UNIVERSITY FOR DEVELOPMENT STUDIES

PREVALENCE AND PREDICTORS OF IRON DEFICIENCY ANAEMIA AMONG CHILDREN LIVING IN ORPHANAGES IN THE TAMALE METROPOLIS

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2017

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BY

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(UDS/CHD/0099/12)

A THESIS SUBMITTED TO THE DEPARTMENT OF PUBLIC HEALTH, SCHOOL OF ALLIED HEALTH SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN COMMUNITY HEALTH AND DEVELOPMENT

SEPTEMBER, 2017

DECLARATION

Student

I hereby declare that this thesis is the result of my own research work and that all the sources that I used have been duly acknowledged by way of references and that this work has not been submitted to any institution for the award of any degree.

…… ……

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I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

…… …….

DR. PAUL ARMAH ARYEE **DATE**

(SUPERVISOR)

ABSTRACT

Anaemia and malnutrition are considered the most widespread nutrition related problems among children in developing countries. Nonetheless, there is little information especially in relation to the prevalence of anaemia in children living in foster care and orphanages. Thus, the study sought to determine the prevalence and predictors of iron deficiency anaemia among orphans living in the Tamale Metropolis. The study employed a cross sectional study design. Both quantitative and qualitative data collection methods were used. Participants who were considered as eligible were children (6months-8 years) living in orphanages in the study area. Descriptive and inferential statistics were mainly used in analyzing data and presenting results. Over 53.2% of orphans were found to have some level of anaemia and a 22.6% prevalence of IDA. The level of hookworm infection was observed to be 21%, suggesting a major public health concern at the orphanages. IDA was also found to be more among orphans with worm infestation compared to those without worm infestation (76.9% versus 44.9%, p=0.04). After controlling for other factors, only worm infestation was found to be a predictor of iron deficiency anaemia among orphans in the study (p=0.042). The findings confirm widespread anemia and IDA in the orphanages and strongly recommend routine deworming coupled with proper hygienic practices and dietary modifications as a relevant strategy to tackle IDA and malnutrition in Ghanaian orphanages.

ACKNOWLEDGEMENT

The final outcome of this thesis would not have been possible without the support of Individuals and Agencies responsible for regulating the operations of orphanages in the country. At the risk of inadvertently leaving out some people, I would like to say THANK YOU to all who have contributed in diverse ways from start to the compilation of this thesis but have not been singled out for mention here.

I am grateful to Almighty Allah for the strength and Guidance throughout this research period.

My sincere gratitude also goes to my supervisor**,** Dr Paul Armah Aryee for his immense contribution and technical support throughout the study.

Mr. Manson Ernest Ziem, words are simply not enough to express my gratitude for the support throughout this study.

Also Mr. Prosper Kwasi Oyeh, (Regional Director of Social Welfare Department- Northern Region), Dr. Francis Soah Ali (Tamale Metropolitan Director of Health Services -Tamale), Mr. Osman Mohammed Shaibu (Senior Nutrition Officer, Tamale Teaching Hospital), Mr. Eliasu Yakubu (Nutrition Officer, Tamale Teaching Hospital), Mr. Abass Abdul Karim (Tamale Teaching Hospital Public Health Laboratory) I would like to thank you to all of you for the invaluable Technical support during the study.

I am grateful to the following research Assistants Mr. Rashad Ali, Mrs. Fauzia Abdul Aziz, Mr. Mohammed Doobia, Mr Ahmed Alhassan and Mr. Muktar and Miss Dokurugu Esther Asana.

Special thanks also to the Staff of the Nyohini and Anfaani Orphanages as well as the data entry clerks for their selfless contribution and support throughout the study.

DEDICATION

This work is dedicated to my Family and Friends.

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LIST OF ACRONYMS/ABBREVIATIONS

ACD	Anaemia of Chronic Disease
AGP	α_1-Acid Glycoprotein
BMI	Body Mass Index
CDC	Centre for Disease Control
CRP	C-Reactive Protein
CSB	Corn Soy Blend
DD	Dietary Diversity
DHS	Demographic Health Survey
FAO	Food and Agricultural Organization
GAM	Global Acute Malnutrition
GDHS	Ghana Demographic Health Survey
GSS	Ghana Statistical Service
HCT	Hematocrit
ID	Iron Deficiency
IDA	Iron Deficiency Anaemia
IRIN	Integrated Regional Information Networks
KAP	Knowledge Attitude Practices
MAM	Moderate Acute Malnutrition
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Corpuscular Volume
MUAC	Mid Upper Arm Circumference
NGO's	Non-Governmental Organizations
NTDs	Neglected Tropical Diseases

RUSFs	Ready to-Use Supplementary Foods
RUTFs	Ready to-Use Therapeutic Foods
SAM	Severe Acute Malnutrition
TfR	Transferrin Receptor
UNCRC	United Nation's Convention on the Rights of the Child
UNICEF	United Nations Children's Emergency Fund
VAD	Vitamin A Deficiency
WFP	World Food Programme
WHO	World Health Organization
WHR	Waist-Hip-Ratio

CHAPTER ONE

INTRODUCTION TO STUDY

1.0 Introduction

Chapter one examines the topic under investigation and provides a general overview of the study. It presents information on the background of the study, the problem statement and justifies the need for the study. It also captures the main and specific objectives of the study as well as research questions. Again, the chapter reviews the significance and scope of the study and concludes with the structure of the thesis.

1.1 Background to the study

Anaemia and malnutrition are considered the most widespread nutrition related problems in developing countries. Globally, iron deficiency is regarded as the most pervasive micronutrient and nutritional deficiency. The WHO (2007b) reckons that the numbers are staggering, with an estimated 2 billion people, an equivalent of about 30% of the world's population considered anaemic, with close to 1 billion suffering from iron deficiency anaemia (IDA).

Anaemia and IDA are undoubtedly among the world's most widespread health problems, especially in children. Iron-deficiency anaemia is caused by poor diets and loss of blood due to worm infestations among others. Anaemia leads to weakness, poor physical and psychological growth, and a compromised immune system – decreasing the ability to fight infections and increasing morbidity. It is also estimated that about 800,000 deaths globally

are attributed to iron deficiency anaemia, which remains among the 15 leading contributors to the burden of disease worldwide (WHO, 2002; WHO, 2007b).

Out of the almost 30% of the world's population estimated with anaemia, the global prevalence of anaemia among children aged 6-12 years stands at 36% and reaches 77% in the developing world (DeMaeyer, et al., 1989; DeMaeyer & Adiels-Tegman, 1985; Stoltfuz, et al., 1997; Verma, Chhatwal, Kaur, 1998). Studies conducted earlier found similar prevalence rates among children aged 5-14 years. It is also estimated that about 90% of all anaemia have an iron deficiency component (Fernando, 2008).

Across various African and Asian settings approximately 40% of children are anaemic with an estimated 200 million and over suffering from IDA resulting from poor diet and worm infestation. Parasitic infections and malaria have triggered Iron deficiency among children in developing countries to more than 90%. Globally, the burden of micronutrient deficiencies due to food insecurity also account for about 4.5 billion suffering from deficiencies of iron, vitamin A and iodine (Khan & Bhutta, 2010).

In many parts of the developing world, more than 1 out of every 3 preschool children is estimated to be anaemic (Ghana Health Service, 2003). Data on children under five years of age in Ghana has shown consistently that about three-quarters (75.0%) of children have various degrees of anaemia including mild anaemia (haemoglobin concentration less than 12g/L; moderate anaemia, haemoglobin concentration < 10g/L and severe anaemia, haemoglobin concentration < 7g/L (Ghana Health Service, 2003; GDHS, 2008; 2014). The GDHS (2008) indicated that 23%, 48% and 7% of Ghanaian children 6-59 months are mildly, moderately and severely anaemic respectively. In children, the prevalence of

anaemia is said to increase with age and peaks at 88% for 9-17 months and then decreases to 70% for 48-59 months. Anaemia was found to be slightly higher in boys (79%) than in girls (77%) with 84% and 68% of children in rural and urban areas more likely to be anaemic respectively. The prevalence of anaemia in children was found to have increased slightly over a 5 year period from 76% in 2003 to 78% in 2008. In the Northern region, 16.0%, 53.5% and 11.9% of children aged 6-59 months were reported to have mild, moderate and severe anaemia respectively, with an overall prevalence of 81.4%. However, according to the recently published GDHS (2014) data, anaemia prevalence has seen a slight reduction with 66% of children aged 6-59 months having some form of anaemia. The prevalence of severe mild, moderate and severe anaemia all reduced to 27%, 37% and 2% respectively.

The GDHS (2014) reports that inadequate dietary intake of iron, malaria and intestinal worm infestation are the most common causes of anaemia among children in Ghana. It further opines that promoting the use of insecticide treated bed nets by children under age 5, deworming at 6 months for children aged 2 to 5 are some important measures to reduce anaemia burden among vulnerable groups.

Other studies have shown that orphaned children lived disproportionately in the poorest households, and are more likely to be anaemic and malnourished compared to their non-orphaned counterparts (Miller, Gruskin, Subramanian & Heymann, 2007; Lindblade, Odhiambo, Rosen & DeCock, 2003).

1.2 Problem statement and justification

The incidence of anaemia in Ghanaian orphanages is not clearly defined; due to the previous absence of national nutrition surveillance programmes. The only data available consist of a fragmented survey undertaken amongst some isolated groups (GDHS, 2003) with very little or no attention given to anaemia in orphanages. This neglect is further accentuated by the failure of recent national nutrition surveys to give it coverage. Poor nutrition and limited access to health services put orphans at increased risk of starvation, illness and death. Without nurturing Children living in orphanages are vulnerable and increasingly continue to face discrimination and stigmatization whilst receiving poor nutrition. Findings by Sadik (2010) indicate low intake of both macro and micronutrients except protein by some orphanage children in Ghana. Nutritional status assessments also indicated that 15% and 10% of the children were severely stunted and wasted respectively. Nonetheless, there is little information especially in relation to the prevalence of anaemia and IDA among children in foster care and orphanages (Senthamarai, Shankar, Rama and Nafil, 2014).

In view of the high rate of anaemia (82%) among children in the Northern region (GDHS, 2014), coupled with the fact that orphaned children are more likely to be underweight relative to their non-orphan counterparts as reported by Miller et al. (2007) and also because of the increased predisposition of children living in orphanages to illness and starvation as a result of poor nutrition and limited access to health services, this study has become necessary. Furthermore, the study has become necessary in view of the seeming scarcity or lack of available information in relation to IDA among children in orphanages in the Tamale Metropolis.

