medium (4-5 food groups)	71 (27.3)	18.26±2.07	15.38, 21.69	
High (≥6 food groups)	182 (70.0)	18.64±2.37	16.44, 21.15	
HAZ (WHO)				.97
Stunted	136 (52.1)	18.63±2.43	16.03, 21.66	
Normal	125 (47.9)	18.71±2.19	16.29, 21.49	
WAZ (WHO)				.86
Under weight	95 (36.4)	18.44±2.56	15.22, 22.34	
Normal	166 (63.6)	18.80±2.17	16.70, 21.17	
WHZ (WHO)				.51
Wasted	28 (10.7)	16.91±2.53	11.79, 24.25	
Normal	233 (89.3)	18.89±2.29	16.98, 21.02	
Malaria infection				.57
Infected	16 (6.2)	20.99±1.91	14.86, 29.65	
Not Infected	242 (93.8)	18.57±2.34	16.67, 20.68	
Marital status of mother				.08
Married	206 (82.4)	17.64±2.32	15.71, 19.81	
Unmarried	44 (17.6)	22.49±2.30	17.46, 28.97	
Marital status of Household Head				.80
Married	206 (78.9)	18.80±2.28	16.79, 21.05	
Unmarried	55 (21.1)	18.19±2.46	14.27, 23.19	
Marital type				.14
Monogamous	246 (94.3)	25.53±2.40	15.73, 41.42	
Polygamous	15 (5.7)	18.31±2.30	16.50, 20.34	
Infection (CRP)				.995
Normal	176 (67.4)	18.66±2.43	16.36, 21.30	
Infected	85 (32.6)	18.68±2.07	15.97, 21.85	
Main source of food				.84
Farm	113 (43.5)	18.93±2.47	15.99, 22.40	
Market	147 (56.5)	18.52±2.20	16.29, 21.05	
Birth order				.88
1st and 2nd	127 (48.7)	19.17±2.40	16.44, 22.35	
3rd and 4th	79 (30.3)	18.32±2.24	15.29, 21.96	
5th and above	55 (21.1)	18.03±2.24	14.50, 22.42	
Immunization				.39
Fully immunized	250 (96.2)	18.53±2.27	16.73, 20.53	
Not fully immunized	10 (3.8)	23.40±3.40	9.74, 56.21	
Morbidity experience				.88
Sick last 2wks	198 (75.9)	18.59±2.41	16.43, 21.03	
Well last 2wks	63 (24.1)	18.93±1.99	15.91, 22.52	
Occupation of Household Head				.46
Salaried	52 (19.9)	22.03±2.21	17.67, 27.46	
Farmer	72 (27.6)	19.48±2.21	16.17, 23.48	
Self employed	53 (20.3)	17.23±2.32	13.66, 21.74	
Casual labourer	63 (24.1)	16.99±2.53	13.45, 21.46	
Housewife	21 (8.0)	17.38±2.22	12.09, 24.99	
Occupation of the Mother				.56
Salaried	6 (2.4)	19.84±3.11	6.03, 65.30	

Farmer	42 (16.9)	17.74±2.79	12.88, 24.43	
Self employed	23 (9.2)	22.75±2.66	14.91, 34.71	
Casual labourer	21 (8.4)	22.16±1.87	16.69, 29.44	
Housewife	157 (63.1)	17.59±2.19	15.54, 19.91	
Education of the Household Head				**.051**
No education	52 (19.9)	18.79±2.37	14.77, 23.90	
Primary incomplete	25 (9.6)	28.62±1.91	21.89, 37.39	
Primary complete	120 (46.0)	17.16±2.45	14.60, 2017	
Secondary education +	64 (24.5)	18.40±2.08	15.33, 22.07	
Education of the mother				**.87**
No education	4 (1.6)	16.92±1.83	6.48, 44.15	
Primary incomplete	43 (17.2)	17.23±2.38	13.19, 22.51	
Primary complete	167 (66.8)	18.40±2.37	16.13, 20.99	
Secondary education +	36 (14.4)	20.18±2.14	15.59, 26.12	
Household size				**.67**
2-3 members	15 (5.7)	17.79±2.08	11.86, 26.69	
4-5 members	72 (27.6)	17.36±2.45	14.06, 21.44	
6-7 members	92 (35.2)	20.30±2.48	16.83, 24.50	
8-9 members	50 (19.2)	19.50±2.22	15.56, 24.45	
10 and more	32 (12.3)	16.49±1.77	13.42, 20.27	
No of meals				**.32**
1-2 (low)	17 (6.5)	20.94±2.04	14.51, 30.21	
3-4 (medium)	228 (87.7)	18.12±2.33	16.23, 20.23	
5-6 (high)	15 (5.8)	24.72±2.39	15.27, 40.01	
Vitamin A supplementation				**.22**
Yes	175 (67.0)	17.86±2.32	15.75, 20.24	
No	86 (33.0)	20.44±2.29	17.11, 24.42	
De-worming				**.05**
Yes	84 (32.2)	21.61±2.67	17.46, 26.75	
No	177 (67.8)	17.41±2.12	15.58, 19.47	
Breastfeeding				**.0007***
Yes	55 (21.2)	14.20±2.42	11.18, 18.03	
No	205 (78.8)	20.04±2.25	17.91, 22.41	