1.3 Objectives of the study

1.3.1 Main Objective

The main objective of the study was to determine the prevalence and predictors of iron deficiency anaemia among children living in orphanages in the Tamale Metropolis.

1.3.2 Specific Objectives

The specific objectives of the study were;

I. To determine the prevalence of Iron Deficiency Anemia (IDA) among children in orphanages in the Tamale Metropolis.

II. To determine the relationship between hookworm infestation and IDA.

III. To assess the relationship between dietary diversity (DD) and IDA of children in orphanages.

IV. To assess the relationship between nutritional status and IDA of children in orphanages.

V. To determine the predictors of IDA among children in orphanages in the Tamale Metropolis.

1.4 Significance of the study

A variety of elaborate intervention strategies and financial commitments by governments and non-governmental organizations have been directed at promoting the health and nutrition of children living in orphanages and other vulnerable children in Ghana. Nonetheless, in a 2009 reportage by the Daily graphic, it contends that despite these nutrition intervention strategies and huge emphasis on orphanages by government, multinationals and religious groups, there is a looming danger that might create a loss of

generation of these vulnerable children and create even more orphans as a result of care, HIV/AIDS and high illiteracy rate among others (Adams & Djabaku, 2009).

It is expected therefore that this study will help generate relevant data that borders on nutrition and health status of children in orphanages in the Tamale Metropolis. Again, this study is expected to help understand and develop appropriate care regimes for children living in orphanages who suffer from anaemia and IDA. Going forward, the findings will serve as a basis for carrying out nutrition status related studies among children living in foster care and orphanages.

1.5 Scope of the study

The study attempted to investigate anaemia/IDA of children living in orphanages and how it is connected with other factors. In respect of biochemical assessment, the study specifically examined the prevalence and predictors of IDA (focusing on haemoglobin (Hb) levels, serum ferritin and transferrin receptor) among the children within orphanages in the Tamale Metropolis.

1.6 Structure of the thesis

The thesis is a six-chapter thesis with other accompanying inclusions. Chapter one takes a look at the general background to the study, statement and justification of the problem and the research objectives. It concludes with the relevance and scope of the study. Chapter two is a review of existing literature relevant to the topic under investigation. In chapter three, an outline of the research methodology is presented. Here, details on study design, sample characteristics, sampling techniques as well as research variables are presented. Data

collection and study instruments, quality control, research ethics and data analysis techniques are also indicated. Chapter four is a presentation of results and analysis whiles chapter five is a discussion of the results. Finally, chapter six summarizes the study by way of conclusions and recommendations.

1.7 Conceptual framework of the study

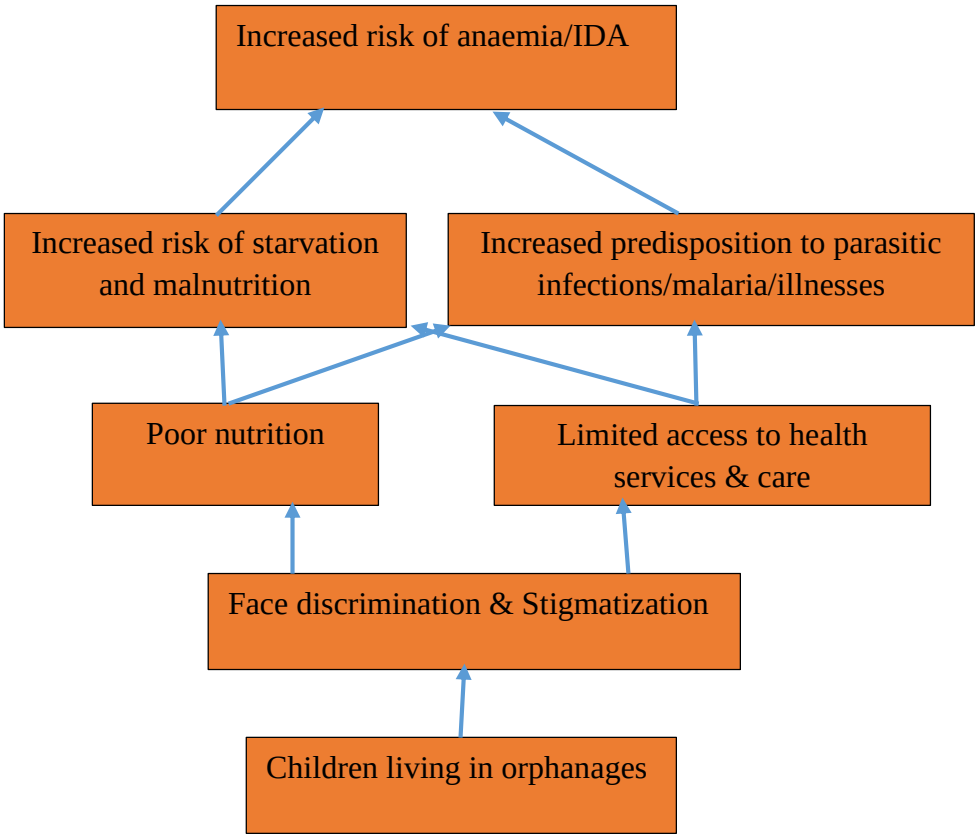


Figure 1.1: Conceptual framework of factors that interact to cause IDA among children living in orphanages (Author's construct, 2017)

Without nurturing, children living in orphanages are vulnerable and increasingly continue to face discrimination and stigmatization whilst receiving poor nutrition. Consequently, they are more likely to be underweight as compared to their non-orphan counterparts because of their increased predisposition to illness and starvation as a result of poor nutrition and limited access to health services. As a result, the culminating malnutrition coupled with parasitic infections and malaria trigger iron deficiency among the children (Figure 1.1).

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section reviews existing literature that border on the general nutritional and health status of orphans and vulnerable children. It examines the different indicators employed in the determination of iron deficiency anaemia of the target group and also presents an overview of orphans and orphanages in general. The section also captures information on the nutritional deficiencies (mostly micronutrient) of orphans and vulnerable children in Ghana. It further gives a snapshot of the care and feeding practices as well as malnutrition amongst participants and the strategies needed to eliminate it. In totality, this chapter attempts to review previous work undertaken in relation to the iron deficiency anaemia amongst orphans aged 6 month - 8 years.

2.1 Vulnerable Children and Orphanages

Vaida (2013) defines an orphanage as an institution dedicated to the care and upbringing of children who have lost their parents. Historically, such institutions were quite prevalent in Western societies in the past. Over 50 years of research dedicated to orphanages provides compelling evidence to the effect that the type of institutional care provided in western countries has a detrimental effect on behavioral, cognition, social and emotional development of young children. However, in some poverty stricken countries, its' been observed that orphanage children have better chances of cognitive development when encouraged to participate with staff in decisions that affect them. Vulnerability has been defined variedly and so it is unclear who should be included or who should not. It does

appear however that through some HIV/AIDS intervention strategies, the orphan assumes the predominantly descriptive vulnerable category which communities and individuals generally try to help (Vaida, 2013).

According to UNICEF (2005), an orphan is a child below the age of 18 who has lost one or both parents. In Ghana, estimates of orphans vary according to the definition of orphans. Most estimates are premised on child population estimates or from sample surveys where the percentage of orphans in the survey is small and unreliable when disaggregated by sex or age. In a similar case, not all surveys use the UN Convention on the Rights of the Child (UNCRC) definition of a child as a person below age 18. A similar issue arises with orphanages which provide shelter for children on the grounds of poverty rather than because they have no parents or relatives to provide care (Save the Children, 2003).

Currently, about 148 children's homes are estimated to be operating in Ghana, although only ten of them are registered with the Department of Social Welfare (DSW) at present. The alarming rate at which these institutions have been established over the last few years has been an issue of concern to the DSW due to reasons not limited to poor management of the institutions as they operate without financial planning or annual budgets, inability to engage qualified child care personnel, poor carer-to-child ratio, unavailability of adequate bedding and space, medication, food, training and academic facilities for the children, failure to meet the minimum standards for the operation of children's homes and others. Children who ought to live out-of-home usually find themselves in very distraught conditions in some of these children's homes. These children become vulnerable because need additional care and support following the trauma of separation. Failure to provide them with the needed support exposes them to diverse forms of abuses, or human right

violations, which could negatively affect them for the rest of their lives (Care Reform Initiative, 2015).

It has further been shown by extensive international research undertaken notably by UNICEF, Save the Children and International Social Services on the consequences of residential care for children that institutions should only be used as a last resort. For children to successfully integrate and thrive in the society, they need families, as the family is the best context within which a child develops successfully (Care Reform Initiative, 2015).

Among the general problems that have been identified for children living in residential care settings include;

- Stigmatization of children living in Homes by the larger society
- Invasion of their right to privacy
- Limited contact with family and community
- Religious and ethnic identities are compromised; with minorities being brought up in the belief system of the majority
- Neglect
- Overcrowded homes
- Limited interpersonal skills of children due to lack of exposure to daily life
- Little stimulation is provided, therefore children particularly babies often fail to reach developmental milestones
- Disabled children do not receive proper care in group setting
- Child labor and abuse are encouraged by an institutional setting

The GDHS (2003) reckons that the total number of orphans in the country was 5.6 percent of all children; with maternal orphans, paternal orphans and double orphans accounting for 1 percent, 4 percent and 0.6 percent respectively. A 2008 child population estimates also puts all orphans at about 6 percent and double orphans at 0.7 percent. However, other recent orphan projections from Demographic Health Survey (2008) technical report estimates that there are a total of 1.3 million orphans which accounts for 12 percent of all children and 127,000 double orphans accounting for 1.2 percent. This trend generally shares some commonality with other African countries to the effect that orphanhood rates rise with a child's age with children under age 2 making up less than 1 percent whiles those aged 15-17 years make up about 10 percent.

A UNICEF study by Deininger et al. (2003) reports that orphans are more likely to be stunted in their growth and less likely to be enrolled in school than children living with both parents. Additionally, Vaida (2013) reckons that there are differences in nutrition related problems such as Vitamin A and B complex deficiencies, iron deficiency anaemia and iodine deficiency disorders between children who are living with their families and children who are living in institutions run by government and non-governmental organizations such as orphanages.

Ghana is home to 1.1 million orphans (UNICEF, 2010). According to Integrated Regional Information Networks (IRIN) (2008), orphans in the past were supported by large matrilineal kin networks and catered for by their extended families. Presently, with the rise in international non-governmental organizations (NGO's) and HIV/AIDS, institutionalized care is on the ascendency. Nonetheless, orphans are increasingly vulnerable and continue to face discrimination and stigmatization and are envied because they receive international

support. Colburn (2010) contends that there are approximately 148 orphanages in Ghana with no set requirements for staff members including the licensed orphanages. There are even many reported instances of neglect and abuse among the registered ones. A study conducted by IRIN revealed that even though orphans have access to more material goods as opposed to their community peers, only about 30% of an orphanage's funds actually go to childcare in Ghana (IRIN, 2009).

Most orphans living in Ghana's orphanages do not meet the western definition of an orphan, which is a child who has lost both parents. As per UNICEF's definition of an orphan, there are about 132 million orphans worldwide although only 13 million have lost both parents. The variations in the definitions can delude international donors into thinking that all 132 million need a new home. International sponsors will certainly be provided with orphans if they give community aid through orphanage care (Voyk, 2011).

In the view of Freidus (2010), children with living parents or relatives are sent to the orphanages due to poverty at home, stigma and the "hope for a better life". Some parents perceive the orphanage as a means to give their children the life they could never afford. They feel that the immediate benefits of the orphanage surpass the long term challenges that the child is most likely to face. Sometimes, other children in the community may express interest in coming to the orphanage because they want to experience the benefits orphans have such as attention, material goods and quality education.

2.2 Care and feeding practices in orphanages

Care has been defined as the behaviors and practices of caregivers (mothers, fathers, siblings, and child-care providers) to provide the food, healthcare, emotional support and simulation needed for children's healthy growth and development. These practices transform food security and healthcare resources into a child's wellbeing not only by themselves but also the ways they are performed – with responsiveness and affection to children are crucial to children's growth and development (Engle, Lhotska & Armstrong, 1997). According to UNICEF's conceptual framework, food, health and care are all necessary for but none alone is adequate for healthy growth and development (UNICEF, 1990). All three components must be satisfactory for good nutrition. Even when food insecurity and limited healthcare are occasioned by poverty, improved caregiving can optimize the use of existing resources to support good health and nutrition in children and women. For instance, breastfeeding is one such practice that provides food, health and care concurrently. According to Engle and Lhotska (1999), aspects of the environment directly experienced by the child are regarded proximal and encompass both physical and social dimensions. Care behaviors or practices are proximal components of the environment that are fundamentally social and impact children's growth and their development. Many behaviors that have been long identified as important for child nutrition, such as breastfeeding, hygiene practices, home health care, and other less recognized behaviors such as psychosocial care and family's care for women are all captured as proximal aspects of the environment. On the other hand, the amount of food available on a daily basis, the availability of water source within the house or the knowledge or energy of a primary caregiver tend to indirectly affect child nutrition and are said to be distal aspects of the environment. The relevant aspects are those that provide resources for care, and may be

human, economic or organizational. At the family level, human resources include caregiver's knowledge, education, beliefs and adequate physical and mental health and confidence to put the knowledge into practice. Economic resources also include the caregiver's control over resources and time to provide the required care. Organizational resources comprise alternative caregivers and community care arrangements as well as emotional support from family members and community networks (Jonsson, 1995). Care practices and resources according to Engle and Lhotska (1999) vary enormously by culture and maybe even more among families within cultures. Children's rudimentary needs for food, protection, healthcare, love, shelter are similar in all cultures. Differences may arise in how each family and culture attempts to meet these needs. General changes in families resulting from urbanization, expansion of primary education, population increase and increased economic role of women require changes and adaptation in care practices for which families may be ill-prepared.

Care practices which are deemed to be good at the level of the household ensure that healthcare and food resources made available to individual members result in optimal growth, survival and development. Care practices differ in terms of age and culture and the ones which are considered to be beneficial need to be supported whiles harmful practices need to be discouraged. These care practices generally border on psychosocial care (responsiveness and attention to the needs of individual household members), hygienic practices (bathing, hand washing, food hygiene, hygiene of clothing, bedding and contact environment) and food preparation (cooking and preparation methods, hygienic storage). They also involve home health practices (home remedies and management of common ailments, promotion of good health, recognizing ill-health and deciding to seek assistance),

specific care during times of vulnerability (childhood, illness, pregnancy, intra household food distribution, prioritizing the needs of vulnerable people, ensuring that the needs of all household members are met) and eating habits (which determines the quantity, type of food and frequency. As indicated by the FAO (2005), nutrition status is influenced by the environment, tradition and practices within the household and the community. Promoting children's health and nutrition in orphanages is, therefore, a priority and requires attention by all. Causes of death of children placed in orphanages are largely preventable and thousands of children can be saved if their nutritional needs are catered for (UNICEF, 1990).

2.3 Micronutrient deficiencies among vulnerable children

Micronutrient deficiencies are estimated to affect close to 2 billion people (including 250 million children) worldwide (World Food Programme, 2010). These micronutrient deficiencies (hidden hunger) continue to impose substantial health, economic and social burdens worldwide (Jones, Specio, Shrestha, Brown & Allen, 2005). Micronutrients deficiencies have public health implications especially in children who require them for various physiological functions (Gopalan, 1994).

According to the GDHS (2014), micronutrient deficiency is a key contributor to childhood morbidity and mortality. The prevailing levels of micronutrient deficiencies that relate to anaemia, vitamin A and iodine are regarded high and constitute major public health significance by WHO standards.

Micronutrient deficiencies occur as a result of the inadequate intake of nutrients needed by the body in minute amounts for the body to function normally. Anaemia/IDA, Vitamin A

Deficiency (VAD), Iodine Deficiency Disorder (IDD) and Zinc Deficiency are the main micronutrient deficiencies of public health concern especially among children. These deficiency diseases have the tendency to cause permanent damage to health and even death (FAO, 2005).

Deficiencies of iron, vitamin A, iodine and zinc among children are the most damaging in respect of impaired development and mortality. Studies have comprehensively assessed the dietary intakes of vitamin A, zinc, iron and iodine of Ghanaian children (Agyepong & Amoaful, 1999; Asibey-Berko, 1994; Takyi & Asibey-Berko, 1999; Takyi, 1999). However there is not enough data in relation to the biochemical assessment of these micronutrients in children in orphanages (Egbi, 2012).

Among different populations in the world, anaemia is likely to be the most identified consequence of micronutrient deficiencies suffered by a high proportion of population groups (Rosado, et al., 2010). The most common form of micronutrient deficiency, iron deficiency in school-age children, is caused by inadequate diet and infection, particularly hookworm and malaria (Hall, Bobrow, Brooker & Jukes, 2001).

2.3.1 Anaemia and Iron Deficiency in Vulnerable Children

The World Bank (2003) defined anaemia as a condition characterized by a low level of hemoglobin in the blood, as demonstrated by a reduced quality or quantity of red blood cells. Anaemia occurs when there is an inadequate number of a red blood cell or inadequate amount of haemoglobin required for the body to function properly. Anaemia may result from defects in red cell synthesis and haemoglobin production at any stage or when an increased rate of red cell destruction (haemolysis) outstrips the capacity of the bone marrow

to compensate for the increase in production (erythropoiesis). A reduction in the haemoglobin concentration may also be occasioned by changes in the relationships between red cell and plasma volumes. These changes usually occur physiologically in pregnancy where red cell volume increases less markedly than plasma volume.

Generally, anaemia is said to occur at a haemoglobin level below 11g/dl. Anaemia is likely to be present below certain haemoglobin concentration levels including 11g/dl for children aged 6 months – 6 years, 12g/dl for children 6-14 years, 13g/dl for adult males, 11g/dl for non-pregnant females and 12g/dl for pregnant females. People who suffer from anaemia show signs and symptoms that are attributed to tissue and organ hypoxia and its resultant reduced metabolism.

Haemoglobin is a protein present in the red blood cells that transports oxygen to the brain, muscular system, immune system and other parts of the body. In the absence of adequate oxygen, the physical and mental capacities of individuals are reduced (Verhoeff, Brabin, Chimsuku, Kazembe & Broadhead, 1999).

Anaemia has serious negative implications including high mortality in women and children, reduced capacity to learn and decreased productivity in all individuals. Again, the World Bank (2003) contends that anaemia, by virtue of its devastating effects on health and physical and mental productivity can affect the quality of life and result in considerable economic losses both for individuals and countries with high anaemia prevalence. With over 2 billion people (one third of the world's population) affected worldwide, anaemia is one of the world's most widespread health problems. It is estimated that between one-third and one-half of the child and female populations in almost all developing countries are

anaemic. The prevalence of anaemia among the groups at highest risk (children under 2 years of age and pregnant women) is more than 50%.

According to ACC/SCN (1991), Iron deficiency remains the most common nutritional disorder in the world. Iron deficiency occurs when the quantity of iron absorbed in the body is not sufficient to meet its requirements, and if prolonged leads to iron deficiency anaemia (IDA). Globally, an estimated 2,150 million people are iron deficient and this deficiency is severe enough to cause anaemia in 1,200 million people worldwide. It is also estimated that about 90% of all anaemia have an iron deficiency component (Fernando, 2008). The frequency of IDA amongst pregnant women and pre-school children in many communities is said to be more than 50% but progressively less in school children, non-pregnant women and adult males. In infancy and childhood, IDA is associated with apathy, inactivity and significant loss of cognitive abilities (ACC/SCN, 1991).

Iron deficiency with or without anaemia significantly reduces work productivity in adults and limits cognitive development in children, thus restricting their achievement in school and eventually reducing investment benefits in education (WHO, 2002a).

IDA is most often occasioned by iron deficiency in its severe form. Since the determination of haemoglobin concentration is relatively easy, the prevalence of anaemia is more often used as a proxy for IDA. This approach, although, may be useful in areas where iron deficiency is known to be the major cause of anaemia is invalid for settings with a more complex etiology of anaemia. For example, available data from Cote' dIvoire showed that close to 40-50% of children and adult women are anaemic and that 50% of the anaemia in

school children and women is caused by IDA and 80% in preschool children aged 2-5 years (Asobayire, Adou, Davidsson, Cook & Hurrell, 2001).