[§]Serum ferritin corrected for infection

*shows the significant P-Values

**Geometric mean

Appendix 12: Iron Deficiency and Associated Factors

Characteristics of the pre-school children	N (%)	Iron Deficiency % (95% CI)	Bivariate Analysis OR (95%CI)	P -value
Total	261	29.5 (24.0, 35.4)		
Age Group			1.08 (1.03, 1.09)	.0000*
12 – 23	72 (27.6)	44.4 (32.7, 56.6)		
24 – 35	107 (41.0)	31.8 (23.1, 41.5)		
36 – 47	49 (18.8)	16.3 (7.3, 29.7)		
48 - 59	33 (12.6)	9.1 (1.9, 24.3)		
Sex			0.88 (0.52, 1.50)	.63
Male	128 (49.0)	28.1 (20.5, 36.8)		
Female	133 (51.0)	30.8 (23.1, 39.4)		
DDS			0.79 (0.16, 4.10)	.78
Low (≤3 food groups)	7 (2.7)	28.6 (3.7, 71.0)		
Medium (4-5 food groups)	71 (27.3)	26.8 (16.9, 38.6)		
High (≥6 food groups)	182 (70.0)	30.8 (24.2, 38.0)		
HAZ Scores (WHO)			1.07 (0.63, 1.82)	.81
Stunted	136 (52.1)	30.1 (22.6, 38.6)		
Not Stunted	125 (47.9)	28.8 (21.1, 37.6)		
WAZ Scores (WHO)			1.17 (0.68, 2.02)	.58
Underweight	95 (36.4)	31.6 (22.4, 41.9)		
Not Underweight	166 (63.6)	28.3 (21.6, 35.8)		
WHZ Scores (WHO)			0.95 (0.40, 2.26)	.91
Wasted	28 (10.7)	28.6 (13.2, 48.7)		
Not wasted	233 (89.3)	29.6 (23.8, 35.9)		
Malaria infection			0.53 (0.15, 1.93)	.34
Infected	16 (6.2)	18.8 (4.0, 45.6)		
Not Infected	242 (93.8)	30.2 (24.5, 36.4)		
Marital status of mother			1.87 (0.85, 4.12)	.12
Married	206 (82.4)	32.5 (26.2, 39.4)		
Unmarried	44 (17.6)	20.5 (9.8, 35.3)		
Marital status of Household Head			0.74 (0.39, 1.40)	.36
Married	206 (78.9)	28.2 (22.1, 34.8)		
Unmarried	55 (21.1)	34.5 (22.2, 48.6)		
Marital type			0.58 (0.16, 2.12)	.41
Monogamous	246 (94.3)	30.1 (24.4, 36.2)		
Polygamous	15 (5.7)	20.0 (4.3, 48.1)		
Infection (CRP)			1.10 (0.62, 1.94)	.76
Normal	176 (67.4)	30.1 (23.4, 37.5)		
Infected	85 (32.6)	28.2 (19.0, 39.0)		
Main source of food			0.90 (0.52, 1.54)	.69
Farm	113 (43.5)	28.3 (20.2, 37.6)		
Market	147 (56.5)	30.6 (23.3, 38.7)		
Birth order			0.97 (0.86, 1.09)	.58
1st and 2nd	127 (48.7)	26.8 (19.3, 35.4)		
3rd and 4th	79 (30.3)	30.4 (20.5, 41.8)		
5th and above	55 (21.1)	34.5 (22.2, 48.6)		
Immunization			0.58 (0.12, 2.81)	.50
Fully immunized	250 (96.2)	30.0 (24.4, 36.1)		
Not fully immunized	10 (3.8)	20.0 (2.5, 55.6)		
Morbidity experience			1.31 (0.69, 2.49)	.41
Sick last 2wks	198 (75.9)	30.8 (24.5, 37.7)		
Well last 2wks	63 (24.1)	25.4 (15.3, 37.6)		
Occupation of Household Head			0.71 (0.39, 1.30)	.27
Salaried	52 (19.9)	21.2 (11.1, 34.7)		
Farmer	72 (27.6)	29.2 (19.0, 41.1)		
Self employed	53 (20.3)	32.1 (19.9, 46.3)		
Casual labourer	63 (24.1)	34.9 (23.3, 48.0)		
Housewife	21 (8.0)	28.6 (11.3, 52.2)		
Occupation of the Mother			1.75 (0.68, 4.49)	.24
Salaried	6 (2.4)	16.7 (0.4, 64.1)		
Farmer	42 (16.9)	35.7 (21.6, 52.0)		

Self employed	23 (9.2)	21.7 (7.5, 43.7)		
Casual labourer	21 (8.4)	19.0 (5.4, 41.9)		
Housewife	157 (63.1)	31.8 (24.6, 39.7)		
Education of the Household Head			**0.71 (0.39,1.30)**	**.27**
No education	52 (19.9)	32.7 (20.3, 47.1)		
Primary incomplete	25 (9.6)	8.0 (1.0, 26.0)		
Primary complete	120 (46.0)	33.3 (25.0, 42.5)		
Secondary education +	64 (24.5)	28.1 (17.6, 40.8)		
Education of the mother			**1.28 (0.64, 2.56)**	**.49**
No education	4 (1.6)	25.0 (0.6, 80.6)		
Primary incomplete	43 (17.2)	34.9 (21.0, 50.9)		
Primary complete	167 (66.8)	31.1 (24.2, 38.8)		
Secondary education +	36 (14.4)	22.2 (10.1, 39.2)		
Household size			**1.01 (0.90, 1.13)**	**.89**
2-3 members	15 (5.7)	26.7 (7.8, 55.1)		
4-5 members	72 (27.6)	33.3 (22.7, 45.4)		
6-7 members	92 (35.2)	29.3 (20.3, 39.8)		
8-9 members	50 (19.2)	26.0 (14.6, 40.3)		
10 and more	32 (12.3)	28.1 (13.7, 46.7)		
No of meals			**1.05 (0.73, 1.51)**	**.81**
1-2 (low)	17 (6.5)	23.5 (6.8, 49.9)		
3-4 (medium)	228 (87.7)	30.7 (24.8, 37.1)		
5-6 (high)	15 (5.8)	20.0 (4.3, 48.1)		
Vitamin A supplementation			**1.03 (0.59, 1.82)**	**.91**
Yes	175 (67.0)	29.7 (23.1, 37.1)		
No	86 (33.0)	29.1 (19.8, 39.9)		
De-worming			**0.79 (0.44, 1.41)**	**.42**
Yes	84 (32.2)	26.2 (17.2, 36.9)		
No	177 (67.8)	31.1 (24.3, 38.5)		
Breastfeeding			**2.22 (1.20, 4.12)**	**.01***
Yes	55 (21.2)	43.6 (30.3, 57.7)		
No	205 (78.8)	25.9 (20.0, 32.4)		

[$]Iron deficiency adjusted for infection

*significant difference in occurrence of ID

Appendix 13: HAZ Scores and Mean Differences

Characteristics of the pre-school children	N (%)	HAZ Scores		Difference in Means
		Mean ±SD	95% CI	*P* - value
Total	292	-2.12±1.11	-2.47,-1.77	
Iron Status				.78
ID	77 (29.5)	-2.10±1.18	-2.39, -1.81	
Normal	184 (70.5)	-2.06±1.02	-2.39, -1.73	
Age Group				.71
12 – 23	89 (30.4)	-2.08±1.11	-2.42, -1.74	
24 – 35	113 (38.6)	-2.07±1.10	-2.35, -1.79	
36 – 47	56 (19.1)	-2.16±0.99	-2.57, -1.75	
48 - 59	35 (11.9)	-2.31±1.33	-2.82, -1.80	
Sex				.94
Male	147 (50.6)	-2.11±1.10	-2.46, -1.77	
Female	146 (49.4)	-2.12±1.12	-2.47, -1.78	
DDS				.81
Low (≤3 food groups)	8 (2.7)	-2.33±1.18	-3.02, -1.64	
Medium (4-5 food groups)	80 (27.4)	-2.07±1.03	-2.32, -1.83	
High (≥6 food groups)	204 (69.9)	-2.13±1.14	-2.50, -1.76	
WAZ Scores (WHO)				.000*
Underweight	105 (35.8)	-2.90±0.77	-3.01, -2.78	
Normal	188 (64.2)	-1.69±1.03	-2.20, -1.17	
Marital status of mother				.46
Married	229 (81.2)	-2.10±1.05	-2.39, -1.82	
Unmarried	53 (18.8)	-2.23±1.33	-2.73, -1.73	
Marital status of HHH				.44
Married	231 (78.8)	-2.15±1.14	-2.57, -1.72	
Unmarried	62 (21.2)	-2.02±0.99	-2.12, -1.93	
Marital type				.63
Monogamous	277 (94.5)	-2.11±1.13	-2.45, -1.86	
Polygamous	16 (5.5)	-2.25±0.73	-2.64, -1.86	
Main source of food				.90
Farm	128 (43.8)	-2.13±1.14	-2.49, -1.77	
Market	164 (56.2)	-2.11±1.09	-2.46, -1.76	
Birth order				.004*
1st and 2nd	145 (49.5)	-1.91±1.09	-2.48, -1.34	
3rd and 4th	85 (29.0)	-2.35±1.16	-2.46, -2.25	
5th and above	63 (21.5)	-2.30±1.00	-2.40, -2.19	
Immunization				.64
Fully immunized	280 (95.9)	-2.11±1.12	-2.48, -1.75	
Partially immunized	12 (4.1)	-2.26±0.87	-2.30, -2.23	
Occupation of Household Head				.70
Salaried	56 (19.1)	-2.02±0.98	-2.36, 1.69	
Farmer	80 (27.3)	-2.10±1.15	-2.40, -1.80	
Self employed	59 (20.1)	-2.30±1.24	-2.70, -1.89	
Casual labourer	73 (24.9)	-2.11±1.14	-2.52, -1.70	
Housewife	25 (8.5)	-2.01±0.83	-2.21, -1.82	
Occupation of the Mother				0.08
Salaried	6 (2.1)	-2.64±1.13		
Farmer	44 (15.7)	-1.99±1.14	-2.47, -1.51	
Self employed	29 (10.4)	-1.72±1.07	-1.73, -1.70	
Casual labourer	25 (8.9)	-2.46±1.06	-2.57, -2.35	
Housewife	176 (62.9)	-2.15±1.10	-2.47, -1.82	
Education of the Household Head				.47
No education	59 (20.1)	-2.08±0.97	-2.71, -1.45	
Primary incomplete	135 (46.1)	-2.23±1.24	-2.45, -2.00	
Primary complete	29 (9.9)	-2.01±0.91	-2.17, -1.86	
Secondary education +	70 (23.9)	-1.99±1.04	-2.37, -1.61	
Education of the mother				.23