The World Health Organization, in a 2002 report lists iron deficiency anaemia as one of the top ten (10) risk factors in the developing world for what it describes as "lost years of healthy life" (World Bank, 2003).

2.3.1.1 Causes and effects of anaemia and IDA

According to a WHO report (2001), dietary iron deficiency, infections (malaria, hookworm infection and schistosomiasis), deficiencies of other key micronutrients (folate, vitamin A, vitamin B_{12}) and other inherited conditions that affect the stability of red cell (sickle cell anaemia and thalassemia) are the main causes of anaemia. Over the last 2 decades, many attempts have been made at reducing the prevalence of anaemia but despite these efforts, the condition persists.

Apparently, a key reason for the failure to reduce its prevalence is the fact that many interventions and programs have been designed on the premise that iron deficiency is the only cause (WHO/CDC, 2005). It has become more widely recognized now that infection is much more an important cause of anaemia than previously thought and that anaemia is a combined effect of insufficient dietary iron and inflammation Figure 2.1: Exogenous factors contributing to anaemia and IDA (Thurnham & Northrop-Clewes, 2007).

, the 3 main exogenous causes of anaemia (diet, disease and blood loss) are explored and demonstrate the focal role of inflammation in all three. In view of this therefore, the solution to anaemia problem in the developing world will be unsuccessful without tackling the

causes of disease and understanding how inflammation weakens the proper utilization of dietary iron.

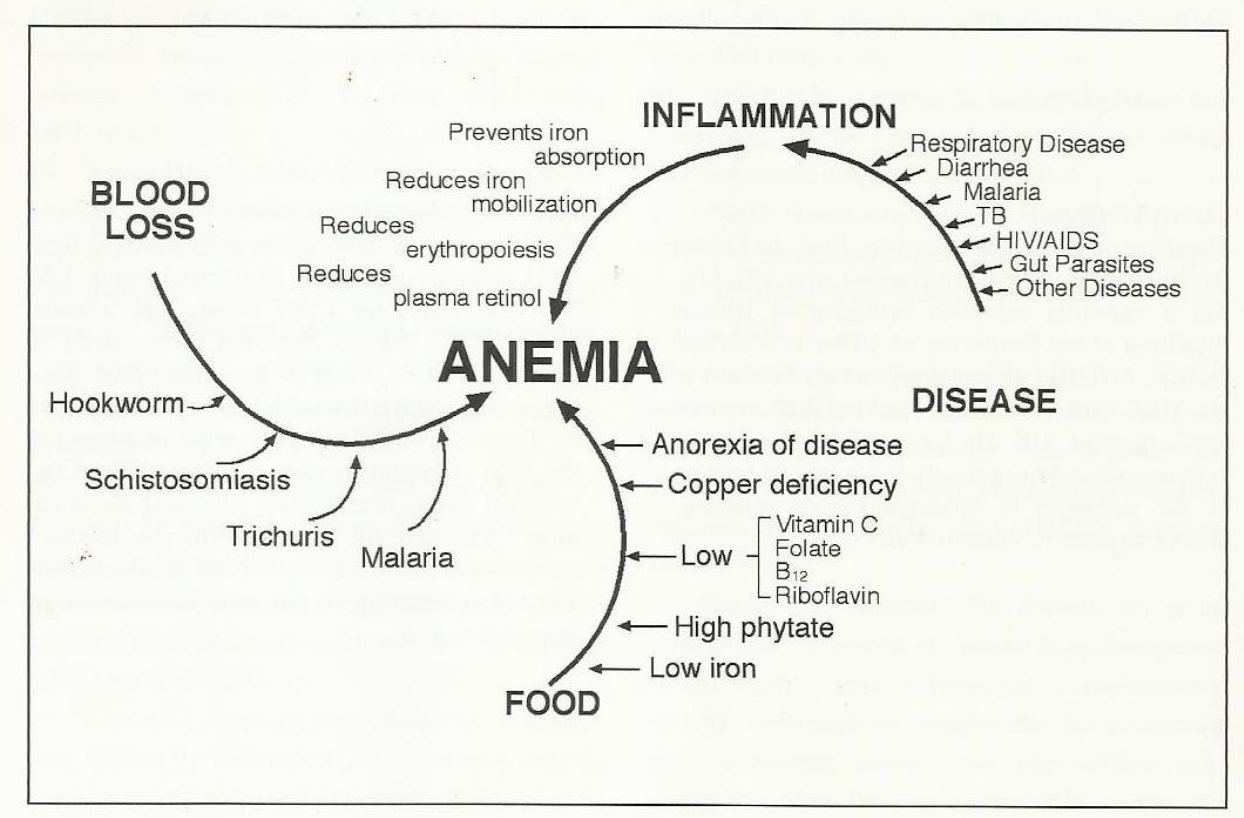


Figure 2.1: Exogenous factors contributing to anaemia and IDA (Thurnham & Northrop-Clewes, 2007).

Regardless of the cause, anaemia is a vital indicator of poor nutrition and poor health. Even mild or moderate anaemia can change the quality of life (QOL) or sense of wellbeing of victims. Severe anaemia can have dramatic effects. When severe, anaemia increases the risk of child and maternal mortality, impairs cognitive development and growth in children and leads to low school performance. Severe anaemia is also noted to reduce physical capacity and work performance in adolescents and adults (Stoltzfus, 2001). Severe anaemia also reduces resistance to infections in affected people (Aryee, 2009).

As can be seen from Figure 2.1: Exogenous factors contributing to anaemia and IDA (Thurnham & Northrop-Clewes, 2007).

above, in addition to deficiencies of iron and vitamin A, there are a number of other dietary factors that contribute to anaemia. Protein and energy when supplied in adequate amounts are necessary for the proper development and growth of both children and adults. However, the foods that provide these nutrients most often also contain the key dietary component that limits the bioavailability of dietary iron, referred to as phytate. Cereals mostly contain large quantities of phytate that bind to divalent cations like zinc and iron, making them largely unavailable for absorption (Hallberg, Brune and Rossander, 1989).

Also, vitamin C has been demonstrated to enhance the absorption of iron from vegetable sources by reducing ferric to ferrous forms and by so doing increasing its solubility (Hallberg, Brune & Rossander, 1989). According to Bates, Fleming, Paul, Black & Mandel (1980), vitamin C status is often minimal, since dietary sources mostly depend on seasonal availability and supplies of fruits and vegetables. Vitamin B_{12} and folate are important for synthesis of DNA and erythropoiesis. Animal products, which are the main source of vitamin B_{12} and green vegetables, an important source of folate are usually in short supply in developing countries (Powers and Bates, 1987; Bates, Fleming, Paul, Black & Mandel, 1980). Riboflavin deficiency may be pervasive in countries where dairy foods are in poor supply and may limit the absorption and utilization of iron according to Power and Bates (1987). Lastly, vitamin B_6 is also known to be required in erythropoiesis to synthesize heme. This vitamin exists in several forms in the diet and so its supply is not usually limited. It has also been observed that if the iron in the diet is too little, if the iron consumed has poor bioavailability or if the entire meal has components that interact to curtail availability

in a way that exceeds the body's capacity to up-regulate absorption to meet iron requirements, stored iron will be used up and iron deficiency will ensue.

Infectious diseases, particularly helminth infections, malaria and other infections such as HIV/AIDS and tuberculosis are key factors that lend a hand to the high prevalence of anaemia observed in many populations (Asobayire, Adou, Davidsson, Cook & Hurrell, 2001; Van den Broek and Letsky, 2000). For instance, anaemia related to *Plasmodium falciparum* malaria contributes hugely to child and maternal mortality and therefore the prevention and treatment of anaemia and at-risk young children and pregnant women is crucial. Also, helminth infections such as hookworm infection and schistosomiasis cause loss of blood and thus play a role in the etiology of anaemia. Again, HIV/AIDS increasingly causes anaemia and anaemia is regarded as an independent risk factor early death among people with HIV/AIDS (International Nutritional Anaemia Consultative Group, 2003).

According to WHO (2004), other nutritional deficiencies apart from iron, such as vitamin B_{12}, folate and vitamin A are also known to cause anaemia even though the degree of their contribution is unclear. It is only after the complexity of anaemia is recognized that effective strategies can be used.

Intestinal parasitic infections are a major public health challenge in developing countries. According to the WHO (2007a), an estimated 3.5 billion people are affected with children as most affected. Conditions such as iron deficiency anaemia, diarrhea, growth retardation and poor mental development have been associated with parasitic infections. In Ghana, the prevalence of parasitic infections has been reported to be between 2% and 78% for different parasites.

According to Diemert (2006), hookworm infection is an intestinal helminthiasis caused by two different species of hookworm; *Necator americanus and Ancylostoma duodenale*. Hookworm infection forms part of the group of diseases commonly referred to as neglected tropical diseases (NTD). Most hookworm cases are reported in tropical and sub-tropical countries, where it constitutes a relevant public health issue. It is estimated that close to 740 million people are infected by hookworm globally, most of whom live in the Caribbean and Latin America, with about 514 million people in this region considered as at risk population (Diemert, 2006 & Hotez, 2008). Clinically, it is mainly manifested as iron deficiency anaemia, since these helminthes feed on blood.

Hookworm infection is a public health issue around the world. The major risk factors associated with this infection include living in rural, tropical and sub-tropical areas, poor hygiene, social and economic factors, walking barefoot, which aids the penetration of the parasite into the skin and poor management of biological waste. The time between the penetration of the parasite into the skin and the appearance of its eggs in the faeces is about 5-6 weeks. However, the infection usually happens some years since adult hookworms are long lasting (average lifespan of 3-5 years). Hookworms live in the small intestines. Their eggs are released through human stool and with the necessary conditions they hatch in the soil, releasing larvae, which mature into infective filiariform larvae or L3. Hookworm infection is transmitted through larval penetration into the skin. The larvae migrate into the blood vessels and are transported to the lungs and eventually to the pharynx, where they complete their lifecycle in the intestines (Roca, et al., 2003; Hotez, 2008).