No education	4 (1.4)	-1.47±1.01	-2.73, -0.20	
Primary incomplete	47 (16.7)	-2.10±1.11	-2.46, -1.74	
Primary complete	190 (67.4)	-2.20±1.10	-2.47, -1.93	
Secondary education +	41 (14.5)	-1.88±1.13	-2.26, -1.50	
Household size				**.03***
2-3 members	17 (5.8)	-1.43±0.97	-1.73, -1.13	
4-5 members	76 (25.9)	-1.98±1.13	-2.03, -1.93	
6-7 members	104 (35.5)	-2.18±1.04	-2.65, -1.70	
8-9 members	63 (21.5)	-2.30±1.22	-2.87, -1.74	
10 and more	33 (11.3)	-2.27±1.03	-2.58, -1.95	
No of meals				**.69**
1-2 (low)	19 (6.5)	-2.12±1.01	-2.72, -1.51	
3-4 (medium)	257 (88.0)	-2.13±1.13	-2.46, -1.81	
5-6 (high)	16 (5.5)	-1.89±0.94	-2.52, -1.25	
Vitamin A supplementation				**.09**
Yes	200 (68.3)	-2.04±1.14	-2.36, -1.73	
No	93 (31.7)	-2.28±1.02	-2.60, -1.96	
De-worming				**.12**
Yes	91 (31.1)	-1.97±1.00	-2.14, -1.80	
No	202 (68.9)	-2.19±1.15	-2.57, -1.81	
Breastfeeding				**.26**
Yes	68 (23.3)	-1.99±1.07	-2.45, -1.52	
No	224 (76.7)	-2.16±1.12	-2.47, -1.84	

*P- Values showing significance difference

Appendix 14: Stunting and Associated Factors

Characteristics of the pre-school children	N (%)	Stunting % (95% CI)	Bivariate Analysis Odds Ratio (95%CI)	P -value
Total	292	53.8 (32.9, 73.4)		
Iron Status			**1.07 (0.63, 1.82)**	**.81**
ID	77 (29.5)	53.2 (41.5, 64.7)		
Normal	184 (70.5)	51.6 (44.2, 59.0)		
Age Group			**0.99 (0.98, 1.01)**	**.60**
12 – 23	89 (30.4)	57.3 (46.4, 67.7)		
24 – 35	113 (38.6)	51.3 (41.7, 60.8)		
36 – 47	56 (19.1)	48.2 (34.7, 62.0)		
48 - 59	35 (11.9)	62.9 (44.9, 78.5)		
Sex			**0.98(0.62, 1.56)**	**.95**
Male	147 (50.6)	53.7 (45.3, 62.0)		
Female	146 (49.4)	54.1 (45.7, 62.4)		
DDS			**1.74(0.43, 7.08)**	**0.44**
Low (≤3 food groups)	8 (2.7)	62.5 (24.5, 91.5)		
Medium (4-5 food groups)	80 (27.4)	55.0 (43.5, 66.2)		
High (≥6 food groups)	204 (69.9)	52.9 (45.8, 59.9)		
WAZ scores (WHO)			**14.67(7.49,28.72)**	**.000***
Underweight	105 (35.8)	88.6 (80.9, 94.0)		
Normal	188 (64.2)	34.6 (27.8, 41.8)		
Marital status of mother			**0.91(0.50, 1.65)**	**.75**
Married	229 (81.2)	54.1(47.5, 60.7)		
Unmarried	53 (18.8)	56.6 (42.3, 70.2)		
Marital status of Household Head			**1.04(0.59, 1.82)**	**0.90**
Married	231 (78.8)	54.1(47.5, 60.7)		
Unmarried	62 (21.2)	53.2 (40.1, 66.0)		
Marital type			**1.45(0.51, 4.11)**	**.48**
Monogamous	277 (94.5)	53.4 (47.4, 59.4)		
Polygamous	16 (5.5)	62.5(35.4, 84.8)		
Main source of food			**0.90(0.57, 1.44)**	**.67**
Farm	128 (43.8)	52.3 (43.3, 61.2)		
Market	164 (56.2)	54.9 (46.9, 62.6)		
Birth order			**0.93(0.84, 1.04)**	**.20**
1st and 2nd	145 (49.5)	46.2 (37.9, 54.7)		
3rd and 4th	85 (29.0)	64.7 (53.6, 74.8)		
5th and above	63 (21.5)	57.1 (44.0, 69.5)		
Immunization			**1.21(0.38, 3.91)**	**.75**
Fully immunized	280 (95.9)	53.6 (47.5, 59.5)		
Partially immunized	12 (4.1)	58.3 (27.7, 84.8)		
Occupation of Household Head			**0.94(0.59, 1.51)**	**.81**
Salaried	56 (19.1)	42.9(29.7, 56.8)		
Farmer	80 (27.3)	53.8(42.2, 65.0)		
Self employed	59 (20.1)	66.1(52.6, 77.9)		
Casual labourer	73 (24.9)	53.4(41.4, 65.2)		
Housewife	25 (8.5)	52.0(31.3, 72.2)		
Occupation of the Mother			**1.48(0.73, 3.02)**	**.18**
Salaried	6 (2.1)	66.7(22.3, 95.7)		
Farmer	44 (15.7)	47.7(32.5, 63.3)		
Self employed	29 (10.4)	41.4(23.5, 61.1)		
Casual labourer	25 (8.9)	52.0(31.3, 72.2)		
Housewife	176 (62.9)	58.0(50.3, 65.3)		
Education of the Household Head			**0.85(0.52, 1.41)**	**.31**
No education	59 (20.1)	52.5(39.1, 65.7)		
Primary incomplete	135 (46.1)	58.5(49.7, 66.9)		
Primary complete	29 (9.9)	48.3(29.4, 67.5)		
Secondary education +	70 (23.9)	48.6(36.4, 60.8)		