Adult worms attach to the mucous wall of the small intestine and are able to soften the wall of the intestinal villi, break blood capillaries and feed on blood and tissue fragments (Ranjit,

Jones, Stenzel, Gasser & Loukas, 2006). Lesions mostly depend on the number of larvae that produces the infection, number of migratory larvae and finally the number of adult parasites developed. An infection is considered to be severe when there are over 500 parasites. Chronic infection is asymptomatic. Nonetheless, signs and symptoms associated with iron deficiency anaemia may manifest since worms feed on haemoglobin and also because the infection may give rise to duodenal ulcers. This makes iron deficiency anaemia one of the most frequently observed manifestations of the infection in its chronic phase. It has been shown that one worm can take up to 0.1-0.2 ml blood daily. The infection is diagnosed by egg identification in stool analysis or examination (Hotez, et al., 2004; Roca & Balanzó, 2006).

In a study of the epidemiology of iron deficiency anaemia in Zanzibari school children (n=3,595) from Pemba Island, hookworm infection intensity was found to be the strongest explanatory factor for haemoglobin and serum ferritin concentrations (Stoltfuz, et al., 1997). In another epidemiological study in Pemba Island, in about 525 school children, with 94% hookworm prevalence, Albonico, Stoltfuz & Savioli (1998) argued that the prevalence of anaemia as indicated by Hb < 110 g/dL) and low serum ferritin levels (< 12µg/L) were both higher in children with ≥ 50%.

2.3.1.2 Anemia and IDA among vulnerable children in Ghana

The GDHS (2014) reveals that 66% of children under age 5 have one form of anaemia or the other with 27% 37% and 2% considered to have mild, moderate and severe anaemia respectively. These reported figures vary from the ones presented by the 2008 GDHS report

(78%), indicating an overall reduction of anaemia over the 5 year period. In line with this, it reports that 23%, 48% and 7% of Ghanaian children 6-59 months are mildly, moderately and severely anaemic. The prevalence of anaemia is said to increase with age and peaks at 88% for 9-11 months and 12-17months and then decreases to 70% for 48-59 months. Anaemia was found to be slightly higher in boys (79%) than in girls (77%) with 84% and 68% of children in rural and urban areas more likely to be anaemic respectively. The prevalence of anaemia in children was found to have increased slightly over the past 5 years from 76% in 2003 to 78% in 2008. In the Northern region, 16.0%, 53.5% and 11.9% of children aged 6-59 months were reported to have mild, moderate and severe anaemia respectively. Also, the prevalence of any anaemia was found to be 81.4% in the same region.

In addition, data of children under five years of age in Ghana showed that 76.1% of the children had various degrees of anaemia: 23% had mild anaemia (haemoglobin concentration less than 12g/L; 47% had moderate anaemia, haemoglobin concentration < 10g/L and six percent had severe anaemia, haemoglobin concentration < 7g/L (Ghana Health Service, 2003).

In low-income countries, over half the school-age children are estimated to suffer from iron deficiency anaemia (Bundy, et al., 2006). Iron deficiency hampers cognitive development and evidence available points to the fact that iron deficient children perform poorer in educational tests and thus is less likely to attend school (Bundy, et al., 2006; Grantham-McGregor and Ani, 2001).

A considerable number of studies on the relationship between iron status, cognition, and behavior have been conducted over the past three decades. These studies have been conclusive that young children who suffer from iron-deficiency anaemia frequently perform worse in tests of mental and motor development than do iron-sufficient infants of a comparable age and behave differently from those who are not iron deficient. Despite the wealth of studies the question of whether a causal relationship exists between iron deficiency and lower cognition remain controversial (Hall, Bobrow, Brooker & Jukes, 2001). In a review of observational studies by Horton and Ross (2003), they note that there is a remarkable consistency to the effect that infants with moderate iron deficiency anaemia have test scores 0.5 to 1.5 standard deviations lower than those infants with sufficient iron stores. They further put forward that these differences are large enough to be of great concern, especially given the high prevalence of child anaemia in poor environments. However, observational studies have confounding factors, not all of which can be controlled for.

2.3.1.3 Classification of Anaemia

In the diagnosis of nutritional anaemia, it is important to measure haemoglobin in blood. It is largely regarded as one of the most common and inexpensive measurements carried out in a nutritional laboratory. Diagnosing iron deficiency anaemia (Figure 2.2) requires a laboratory confirmation of evidence of anaemia as well as evidence of low iron stores according to U.S Preventive Services Task Force (2006). Measurement of ferritin is currently the most important indicator for determining iron status. There exists a good correlation between the iron stores and plasma content, and in the early stages of iron deficiency the level of ferritin already reduces, thus making it the most sensitive parameter.

Low levels of ferritin are always indicative of storage iron depletion. The levels of ferritin are affected by factors particularly infection and inflammation and so a high ferritin value is not unavoidably a sign of good iron status. In line with this, it is helpful to also measure indicators for acute and chronic infection to enable identify subjects whose ferritin concentration might be increased by infection. At the moment, the most widely used parameter for acute infections is C-reactive protein (CRP), and alpha-1 glycoprotein (AGP) for chronic infections. Another solution to this problem is to determine soluble transferrin receptor (sTfR), an indicator which is less affected by infection (Gibson, 2005).

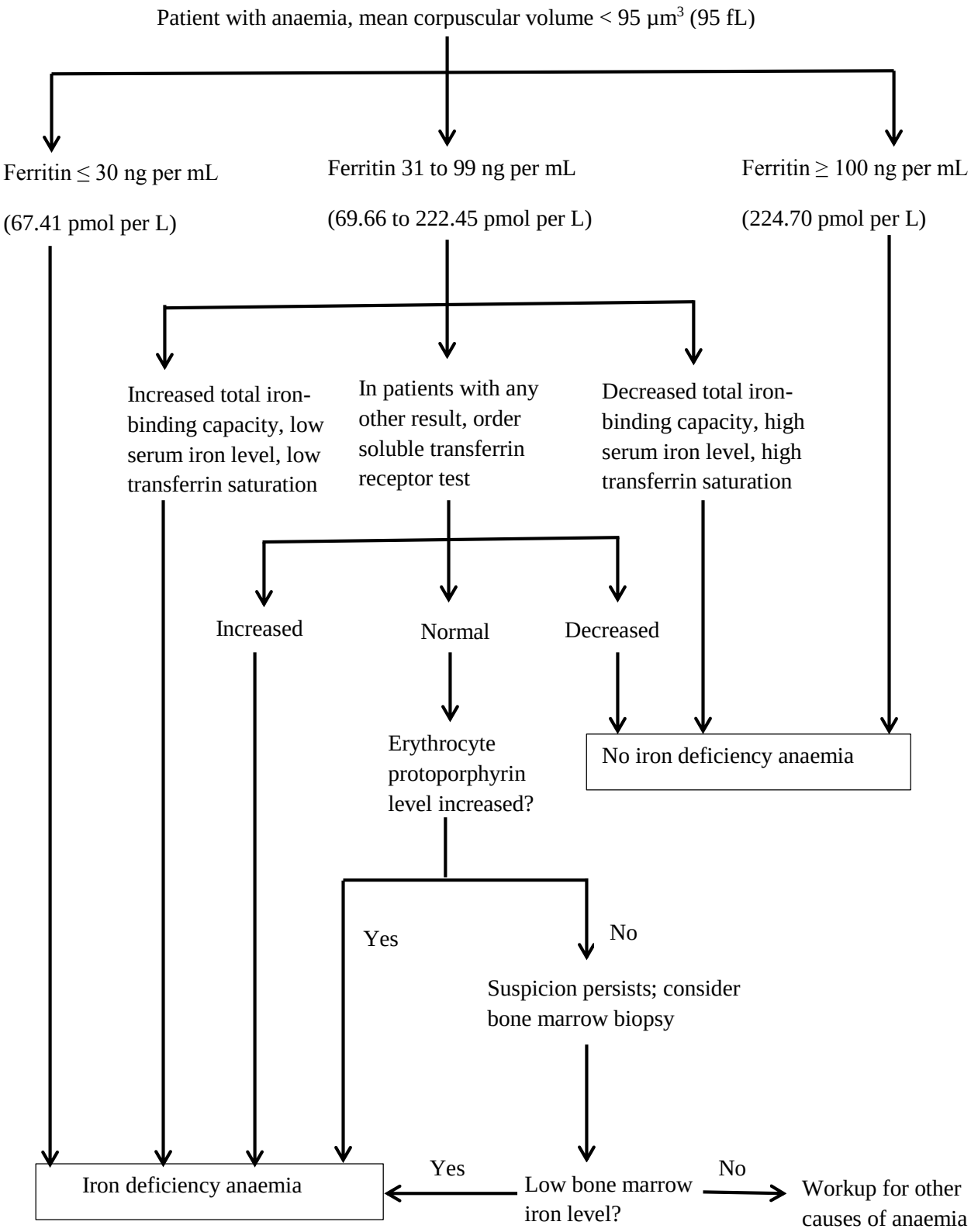


Figure 2.2: Algorithm for diagnosis of iron deficiency anaemia *(Short & Domagalski, 2013)*.

Table 2.1: Age-related Variations in Hemoglobin Level

	Anaemia measured by haemoglobin level (g/dL)			
	Anaemia	**Mild**	**Moderate**	**Severe**
Children 6-59 months	<11.0	10 - 10.9	7.0 - 9.9	<7.0
Children 5-11 years	<11.5	10 – 11.4	7.0 – 9.9	<7.0
Children 12-14 years	<12.0	10 – 11.9	7.0 – 9.9	<7.0

WHO/UNICEF/UNU (2001).

2.3.1.4 Indicators for Iron Status

A joint World Health Organization - Centre for Disease Control working group in January 2004 met to review the existing literature on indicators of iron status and consequently to select the indicators regarded as the best. Indicators considered were each evaluated in relation to the practicality for its measurement and its theoretical advantage as an indicator of iron status. Subsequently, five indicators were identified to assess iron status together with an acute phase protein and the methods commonly used to measure them. The basis for selecting these five indicators is as follows;

2.3.1.4.1 Haemoglobin concentration

This is a measure of anaemia and for that matter a condition that has important outcomes for health and child development that have linkages to international development goals

2.3.1.4.2 Zinc protoporphyrin

This is a measure of the severity of iron deficiency and a reflection of a shortage in the supply of iron in the latter stages of making haemoglobin. Zinc protoporphyrin is detected in red blood cells by fluorimetry

2.3.1.4.3 Mean cell volume

This gives an indication as to whether red blood cells are smaller than usual (microcytic), a common sign of iron deficiency anaemia, or larger than normal (macrocytic), mostly symptomatic of megaloblastic anaemia occurring as a result of vitamin B_{12} or folate deficiency

2.3.1.4.4 Transferrin receptor

The presence of transferrin receptor in serum mostly arises from developing red blood cells and thus indicates the intensity of erythropoiesis and the demand for iron. The concentration of transferrin receptor rises in iron deficiency anaemia and therefore is a pointer of the severity of iron insufficiency in only instances when iron stores have been depleted, given that there are no other causes of abnormal erythropoiesis. The concentration of transferrin receptor is also known to increase in thalassaemia and haemolytic anaemia. Evidence available from clinical studies suggests that serum transferrin receptor is less affected by inflammation as compared to serum ferritin (Beguin, 2003).