Education of the mother			**1.01(0.54, 1.91)**	**.94**
No education	4 (1.4)	25.0(0.6, 80.6)		
Primary incomplete	47 (16.7)	55.3(40.1, 69.8)		
Primary complete	190 (67.4)	56.3(48.9, 63.5)		
Secondary education +	41 (14.5)	48.8(32.9, 64.9)		
Household size			**0.92(0.83, 1.02)**	**.10**
2-3 members	17 (5.8)	23.5(6.8, 49.9)		
4-5 members	76 (25.9)	50.0(38.3, 61.7)		
6-7 members	104 (35.5)	59.6(49.5, 69.1)		
8-9 members	63 (21.5)	55.6(42.5, 68.1)		
10 and more	33 (11.3)	57.6(39.2, 74.5)		
No of meals			**1.18(0.86, 1.62)**	**.32**
1-2 (low)	19 (6.5)	57.9(33.5, 79.7)		
3-4 (medium)	257 (88.0)	54.7(48.6, 61.1)		
5-6 (high)	16 (5.5)	31.3(11.0, 58.7)		
Vitamin A supplementation			**0.78(0.48, 1.29)**	**.33**
Yes	200 (68.3)	52.0(44.8, 59.1)		
No	93 (31.7)	58.1(47.4, 68.2)		
De-worming			**1.00(0.61, 1.64)**	**.99**
Yes	91 (31.1)	53.8(43.1, 64.4)		
No	202 (68.9)	54.0(46.8, 61.0)		
Breastfeeding			**0.76(0.44, 1.31)**	**.32**
Yes	68 (23.3)	48.5(36.2, 61.0)		
No	224 (76.7)	55.4(48.6, 62.0)		

*P-values showing significance difference

Appendix 15: WAZ Scores and Mean Differences

Characteristics of the pre-school children	N (%)	WAZ Scores		Difference in Means
		Mean ±SD	95% CI)	*P* - value
Total	293	-1.65±0.99	-1.70, -1.61	
Iron Status				.45
ID	77 (29.5)	-1.57±1.13	-1.86, -1.52	
Normal	184 (70.5)	-1.68±0.94	-1.71, -1.65	
Age Group				.35
12 – 23	89 (30.4)	-1.59±1.06	-1.61, -1.58	
24 – 35	113 (38.6)	-1.57±0.99	-1.67, -1.48	
36 – 47	56 (19.1)	-1.80±0.92	-1.87, -1.74	
48 - 59	35 (11.9)	-1.82±0.87	-1.87, -1.77	
Sex				.93
Male	147 (50.6)	-1.65±0.95	-1.67, -1.62	
Female	146 (49.4)	-1.66±1.03	-1.72, -1.59	
DDS				.84
Low (≤3 food groups)	8 (2.7)	-1.79±1.68	-2.55, -1.03	
Medium (4-5 food groups)	80 (27.4)	-1.61±1.00	-1.68, -1.55	
High (≥6 food groups)	204 (69.9)	-1.67±0.95	-1.72, -1.62	
HAZ Scores (WHO)				.000*
Stunted	158(53.9)	-2.20±0.78	-2.34, -2.05	
Normal	135 (46.1)	-1.01±0.80	-1.04, -0.99	
WHZ Scores (WHO)				.000*
Wasted	31 (10.6)	-2.88±0.62	-2.89, -2.88	
Normal	262 (89.4)	-1.51±0.92	-1.66, -1.36	
Malaria infection				.11
Infected	18 (6.2)	-2.01±0.94	-2.21, -1.82	
Not Infected	270 (93.8)	-1.63±0.99	-1.72, -1.53	
Marital status of mother				.85
Married	229 (81.2)	-1.66±0.99	-1.71, -1.61	
Unmarried	53 (18.8)	-1.63±0.98	-1.65, -1.61	
Marital status of Household Head				.82
Married	231 (78.8)	-1.65±1.00	-1.74, -1.55	
Unmarried	62 (21.2)	-1.68±0.94	-1.83, -1.52	
Marital type				.93
Monogamous	277 (94.5)	-1.67±0.82	-1.67, -1.63	
Polygamous	16 (5.5)	-1.65±0.99	-2.16, -1.19	
Infection (CRP)				.34
Infected	176 (67.4)	-1.61±0.99	-1.70, -1.51	
Normal	85 (32.6)	-1.73±1.01	-2.02, -1.45	
Main source of food				.67
Farm	128 (43.8)	-1.62±1.02	-1.63, -1.61	
Market	164 (56.2)	-1.67±0.95	-1.75, -1.58	
Birth order				.07
1st and 2nd	145 (49.5)	-1.52±1.05	-1.72, -1.32	
3rd and 4th	85 (29.0)	-1.80±0.85	-1.93, -1.67	
5th and above	63 (21.5)	-1.75±0.96	-1.98, -1.53	
Immunization				.36
Fully immunized	280 (95.9)	-1.64±0.99	-1.71, -1.57	
Partially immunized	12 (4.1)	-1.90±0.77	-2.45, -1.36	
Morbidity experience				.32
Sick last 2wks	222 (78.8)	-1.68±1.00	-1.79, -1.58	
Well last 2wks	71 (24.2)	-1.55±0.92	-1.70, -1.40	
Occupation of Household Head				.02*
Salaried	56 (19.1)	-1.33±0.92	-1.53, -1.14	
Farmer	80 (27.3)	-1.69±1.00	-1.72, -1.66	
Self employed	59 (20.1)	-1.75±0.89	-1.83, -1.68	
Casual labourer	73 (24.9)	-1.86±1.10	-1.93, 1.78	
Housewife	25 (8.5)	-1.41±0.77	-1.56, -1.26	
Occupation of the Mother				.038*
Salaried	6 (2.1)	-1.60±0.93		
Farmer	44 (15.7)	-1.62±0.98	-1.64, -1.60	