2.3.1.4.5 Serum ferritin

This is a measure of the amount of iron in body stores in the absence of concurrent infection. Iron stores are said to be present when the concentration of serum ferritin ≥ 15 µg/L and depleted when the concentration is low (<12-15 µg/L). The concentration of ferritin may rise amidst low iron stores in the presence of infection.

Inferably, it makes it difficult to interpret ferritin concentration in instances where infectious diseases are prevalent.

2.3.1.5 Estimating Iron Status

2.3.1.5.1 Serum ferritin

For clinical practices, staining of a bone marrow aspirate for iron remains the gold standard for estimating iron stores. However, in view of the fact that this is not practical for population surveys other alternative methods have been sought. As recommended by the World Health Organization, 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 (WHO/UNICEF/UNU, 2001). However, according to WHO/UNICEF/UNU (2001) and Witte (1991), both thresholds may be too low when there is a chronic infection or during an acute phase response. Consequently, they add that a serum ferritin concentration between 30 and 100 µg/l becomes a better indication of depleted iron stores in such circumstances.

In using serum ferritin concentrations for assessing iron status in populations, a consultative meeting by the International Nutritional Anaemia Consultative Group in 1987 concluded

that at all ages a serum ferritin value of less than 10-12 µg/L was indicative of a depletion of iron stores (WHO, 1989).

Table 2.2 is a revised version of these cut-offs and presents serum ferritin concentrations that are reflective of depleted iron stores. Infants and young children most often have serum ferritin values close to the cut-off reflective of depletion although a value near the cut-off does not necessarily denote functional iron deficiency (WHO/UNICEF/UNU, 2001). According to WHO/CDC (2005), a combined serum ferritin – soluble transferrin receptor measurement provides an approach to measuring the iron status of populations in areas where inflammation is not widespread since transferrin receptor does not increase in response to inflammation. In areas where infectious diseases are common, serum ferritin fails to become a useful indicator since inflammation results in a rise in the concentration of serum ferritin occasioned by the acute phase response to the disease. By and large, the levels of transferrin receptor do not rise owing to inflammation and so when combined with serum ferritin levels, it makes it possible to differentiate between iron deficiency anaemia and inflammation.

Table 2.2: Relative extent of iron stores on the basis of serum ferritin concentration

	Serum ferritin (µg/l)			
	Less than 5 years of age		5 years of age or older	
	Male	Female	Male	Female
Depleted iron stores	< 12	< 12	< 15	< 15
Depleted iron stores in the presence of infection	< 30	< 30	-	-
Severe risk of iron overload(adults)	-	-	> 200	> 150

(WHO, 2011b)

It's been known since the 1970's that measuring serum ferritin concentration can be reflective of the total body iron store and an acute phase response, but the exact kinetics of the changes that occur have been sketchy (Feelders, et al.,1998). The interpretation of serum ferritin concentration in the presence of infection lends itself to difficulties and so several approaches have been proposed. An early suggestion was to use the ferritin concentration and the mean corpuscular volume or haematocrit, which is low during anaemia, but this can also be influenced by various conditions including liver, kidney, thyroid disease and B vitamin deficiencies, and so was not considered a good choice. In line with this, it became clear that some measure of the acute phase response was needed to interpret the serum ferritin concentration (Witte, 1991).

According to Herbert et al. (1997), it was therefore suggested that, an independent indicator of the acute phase response, such as CRP or AGP, should be measured in addition to ferritin.

When interpreting ferritin concentration in the presence of infection, other helpful approaches include: the determination of serum iron concentration with the percentage saturation of serum iron-binding capacity (transferrin), because an elevated serum ferritin concentration and a transferrin saturation <45% usually indicates infection (Punnonen, Irjala, Rajamaki, 1997); the measurement of transferrin receptor (TfR) alone because it is thought to be unaffected by infection; and the measurement of TfR plus ferritin. Nonetheless, there is some divergence about the use of ferritin as well as TfR because it is considered that ferritin does not improve the diagnostic efficiency of measuring TfR alone, or that the calculation of the TfR/log ferritin ratio is more useful (Beguin, 2003).

2.3.1.5.2 Serum transferrin receptor

Measuring serum transferrin receptor (TfR) concentration is an alternative method to assess iron status because its concentration increases during iron deficiency. It is believed that the serum TfR concentration does not rise in individuals during an acute phase response therefore the measurement of serum TfR may help to differentiate between individuals with and without iron deficiency in the presence of infection. However, there is no international reference standard for this assay, and in the presence of some chronic infections, there may be difficulties in interpreting serum TfR (Beguin, 2003).

In normal subjects, mean serum TfR concentrations tend to be in the range of 5–8 mg/l, but different commercial assays may have varied standards and results cannot easily be compared. Serum TfR concentrations can range from 8 times below to 20 times above normal values. The most important single factor that controls this variation is bone marrow erythropoietic activity (Beguin, 2003). Serum TfR concentrations are a reflection of the absolute rate of erythropoiesis and the adequacy of marrow proliferative capacity for any level of anaemia. When the supply of iron to the tissues declines the concentration of TfR on cell surfaces rises progressively and independently of the presence of adequate iron stores. This means that a rise in serum TfR concentration is a sensitive and quick response to the development of iron deficiency. On the contrary, the serum TfR concentration decreases in response to treatment with iron before a change in haemoglobin occurs, so the response to iron can be monitored by changes in serum TfR (Beguin, 2003).

The serum TfR concentration may slightly increase to 9 mg/l in non-anaemic iron deficiency, but could be much higher (25 mg/l), in iron deficiency anaemia. The

concentration of serum TfR does not increase during an acute phase response therefore its able to distinguish between IDA and iron deficiency as a result of an acute phase response.

Unfortunately, in the presence of some chronic conditions serum TfR concentration may not always distinguish between individuals with or without iron deficiency. For instance, in some forms of anaemia of chronic disease (ACD), the serum TfR concentration may stay within the normal range even with the presence of IDA, because of the suppressive effect of cytokines on marrow erythropoietic activity. For that reason, the relationship between iron status and the serum TfR concentration during inflammation may be affected not only by the extent of anaemia but also, and perhaps more importantly, by the effect of the cytokines on erythropoietic activity. In the opinions of Remacha, Sarda, Parelleda, Ubeda & Manteiga (1998) and Bultink et al. (2001), it has been suggested that the combined use of the concentration of serum TfR and ferritin, or the use of the ratio of the concentration of serum TfR/ferritin or serum TfR/log ferritin, may be helpful in identifying iron deficiency in individuals with a chronic acute phase reaction. Quite specifically, Beguin (2003) proposes that the log (serum TfR/ferritin) ratio may prove to be the most useful. Also, the assessment of serum transferrin receptor levels has been used to differentiate between iron deficiency anaemia and anaemia of chronic disease since receptors are not affected by inflammation or concurrent infection. Therefore the combination of serum transferrin receptor concentrations and serum ferritin concentrations in what is known as serum transferrin receptor/log ferritin ratio or serum transferrin receptor index has been suggested to increase the diagnostic sensitivity and specificity for diagnosing iron deficiency anaemia (Infusino, Braga, Dolci & Panteghini, 2012 and Angeles Vázquez López, et al., 2006)

2.3.1.6 Clinical manifestation of Anaemia/IDA

According to Gibney, Eliah, Ljungqvist & Dowsett (2005), clinical assessment of nutritional status tries to identify the initial nutritional status and the interplay of the factors that influence the progression or regression of nutritional abnormalities. Clinical assessment of utilizes a variety of physical signs and symptoms that are known to be associated with malnutrition, deficiency of vitamins and/or micronutrients. Detection of relevant signs via clinical examination of skin, hairs, nails, eyes, tongues and angles of the mouth are helpful in establishing the nutritional status of an individual or group of persons (Table 2.3) (Lee and Nieman, 1996; WHO, 1963).

A reduction in haemoglobin biosynthesis (presented as nutritional anaemia) is most often the outcome of inadequate intake of micronutrients. The diagnosis of anaemia may be done via its signs and symptoms including lethargy, fatigue or breathlessness. These clinical manifestations are usually progressive and can lead to death if the deficiency is severe enough (Scott & Browne, 2005). Evaluation should start with a thorough history and physical examination to help identify the cause of iron deficiency. The history should be central on the potential etiologies and may include questions about gastrointestinal (GI) symptoms, diet, history of pica pagophagia (that is compulsive consumption of ice), surgical history (such as gastric bypass), family history of GI malignancy and signs of blood loss (including menorrhagia, melena, and epistaxis). Patients with iron deficiency anaemia are mostly asymptomatic with limited findings. Therefore, risk factors should inform further evaluation (Galloway and Smellie, 2006; American College of Obstetricians and Gynecologists, 2008).

Iron deficiency is largely regarded as the leading cause of nutritional anaemia. However, vitamin A adds to several other hematinic nutrients such as vitamins C, E, B_{12} and folic acid which when deficient adversely affect iron-dependent erythropoiesis and contribute to anaemia. Vitamin A deficiency has the capacity to compromise iron absorption, storage, transport and delivery to bone marrow via several paths. For instance, in a study in South African school children, vitamin A deficiency was found to blunt serum iron responses in those who were given a soup fortified with iron. The increased serum ferritin levels observed was suggestive of the fact that iron had been absorbed and stored, but not released in children with poorer vitamin A status (Semba & Bloem, 2002; van Stuijvenberg, Kruger, Badenhorst, Mansvelt & Laubscher, 1997). Severe and prolonged deficiency of riboflavin (vitamin B_2) is thought to cause a wide range of effects including normocytic normochromic anaemia. Perhaps a case in point which is of more general interest is the suggestion to the effect that even modest reduction in riboflavin status are pervasive and that this may impede iron metabolism or absorption (Powers, 2003 and Prasad, Bamji, Kakshmi & Satyanarayama, 1990).