Self employed	29 (10.4)	-1.42±0.97	-1.49, -1.36	
Casual labourer	25 (8.9)	-2.22±0.97	-2.42, -2.02	
Housewife	176 (62.9)	-1.62±0.98	-1.70, -1.54	
Education of the Household Head				.48
No education	59 (20.1)	-1.51±0.86	-1.74, -1.28	
Primary incomplete	135 (46.1)	-1.74±1.04	-1.88, -1.60	
Primary complete	29 (9.9)	-1.57±0.92	-1.78, -1.36	
Secondary education +	70 (23.9)	-1.64±1.00	-1.81, -1.47	
Education of the mother				.58
No education	4 (1.4)	-1.00±0.73	-1.65, -0.35	
Primary incomplete	47 (16.7)	-1.69±1.00	-1.91, -1.47	
Primary complete	190 (67.4)	-1.67±0.99	-1.67, -1.67	
Secondary education +	41 (14.5)	-1.61±1.02	-1.65, -1.56	
Household size				.12
2-3 members	17 (5.8)	-1.06±1.26	-1.28, -0.84	
4-5 members	76 (25.9)	-1.66±1.08	-1.69, -1.64	
6-7 members	104 (35.5)	-1.66±0.85	-1.93, -1.38	
8-9 members	63 (21.5)	-1.78±0.93	-1.87, -1.70	
10 and more	33 (11.3)	-1.67±1.07	-2.55, -0.78	
No of meals				.80
1-2 (low)	19 (6.5)	-1.65±1.31	-2.12, -1.18	
3-4 (medium)	257 (88.0)	-1.66±0.98	-1.69, -1.64	
5-6 (high)	16 (5.5)	-1.49±0.71	-1.60, -1.39	
Vitamin A supplementation				.19
Yes	200 (68.3)	-1.60±1.00	-1.62, -1.58	
No	93 (31.7)	-1.76±0.95	-1.88, -1.64	
De-worming				.48
Yes	91 (31.1)	-1.59±0.95	-1.63, -1.56	
No	202 (68.9)	-1.68±1.00	-1.71, -1.65	
Breastfeeding				.20
Yes	68 (23.3)	-1.52±0.94	-1.66, -1.39	
No	224 (76.7)	-1.70±1.00	-1.71, -1.68	

*P-Value showing significance difference

Appendix 16: Underweight and Associated Factors

Characteristics of the pre-school children	N (%)	Underweight % (95% CI)	Bivariate Analysis Odds Ratio (95%CI)	P -value
Total	293	35.8(30.7, 41.4)		
Iron Status			**1.17(0.68, 2.02)**	**.58**
ID	77 (29.5)	39.0(28.0, 50.8)		
Normal	184 (70.5)	35.3(28.4, 42.7)		
Age Group			**1.00(0.97, 1.04)**	**.92**
12 – 23	89 (30.4)	32.6(23.0, 43.3)		
24 – 35	113 (38.6)	33.6(25.0, 43.1)		
36 – 47	56 (19.1)	39.3(26.5, 53.2)		
48 - 59	35 (11.9)	45.7(28.8, 63.4)		
Sex			**1.15(0.71, 1.85)**	**.57**
Male	147 (50.6)	37.4(29.6, 45.8)		
Female	146 (49.4)	34.2(26.6, 42.5)		
DDS			**1.45(0.38, 5.52)**	**.59**
Low (≤3 food groups)	8 (2.7)	50.0(15.7, 84.3)		
Medium (4-5 food groups)	80 (27.4)	36.3(25.8, 47.8)		
High (≥6 food groups)	204 (69.9)	35.3(28.7, 42.3)		
HAZ Scores (WHO)			**14.67(7.49,28.72)**	**.000***
Stunted	158(53.9)	58.9(50.8, 66.6)		
Normal	135 (46.1)	8.9(4.7, 15.0)		
WHZ Scores (WHO)			**22.42(6.63,75.89)**	**.000***
Wasted	31 (10.6)	90.3(74.2, 98.0)		
Normal	262 (89.4)	29.4(23.9, 35.3)		
Malaria infection			**1.50(0.57, 3.92)**	**.41**
Infected	18 (6.2)	44.4(21.5, 69.2)		
Not Infected	270 (93.8)	34.8(29.1, 40.8)		
Marital status of mother			**1.15(0.61, 2.15)**	**.67**
Married	229 (81.2)	37.1(30.8, 43.7)		
Unmarried	53 (18.8)	34.0(21.5, 48.3)		
Marital status of Household Head			**0.72(0.41, 1.28)**	**.26**
Married	231 (78.8)	34.2(28.1, 40.7)		
Unmarried	62 (21.2)	41.9(29.5, 55.2)		
Marital type			**0.58(0.18, 1.85)**	**.36**
Monogamous	277 (94.5)	36.5(30.8, 42.4)		
Polygamous	16 (5.5)	25.0(7.3, 52.4)		
Infection (CRP)			**0.86(0.50, 1.46)**	**.57**
Infected	176 (67.4)	35.2(28.2, 42.8)		
Normal	85 (32.6)	38.8(28.4, 50.0)		
Main source of food			**1.03(0.63, 1.66)**	**.92**
Farm	128 (43.8)	35.9(27.7, 44.9)		
Market	164 (56.2)	35.4(28.1, 43.2)		
Birth order			**0.90(0.67, 1.22)**	**.05**
1st and 2nd	145 (49.5)	34.5(26.8, 42.8)		
3rd and 4th	85 (29.0)	35.3(25.2, 46.4)		
5th and above	63 (21.5)	39.7(27.6, 52.8)		
Immunization			**1.86(0.58, 5.91)**	**.29**
Fully immunized	280 (95.9)	35.0(29.4, 40.9)		
Partially immunized	12 (4.1)	50.0(21.1, 78.9)		
Morbidity experience			**1.45(0.81, 2.58)**	**.21**
Sick last 2wks	222 (78.8)	37.8(31.4, 44.6)		
Well last 2wks	71 (24.2)	29.6(19.3, 41.6)		
Occupation of Household Head			**1.69(1.02, 2.79)**	**.04***
Salaried	56 (19.1)	21.4(11.6, 34.4)		
Farmer	80 (27.3)	41.3(30.4, 52.8)		
Self employed	59 (20.1)	35.6(23.6, 49.1)		
Casual labourer	73 (24.9)	46.6(34.8, 58.6)		
Housewife	25 (8.5)	20.0(6.8, 40.7)		
Occupation of the Mother			**1.77(0.79, 3.94)**	**.16**
Salaried	6 (2.1)	33.3(4.3, 77.7)		

Farmer	44 (15.7)	36.4(22.4, 52.2)		
Self employed	29 (10.4)	24.1(10.3, 43.5)		
Casual labourer	25 (8.9)	52.0(31.3, 72.2)		
Housewife	176 (62.9)	36.4(29.3, 43.9)		
Education of the Household Head			**0.78(0.46, 1.32)**	**.35**
No education	59 (20.1)	30.5(19.2, 43.9)		
Primary incomplete	135 (46.1)	40.0(31.7, 48.8)		
Primary complete	29 (9.9)	34.5(17.9, 54.3)		
Secondary education +	70 (23.9)	32.9(22.1, 45.1)		
Education of the mother			**1.09(0.57, 2.07)**	**.80**
No education	4 (1.4)	25.0(0.6, 80.6)		
Primary incomplete	47 (16.7)	38.3(24.5, 53.6)		
Primary complete	190 (67.4)	36.8(30.0, 44.1)		
Secondary education +	41 (14.5)	34.1(20.1, 50.6)		
Household size			**0.96(0.87, 1.07)**	**.46**
2-3 members	17 (5.8)	23.5(6.8, 49.9)		
4-5 members	76 (25.9)	38.2(27.2, 50.0)		
6-7 members	104 (35.5)	33.7(24.7, 43.6)		
8-9 members	63 (21.5)	36.5(24.7, 49.6)		
10 and more	33 (11.3)	42.4(25.5, 60.8)		
No of meals			**1.30(0.93, 1.82)**	**.12**
1-2 (low)	19 (6.5)	47.4(24.4, 71.1)		
3-4 (medium)	257 (88.0)	35.8(29.9, 42.0)		
5-6 (high)	16 (5.5)	25.0(7.3, 52.4)		
Vitamin A Supplementation			**1.1(0.65, 1.84)**	**.74**
Yes	200 (68.3)	36.5(29.8, 43.6)		
No	93 (31.7)	34.4(24.9, 45.0)		
De-worming			**1.03(0.61, 1.72)**	**.92**
Yes	91 (31.1)	36.3(26.4, 47.0)		
No	202 (68.9)	35.6(29.0, 42.7)		
Breastfeeding			**0.52(0.28, 0.95)**	**0.03***
Yes	68 (23.3)	25.0(15.3, 37.0)		
No	224 (76.7)	39.3(32.8, 46.0)		

*p-value showing significance difference

Appendix 17: WHZ Scores and Mean Differences

Characteristics of the pre-school children	N (%)	WHZ		Difference in Means
		Mean ±SD	95% CI)	*P* - value
Total	293	-0.69±1.03	-0.90, -0.26	
Iron Status				.29
ID	77 (29.5)	-0.72±1.06	-0.77, -0.47	
Normal	184 (70.5)	-0.76±0.94	-1.00, -0.52	
Age Group				.44
12 – 23	89 (30.4)	-0.79±1.10	-1.06, -0.53	
24 – 35	113 (38.6)	-0.58±0.96	-0.67, -0.49	
36 – 47	56 (19.1)	-0.78±0.95	-1.07, -0.49	
48 - 59	35 (11.9)	-0.63±1.16	-1.03, -0.23	
Sex				.49
Male	147 (50.6)	-0.73±1.05	-0.99, -0.48	
Female	146 (49.4)	0.65±1.00	-0.82, -0.48	
DDS				0.96
Low (≤3 food groups)	8 (2.7)	-0.79±1.53	-1.07, -0.51	
Medium (4-5 food groups)	80 (27.4)	-0.69±1.02	-0.97, -0.41	
High (≥6 food groups)	204 (69.9)	-0.69±1.01	-0.91, -0.48	
HAZ Scores (WHO)				.05
Stunted	158(53.9)	-0.80±1.09	-1.06, -0.54	
Normal	135 (46.1)	-0.56±0.94	-0.76, -0.37	
WAZ Scores (WHO)				**.00***
Underweight	105 (35.8)	-1.50±0.75	-1.79, -1.22	
Normal	188 (64.2)	-0.24±0.87	-0.36, -0.11	
Malaria infection				.051
Infected	18 (6.2)	-1.14±0.94	-1.41, -0.87	
Normal	270 (93.8)	-0.65±1.03	-0.83, -0.47	
Marital status of mother				.30
Married	229 (81.2)	-0.72±1.01	-0.88, -0.56	
Unmarried	53 (18.8)	-0.56±1.10	-0.99, -0.13	
Marital status of Household Head				.28
Married	231 (78.8)	-0.66±1.04	-0.87, -0.45	
Unmarried	62 (21.2)	-0.82±0.98	-1.08, -0.55	
Marital type				.73
Monogamous	277 (94.5)	-0.60±0.85	-0.98, -0.23	
Polygamous	16 (5.5)	-0.70±1.04	-0.94, -0.45	
Infection (CRP)				.56
Infected	176 (67.4)	-0.69±0.99	-1.06, -0.32	
Normal	85 (32.6)	-0.77±0.96	-0.86, -0.68	
Main source of food				.57
Farm	128 (43.8)	-0.65±1.02	-0.90, -0.39	
Market	164 (56.2)	-0.71±1.03	-0.89, -0.54	
Birth order				.98
1st and 2nd	145 (49.5)	-0.70±1.09	-0.84, -0.57	
3rd and 4th	85 (29.0)	-0.68±0.96	-0.98, -0.40	
5th and above	63 (21.5)	-0.67±0.97	-0.93, -0.41	
Immunization				.47
Fully immunized	280 (95.9)	-0.68±1.03	-0.87, -0.48	
Partially immunized	12 (4.1)	-0.90±0.98	-1.59, -0.21	
Morbidity experience				**.02***
Sick last 2wks	222 (78.8)	-0.77±0.99	-1.01, -0.53	
Well last 2wks	71 (24.2)	-0.45±1.11	-0.58, -0.32	
Occupation of Household Head				**.005***
Salaried	56 (19.1)	-0.34±1.05	-0.36, -0.32	
Farmer	80 (27.3)	-0.75±0.92	-1.03, -0.48	
Self employed	59 (20.1)	-0.68±1.12	-0.90, -0.46	
Casual labourer	73 (24.9)	-0.99±1.00	-1.25, -0.73	
Housewife	25 (8.5)	-0.44±0.88	-0.73, -0.15	
Occupation of the Mother				.06
Salaried	6 (2.1)	-0.10±0.77		
Farmer	44 (15.7)	-0.77±0.89	-1.10, -0.44	

Self employed	29 (10.4)	-0.71±0.90	-0.73, -0.69	
Casual labourer	25 (8.9)	-1.19±0.94	-1.60, -0.79	
Housewife	176 (62.9)	-0.62±1.08	-0.78, -0.47	
Education of the Household Head				**.66**
No education	59 (20.1)	-0.56±0.93	-0.71, -0.41	
Primary incomplete	135 (46.1)	-0.69±0.90	-1.09, -0.29	
Primary complete	29 (9.9)	-0.70±1.06	-0.70, -0.69	
Secondary education +	70 (23.9)	-0.79±1.10	-1.35, -0.23	
Education of the mother				**.72**
No education	4 (1.4)	-0.37±0.57	-0.43, -0.30	
Primary incomplete	47 (16.7)	-0.77±0.86	-0.79, -0.74	
Primary complete	190 (67.4)	-0.65±1.07	-0.87, -0.44	
Secondary education +	41 (14.5)	-0.80±1.04	-1.17, -0.43	
Household size				**.74**
2-3 members	17 (5.8)	-0.47±1.4	-0.98, 0.05	
4-5 members	76 (25.9)	-0.80±1.01	-0.81, -0.79	
6-7 members	104 (35.5)	-0.67±0.93	-0.67, -0.67	
8-9 members	63 (21.5)	-0.70±1.07	-1.01, -0.38	
10 and more	33 (11.3)	-0.61±1.09	-1.63, 0.42	
No of meals				**.98**
1-2 (low)	19 (6.5)	0.72±1.29	-0.81, -0.63	
3-4 (medium)	257 (88.0)	-0.70±1.01	-0.91, -0.48	
5-6 (high)	16 (5.5)	-0.66±0.94	-1.33, 0.02	
Vitamin A supplementation				**.96**
Yes	200 (68.3)	-0.69±1.06	-0.95, -0.43	
No	93 (31.7)	-0.69±0.96	-0.79, -0.58	
De-worming				**.71**
Yes	91 (31.1)	-0.72±0.95	-0.81, -0.64	
No	202 (68.9)	-0.68±1.06	-0.93, -0.42	
Breastfeeding				**.59**
Yes	68 (23.3)	-0.75±1.02	-0.90, -0.62	
No	224 (76.7)	-0.68±1.03	-0.92, -0.43	