Table 2.3: Clinical manifestation of some nutrient deficiency for physical observation

Nutrient	Clinical sign of deficiency	Clinical sign of normal	Affected body part
Vitamin A	Xeropthalmia, dry skin, Bitot spot	Bright clear eye	Eye and skin
Iron	Pale conjunctiva, Pale skin	Bright and clear conjunctiva Bright skin	Eye and skin
Iodine	Enlarged thyroid gland	Normal thyroid gland	Gland
Vitamin B • Niacin • Thiamin • Riboflavin	• Dry skin • Beriberi • Angular stomatitis	Smooth and good skin colour No swollen tongue	Skin, lips and tongue
Vitamin C	Bleeding and swollen gum	Good pink colour	Gum
Protein and energy	Easily plugged hair, oedema	Smooth skin	Hair, skin

(Kathleen, Escott-Stump & Janice, 2003)

2.3.1.7 Strategies to combat anaemia and IDA

The intake of low dietary bioavailable iron is recognized as an important factor in the development of iron deficiency. In line with this, the use of targeted interventions that provide iron supplements to vulnerable populations especially pregnant women are implemented globally. Also, food-based approaches that are aimed at increasing iron intake through dietary diversification and food fortification are critical sustainable measures for

preventing iron deficiency and IDA in the general population. However, in settings where iron deficiency is not the only cause of anaemia, a combined approach of iron interventions with other measures are required (WHO, 2004). Strategies should be dovetailed into the mainstream primary healthcare system and other existing programmes such as integrated management of childhood illnesses, maternal and child health, roll-back malaria, making pregnancy safer/safe motherhood, adolescent health, stop tuberculosis and deworming (including routine anthelminthic control measures). Strategies are also required to be tailored to local conditions and should consider the specific etiology and prevalence of anaemia in a given population group and setting. Lastly, in order to guarantee effectiveness and sustainability, strategies must receive firm political commitment with strong partnerships involving all relevant sectors (WHO, 2004).

2.3.1.8 Malnutrition and anaemia among vulnerable children

Malnutrition and anaemia in children continue to remain major public health challenges for most developing countries, particularly Africa. Anaemia and malnutrition permeate all facets of their health, growth, social and cognitive development. Together, they cycle to cause irreversible and lifelong effects that stop children from realizing their full potentials (Ewusie, 2013).

Ewusie (2013) has shown that some socio-demographic factors including age of child, mother's education, place of residence and financial status were significantly associated with all forms of malnutrition and/or anaemia. Duration of breastfeeding, source of drinking water, mother's occupation and currently breastfeeding were other factors that were observed to be associated with some form of anaemia and/or malnutrition. In the face

of the alarming prevalence of anaemia (78%) and high rate of malnutrition (36%) in Ghanaian children, particularly those under 2 years old as reported in this study, and the grave consequences thereof, on their behavioral and cognitive development, even in later years, it has become imperative for urgent effective and efficient public health interventions.

Christofides, Schauer & Zlotkin (2005) in a study on iron deficiency anaemia among Canadian children estimated the prevalence to range between 3.5% − 10.5%. In the United States, the prevalence was observed to be approximately 3.6% according to Cusick, Mei, Freedman, Looker, Ogden, Gunter & Cogswell, 2008. In Europe, the prevalence of anaemia in countries such as Sweden and Germany were found to be 8.6% and 7.8% respectively (Benoist, McLean, Egll & Cogswell, 2008). However, in almost all countries in the Sub-Saharan African region, the prevalence of anaemia in children under age 5 was reported to be above the severe prevalence threshold of 40%. The highest overall prevalence of anemia in children under 5 years was recorded in the Western and Central African Region, 75% (Benoist, McLean, Egll & Cogswell, 2008).

In the views of Premji et al (1995), Hedberg et al (1993), Benoist, McLean, Egll & Cogswell (2008) and Karr et al (1996), while the prevalence of anaemia in most African countries were high ranging from 74% in Tanzania to 43% in Democratic Republic of Congo, the prevalence of anemia among children under age 5 in countries such as Monaco and Australia were as low as 5.0% and 1.1% respectively.

The prevalence of stunting, wasting and underweight are reported to be 38%, 9% and 20.8% in respectively in Sub-saharan Africa (UNICEF, WHO & The World Bank, 2012). The

prevalence of stunting was observed to be slightly higher in Eastern and Southern Africa (38.8%) relative to that of Western and Central Africa (36.9%). Conversely, the prevalence of underweight in Central and Western African regions (22.4%) was found to be higher than that of Southern and Eastern Africa (18.3%). Similarly, children in Western and Central Africa were found to have higher prevalence of wasting (10.6%) relative to their counterparts in Eastern and Southern African region (7.3%). The World Food Program & UNICEF (2006) indicate that in some countries such as Niger, Sierra Leone and Central African Republic, the prevalence of underweight between 1990 and 2006 either worsened or did not improve. According to UNICEF (2007), the lack of access to effective health facilities and food resources coupled with adequate health care services are some underlying factors for the high levels of malnutrition and anemia in children in the Sub-Saharan African region. Other factors identified to play a role include struggling economies, high fertility rates which leads to overcrowding and subsequently reduction in the availability of food resources. Hence, there is an increased risk of malnutrition and micro-nutrient deficiency especially in vulnerable children.

The African Child Policy Forum (2008) has argued that with the current trends and estimates of malnutrition, only a few countries in Sub-Saharan Africa were capable of meeting the millennium development goal of halving poverty and hunger. The countries, including Ghana were found to have adopted a mix of basic interventions such as exclusive breastfeeding, vitamin A supplementation, immunization and the use of insecticide treated nets to prevent malaria.

2.3.2 Iodine Deficiency Disease

Iodine deficiency affects an estimated 1.6 billion people worldwide. The consequences of iodine deficiency include severe mental retardation, goitre (a condition involving the enlargement of the thyroid gland and a disruption of normal thyroid production), abortion, hypothyroidism, low birth weight, stillbirths and mild forms of motor and cognitive deficits. Studies in school-age children have found very high levels of goitre and iodine deficiency. School-age children are often targeted Iodine Deficiency Disorders (IDD) assessments because of their physiological vulnerability and their accessibility (Lesley, Celia, Matthew & Anthi, 2002). According to Bundy et al (2006), an estimated 60 million children of school going age are affected by iodine deficiency, which is also linked with lower tests scores and cognitive development. Indeed, iodine deficiency studies suggest that between 35 and 70% of school age children in developing countries may be iodine deficient. In a study by Agyepong & Amoaful (1999), iodine deficiency was found in nine of 27 districts surveyed throughout Ghana.

2.3.3 Vitamin A Deficiency Disease

About 85 million school-age children are estimated to be at increased risk of acute respiratory and other infections because of vitamin A deficiency (Del Rosso, 1999). Vitamin A deficiency also affects iron metabolism so that with any iron supplements taken, subsequent improvement in iron status may be limited when vitamin A status is low. In the past, school-age children have not been regarded an 'at-risk' group for Vitamin A deficiency. Little is known about the occurrence or effects of Vitamin A deficiency in this

age group. However, the small number of recent studies conducted, suggest that Vitamin A deficiency is a public health problem in school-age children (Lesley, Celia, Matthew & Anthi, 2002). Recent data available also regards vitamin A deficiency as a major public health as it affects an estimated 85 million children of school going age (Bundy et al., 2006). Vitamin A deficiency is noted to impair immune function and increase the risk of dying from malaria, diarrhea and measles. In developing countries, vitamin A deficiency is reported to be the leading cause of blindness in children. In the same study by Agyepong & Amoaful (1999), they found that within the middle belt of Ghana called the transitional zone, 51% of children were identified as having severe and moderate vitamin A deficiency (World Food Programme, 2010; Agyepong & Amoaful, 1999). An assessment of the vitamin A status of school children in Ghana, Tanzania, Vietnam and Indonesia found that that Vitamin A deficiency was a moderate problem in Ghana and a mild problem in Vietnam and Indonesia and a severe public health problem in Tanzania (30% deficient in vitamin A), according to WHO criteria (Partnership for Child Development, 2000).

2.3.4 Zinc Deficiency

Zinc deficiency is also known to contribute to weak immunity and growth failure among young children and accounts for some 800,000 child deaths per year (World Food Programme, 2010). Takyi & Asibey-Berko (1999) and Takyi (1999) also indicate that low zinc serum and hair zinc levels were reported among children in southern and northern Ghana.

2.4 Dietary Diversity and malnutrition among vulnerable children

Across the globe, children mostly obtain their energy, macro and micronutrients from diverse sources. However, identifying these different sources and comparing them in terms of age groups poses challenges since foods are sometimes classified in different ways (Jardine and Philpott, 1997). Findings from Sadik (2010) in respect of the nutrient intake of orphans showed a low mean intake of micronutrients including iron, vitamins A and C across all ages and suggested that the children might be at risk of micronutrient deficiencies due to poor dietary diversity and are likely to suffer iron deficiency anaemia and Vitamin A deficiency. The dietary patterns of the children were found not to be good and the children were malnourished as 10% and 15% were severely stunted and severely wasted respectively. These low intakes were however attributed to a lack of planned menu for the orphanage, poor procurement and inadequate nutrition knowledge on the part of caregivers. This observation was backed by Lucas (2000) who suggested that poorly planned menus could affect adequate nutritional intake. Again, Frank and Klass (1996) shared a similar opinion by arguing that the growth failure noticed in institutionalized children, was not necessarily a reflection of insufficient quality and quantity of food, but instead a lack of tactile stimulation and care during the planning of meals for infants, children and adolescents and too few caregivers to make sure that the available food was fed to those too young to feed themselves.