*P-Value showing significance difference

Appendix 18: Wasting and Associated Factors

Characteristics of the pre-school children	N (%)	Wasting % (95% CI)	Bivariate Analysis Odds Ratio (95%CI)	P -value
Total	293	10.6(7.6, 14.6)		
Iron Status			**0.95(0.40, 2.26)**	**.91**
ID	77 (29.5)	10.4(4.6, 19.4)		
Normal	184 (70.5)	10.9(6.8, 16.3)		
Age Group			**1.02(0.99, 1.06)**	**.17**
12 – 23	89 (30.4)	15.7(8.9, 25.0)		
24 – 35	113 (38.6)	6.2(2.5, 12.3)		
36 – 47	56 (19.1)	14.3(6.4, 26.2)		
48 - 59	35 (11.9)	5.7(0.7, 19.2)		
Sex			**1.23(0.58, 2.60)**	**.58**
Male	147 (50.6)	11.6(6.9, 17.9)		
Female	146 (49.4)	9.6(5.3, 15.6)		
DDS			**2.51(0.50, 12.67)**	**.26**
Low (≤3 food groups)	8 (2.7)	25.0(3.2, 65.1)		
Medium (4-5 food groups)	80 (27.4)	13.8(7.1, 23.3)		
High (≥6 food groups)	204 (69.9)	8.8(5.3, 13.6)		
HAZ Scores (WHO)			**1.40(0.65, 3.00)**	**.39**
Stunted	158(53.9)	12.0(7.4, 18.1)		
Normal	135 (46.1)	8.9(4.7, 15.0)		
WAZ scores (WHO)			**22.42(6.63,75.89)**	**.00***
Underweight	105 (35.8)	26.7(18.5, 36.2)		
Normal	188 (64.2)	1.6(0.3, 4.6)		
Malaria infection			**2.68(0.82, 8.75)**	**.10**
Infected	18 (6.2)	22.2(6.4, 47.6)		
Normal	270 (93.8)	9.6(6.4, 13.8)		
Marital status of mother			**0.92(0.36, 2.37)**	**.86**
Married	229 (81.2)	10.5(6.8, 15.2)		
Unmarried	53 (18.8)	11.3(4.3, 23.0)		
Marital status of Household Head			**0.62(0.27, 1.42)**	**.26**
Married	231 (78.8)	9.5(6.1, 14.1)		
Unmarried	62 (21.2)	14.5(6.9, 25.8)		
Marital type			**0.55(0.07, 4.30)**	**.57**
Monogamous	277 (94.5)	10.8(7.4, 15.1)		
Polygamous	16 (5.5)	6.3(0.2, 30.2)		
Infection (CRP)			**0.72(0.32, 1.61)**	**.42**
Infected	176 (67.4)	9.7(5.7, 15.0)		
Normal	85 (32.6)	12.9(6.6, 22.0)		
Main source of food			**0.98(0.46, 2.09)**	**.95**
Farm	128 (43.8)	10.2(5.5, 16.7)		
Market	164 (56.2)	10.4(6.2, 16.1)		
Birth order			**1.07(0.89, 1.29)**	**.45**
1st and 2nd	145 (49.5)	11.7(7.0, 18.1)		
3rd and 4th	85 (29.0)	9.4(4.2, 17.7)		
5th and above	63 (21.5)	9.5(3.6, 19.6)		
Immunization			**1.73(0.36, 8.29)**	**.49**
Fully immunized	280 (95.9)	10.4(7.0, 14.5)		
Partially immunized	12 (4.1)	16.7(2.1, 48.4)		
Morbidity experience			**2.32(0.78, 6.87)**	**0.09**
Sick last 2wks	222 (78.8)	12.2(8.2, 17.2)		
Well last 2wks	71 (24.2)	5.6(1.6, 13.8)		
Occupation of Household Head			**2.40(1.00, 5.78)**	**.0499***
Salaried	56 (19.1)	1.8(0.0, 9.6)		
Farmer	80 (27.3)	13.8(7.1, 23.3)		
Self employed	59 (20.1)	10.2(3.8, 20.8)		
Casual labourer	73 (24.9)	16.4(8.8, 27.0)		

Housewife	25 (8.5)	4.0(0.1, 20.4)		
Occupation of the Mother			**2.13(0.48, 9.36)**	**.32**
Salaried	6 (2.1)	0.0(0.0, 45.9)		
Farmer	44 (15.7)	13.6(5.2, 27.4)		
Self employed	29 (10.4)	6.9(0.8, 22.8)		
Casual labourer	25 (8.9)	24.0(9.4, 45.1)		
Housewife	176 (62.9)	9.1(5.3, 14.3)		
Education of the Household Head			**0.79(0.34, 1.84)**	**.59**
No education	59 (20.1)	10.2(3.8, 20.8)		
Primary incomplete	135 (46.1)	6.9(0.8, 22.8)		
Primary complete	29 (9.9)	9.6(5.2, 15.9)		
Secondary education +	70 (23.9)	14.3(7.1, 24.7)		
Education of the mother			**0.98(0.36, 2.71)**	**.97**
No education	4 (1.4)	0.0(0.0, 60.2)		
Primary incomplete	47 (16.7)	10.6(3.5, 23.1)		
Primary complete	190 (67.4)	9.5(5.7, 14.6)		
Secondary education +	41 (14.5)	17.1(7.2, 32.1)		
Household size			**1.00(0.85, 1.18)**	**.97**
2-3 members	17 (5.8)	17.6(3.8, 43.4)		
4-5 members	76 (25.9)	10.5(4.7, 19.7)		
6-7 members	104 (35.5)	8.7(4.0, 15.8)		
8-9 members	63 (21.5)	11.1(4.6, 21.6)		
10 and more	33 (11.3)	12.1(3.4, 28.2)		
No of meals			**1.23(0.73, 2.04)**	**.45**
1-2 (low)	19 (6.5)	15.8(3.4, 39.6)		
3-4 (medium)	257 (88.0)	10.1(6.7, 14.5)		
5-6 (high)	16 (5.5)	12.5(1.6, 38.3)		
Vitamin A supplementation			**1.68(0.69, 4.04)**	**.25**
Yes	200 (68.3)	12.0(7.8, 17.3)		
No	93 (31.7)	7.5(3.1, 14.9)		
De-worming			**0.90(0.40, 2.04)**	**.80**
Yes	91 (31.1)	9.9(4.6, 17.9)		
No	202 (68.9)	10.9(7.0, 16.0)		
Breastfeeding			**1.40(0.61, 3.21)**	**.41**
Yes	68 (23.3)	13.2(6.2, 23.6)		
No	224 (76.7)	9.8(6.3, 14.5)		

*P-values showing significance difference

Appendix 19: Iron Deficiency Anaemia and Associated Factors

Characteristics of the pre-school children	N (%)	Iron Deficiency anaemia % (95% CI)	Bivariate Analysis Odds Ratio (95%CI)	P -value
Total	261	8.4 (5.4, 12.5)		
Age Group			1.06 (1.03, 1.09)	.00*
12 – 23	72 (27.6)	12.5 (5.9, 22.4)		
24 – 35	107 (41.0)	8.4 (3.9, 15.4)		
36 – 47	49 (18.8)	8.2 (2.3, 19.6)		
48 - 59	33 (12.6)	0.0 (0.0, 10.6)		
Sex			0.88 (0.52, 1.50)	.63
Male	128 (49.0)	9.4 (4.9, 15.8)		
Female	133 (51.0)	7.5 (3.7, 13.4)		
DDS			1.58 (0.19, 13.42)	.68
Low (≤3 food groups)	7 (2.7)	14.3 (0.4, 57.9)		
Medium (4-5 food groups)	71 (27.3)	7.0 (2.3, 15.7)		
High (≥6 food groups)	182 (70.0)	8.8 (5.1, 13.9)		
HAZ Scores (WHO)			1.68 (0.68, 4.15)	.26
Stunted	136 (52.1)	10.3 (5.7, 16.7)		
Normal	125 (47.9)	6.4 (2.8, 12.2)		
WAZ Scores (WHO)			1.85 (0.77, 4.43)	.17
Underweight	95 (36.4)	11.6 (5.9, 19.8)		
Normal	166 (63.6)	6.6 (3.4, 11.5)		
WHZ Scores (WHO)			0.82 (0.18, 3.71)	.80
Wasted	28 (10.7)	7.1 (0.9, 23.5)		
Normal	233 (89.3)	8.6 (5.3, 12.9)		
Malaria infection			0.00 (undefined)	.97
Infected	16 (6.2)	0.0 (0.0, 20.6)		
Normal	242 (93.8)	9.1 (5.8, 13.4)		
Marital status of mother			2.26 (0.51, 10.04)	.28
Married	206 (82.4)	9.7 (6.0, 14.6)		
Unmarried	44 (17.6)	4.5 (0.6, 15.5)		
Marital status of HHH			0.90 (0.32, 2.56)	.84
Married	206 (78.9)	8.3 (4.9, 12.9)		
Unmarried	55 (21.1)	9.1 (3.0, 20.0)		
Marital type			0.00 (undefined)	.97
Monogamous	246 (94.3)	0.0 (0.0, 21.8)		
Polygamous	15 (5.7)	8.9 (5.7, 13.2)		
Infection (CRP)			1.32 (0.50, 3.49)	.58
Normal	176 (67.4)	9.1 (5.3, 14.3)		
Infected	85 (32.6)	7.1 (2.6, 14.7)		
Main source of food			1.63 (0.68, 3.91)	.28
Farm	113 (43.5)	10.6 (5.6, 17.8)		
Market	147 (56.5)	6.8 (3.3, 12.2)		
Birth order			0.80 (0.68, 0.95)	.01*
1st and 2nd	127 (48.7)	3.9 (1.3, 8.9)		
3rd and 4th	79 (30.3)	10.1 (4.5, 19.0)		
5th and above	55 (21.1)	16.4 (7.8, 28.8)		
Immunization			1.21 (0.15, 10.03)	.86
Fully immunized	250 (96.2)	10.0 (0.3, 44.5)		
Partially immunized	10 (3.8)	8.4 (5.3, 12.6)		
Morbidity experience			0.84 (0.31, 2.23)	.72
Sick last 2wks	198 (75.9)	8.1 (4.7, 12.8)		
Well last 2wks	63 (24.1)	9.5 (3.6, 19.6)		
Occupation of Household Head			0.81 (0.60, 1.08)	.15
Salaried	52 (19.9)	9.6 (3.2, 21.0)		
Farmer	72 (27.6)	4.2 (0.9, 11.7)		
Self employed	53 (20.3)	7.5 (2.1, 18.2)		
Casual labourer	63 (24.1)	9.5 (3.6, 19.6)		
Housewife	21 (8.0)	19.0 (5.4, 41.9)		

Occupation of the Mother			**0.90 (0.62, 1.30)**	**.58**
Salaried	6 (2.4)	16.7 (0.4, 64.1)		
Farmer	42 (16.9)	7.1 (1.5, 19.5)		
Self employed	23 (9.2)	4.3 (0.1, 21.9)		
Casual labourer	21 (8.4)	4.8 (0.1, 23.8)		
Housewife	157 (63.1)	10.2 (5.9, 16.0)		
Education of the Household Head			**0.51 (0.17, 1.55)**	**.23**
No education	52 (19.9)	7.7 (2.1, 18.5)		
Primary incomplete	25 (9.6)	0.0 (0.0, 13.7)		
Primary complete	120 (46.0)	11.7 (6.5, 18.8)		
Secondary education +	64 (24.5)	6.3 (1.7, 15.2)		
Education of the mother			**0.47 (0.11, 2.11)**	**.33**
No education	4 (1.6)	25.0 (0.6, 80.6)		
Primary incomplete	43 (17.2)	4.7 (0.6, 15.8)		
Primary complete	167 (66.8)	10.2 (6.0, 15.8)		
Secondary education +	36 (14.4)	5.6 (0.7, 18.7)		
Household size			**0.90 (076, 1.06)**	**.20**
2-3 members	15 (5.7)	6.7 (0.2, 31.9)		
4-5 members	72 (27.6)	8.3 (3.1, 17.3)		
6-7 members	92 (35.2)	6.5 (2.4, 13.7)		
8-9 members	50 (19.2)	10.0 (3.3, 21.8)		
10 and more	32 (12.3)	12.5 (3.5, 29.0)		
Sex of Household Head			**1.01 (0.33, 3.14)**	**.98**
Male	214 (82.0)	8.4 (5.1, 13.0)		
Female	47 (18.0)	8.5 (2.4, 20.4)		
No of meals			**0.86 (0.47, 1.56)**	**.62**
1-2 (low)	17 (6.5)	0.0 (0.0, 19.5)		
3-4 (medium)	228 (87.7)	8.8 (5.4, 13.2)		
5-6 (high)	15 (5.8)	13.3 (1.7, 40.5)		
Vitamin A supplementation			**0.85 (0.34, 2.11)**	**.72**
Yes	175 (67.0)	8.0 (4.4, 13.1)		
No	86 (33.0)	9.3 (4.1, 17.5)		
De-worming			**0.98 (0.38, 2.51)**	**.97**
Yes	84 (32.2)	8.3 (3.4, 16.4)		
No	177 (67.8)	8.5 (4.8, 13.6)		
Breastfeeding			**1.85 (0.71, 4.78)**	**.21**
Yes	55 (21.2)	12.7 (5.3, 24.5)		
No	205 (78.8)	7.3 (4.2, 11.8)		

*P-Value showing significance difference