The growing population of vulnerable and orphaned children in Ghana is characterized by malnutrition and poor health. An estimated 48 million orphaned children live in Sub-Saharan Africa, most of who suffer from malnutrition and poor health with little or no access to health care. Poor nutrition has the capacity to cause disease and hamper mental

and cognitive development. It is estimated that close to 50% of childhood deaths in Ghana are attributable to malnutrition. A majority of caregivers in these homes do not have the requisite basic knowledge to meet the nutritional and health care needs of these orphans. In an attempt to help solve the problem of malnutrition among orphans, AmeriCare Foundation Inc launched a program dabbed "One Child One World" with the aim of improving the nutritional, health and hygienic conditions of approximately 1,500 orphans living in 30 residential homes in Ghana. By this intervention, AmeriCare set out to reduce malnutrition and help improve the long-term health of these orphans by making available nutritional supplements, hygiene and first aid products, infant formula, administering vaccinations for orphans and their caregivers and also providing health and nutritional education to about 300 caregivers. The program is expected to reduce malnutrition in a short-term by 25% among children from infants to children under 5 years. With continued implementation, the level of malnutrition is expected to decrease. The practice of good hygiene coupled with the improvement in sanitary facilities will reduce the risk of infection in the long-term whiles the enhanced knowledge among caregivers will lead to improved health (www.globalgiving.org). In a study to compare the health and nutritional status of children living in orphanages with orphans living with families and non-orphaned children living in the same communities in Malawi, the prevalence of underweight in children under 5 years old was found to be 54.8% and that of severe underweight seen in 38.7% of orphanage children. The prevalence of stunting and wasting in children < 5 years in orphanages were 64.5% and 9.7% respectively. In children over 5 years old however, the prevalence of underweight, stunting and wasting were found to be 6.8%, 9.1% and 0% respectively. Additionally, underweight was observed to be present in 42% of orphanage children who had a history of illness over the preceding 4 weeks. Among children in

orphanages, girls were more likely to be malnourished than boys, and children who stayed less than 1 year at the orphanage were more likely to be malnourished relative to those who stayed 1 year or more. Generally, children under 5 years old in the orphanage were more malnourished and children over 5 years old in the orphanage were less likely to be stunted or wasted compared to orphans in families and non-orphaned children (Panpanich, Brabin, Gonani & Graham, 1999).

Also, in a 2011 study to investigate the prevalence of anaemia in children aged 6-59 months by background characteristics (including age, sex, residence, mother's education etc), the prevalence of any anaemia was found to be 57%, which reflected a significant decline relative to a 78% prevalence in the Demographic Health Survey of 2008. Children aged 12-23 months recorded much higher prevalence (71%) compared with the rest. Although, a significant improvement was observed since 2008, the rates were still above 40%, the WHO's cut-off for a severe public health problem. The prevalence rates were particularly higher in the three northern regions (>75%) whiles the rest of the regions recorded rates below 65%. The study observed that close to half of the anaemia problem was linked to dietary practices, particularly the consumption of iron rich sources. The study also remarked that whiles there are many food sources that contain iron, the bioavailability value was low (GSS, 2011).

2.4.1 Causes and effects of malnutrition

Conceptual frameworks demonstrate the theory of the sequence of cause and effect that ultimately lead to a particular problem or, turned around to a positive view, a particular ultimate result. They typically trace out several layers of causality as well as lateral relationships. In the UNICEF conceptual framework on nutrition model (

Figure **2.3**), three levels of causes of child malnutrition are detailed:

- Child malnutrition, death and disability are the manifestation of a problem
- Inadequate dietary intake, disease are the immediate causes
- The underlying causes are insufficient access to food, inadequate maternal and child-care practices, poor water/sanitation and inadequate health services (UNICEF, 2009).

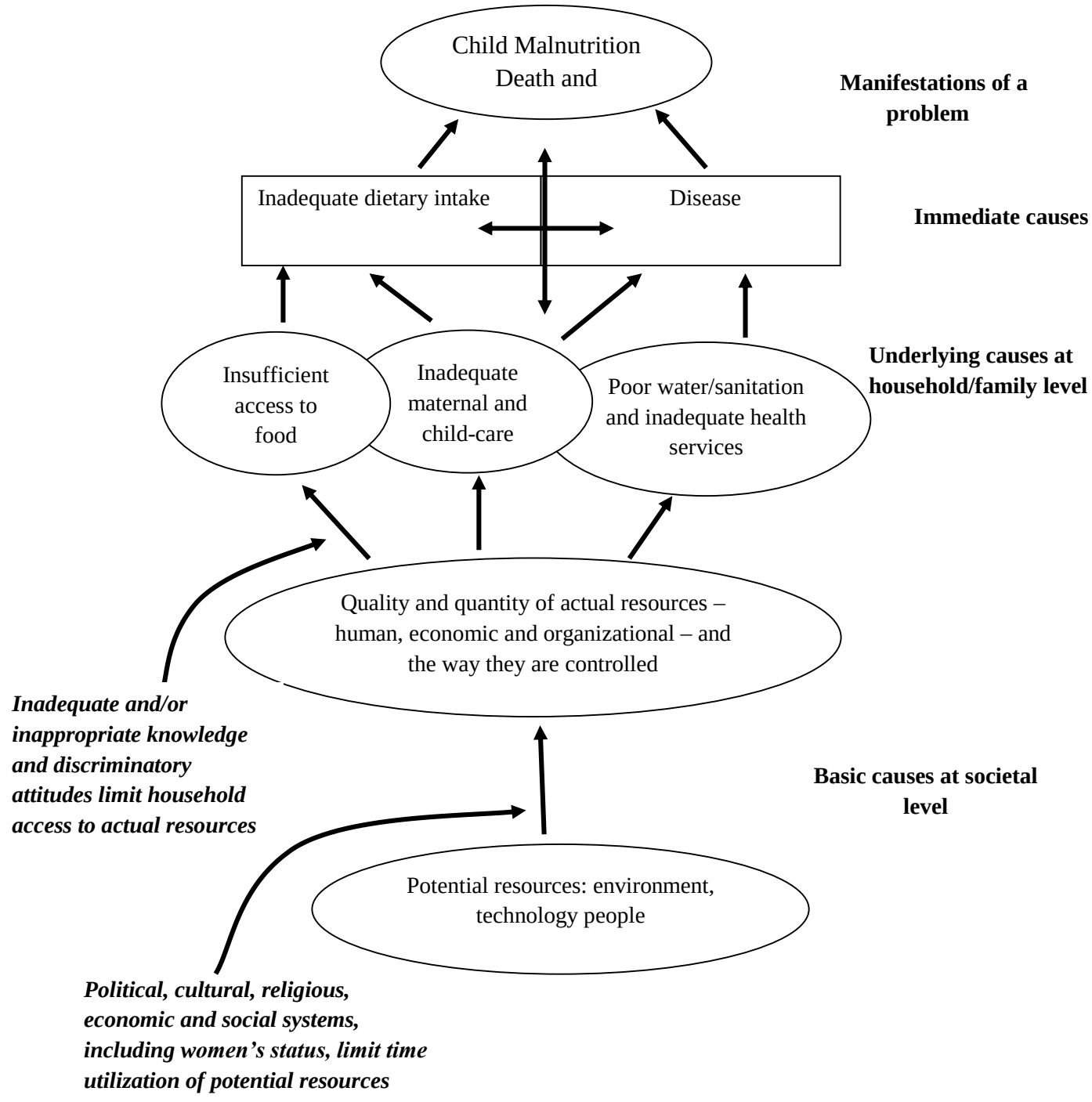


Figure 2.3: Conceptual framework (UNICEF, 2009)

According to the WFP (2009), in Ghana, lack of access to food is only significantly related to wasting, which directly results from acute reduced energy intake due in part to either a worsening diet or inability to absorb ingested nutrients. Stunting, which is a reflection of chronic malnutrition, was more strongly linked with wealth of the household. Inspite of this, the causal factors could change depending on the location. For instance, in the savannah zone, wasting was mostly determined by disease (diarrhea and fever). On the other hand, stunting was mainly occasioned by a lack of access to food at the household level (poor and borderline food consumption). Stunting generally occurs as a result long term, structural shortcomings at the household and community levels. Given this relationship therefore, inadequate diet which is characteristic among the poor populations in this part of the country presented long lasting and irreversible effects on the mental and physical development of children. Further to this, diarrhea, lack of deworming medication and unsafe sanitation facilities were found to be significantly associated with stunting levels.

2.4.2 Acute malnutrition

An estimated 51 million children worldwide are said to be affected by acute malnutrition (both moderate and severe) with 34 million and 17 million suffering from moderate acute malnutrition (MAM) and severe acute malnutrition (SAM) respectively. Moderate acute malnutrition and severe acute malnutrition are defined by weight-for-height z-score (WHZ) between -2 and -3 and < - 3 respectively. Twelve point six (12.6%) of under five deaths are attributable to acute malnutrition, with 7.6% of this due to severe acute malnutrition (UNICEF, WHO, The World Bank, 2012; WHO, 2013). The World Health Assembly has

recognized the need to reduce and maintain the global burden of acute malnutrition to less than 5% by 2025. However, not many countries are on track to achieving this target.

According to WHO (2003b), between 35% and 55% of all childhood deaths are caused by malnutrition. Malnutrition is also considered to account for even more deaths in emergency situations. While emergency programs pay attention to the prevention and treatment of acute malnutrition as evidenced by a low weight for height in relation to a standard reference population small mid-upper arm circumference or nutritional oedema (Table 2.4), development programs focus mainly on preventing underweight or stunting. Apart from lack of access to food, malnutrition may also be caused by poor feeding practices or infection, or a combination of the two.

Table 2.4: Indices for children between 6 – 59 months of age

	Global Acute Malnutrition (GAM)	
	Moderate Acute Malnutrition (MAM)	**Severe Acute Malnutrition (SAM)**
Weight for height or length	Between -2 and -3 SD or 70th to the 79th percentile	Less than -3 SD or below the 70th percentile
Mid Upper Arm Circumference	Less than 12.5 cm	Less than 11 cm
Nutritional Oedema	N/A	Bilateral

(WHO, 2003b)

In the classification of nutrition related emergencies (Table 2.5), the levels of acute malnutrition are also used as one of the reference markers. The WHO system of classification below offers simple guidance using cut-offs for rates of global acute malnutrition and for that matter a reasonable starting point in assessing the extent of a crisis.

Table 2.5: WHO Classification using rates of Global Acute Malnutrition (GAM)

Severity	**Prevalence of Global Acute Malnutrition (GAM)**
Acceptable	< 5 %
Poor	5 – 9 %
Serious	10 – 14 %
Critical	> = 15 %

(WHO, 2003b)

2.4.2.1 Moderate acute malnutrition

The World Health Organization (2003a) defines moderate acute malnutrition as a weight-for-height z-score (WHZ) between -2 and -3 standard deviations (SD), weight-for-height (WFH) 70-80% of the NCHS or WHO reference median or mid-upper arm circumference (MUAC) of 115-125mm. Globally, an estimated 33 million children under five years suffer from moderate acute malnutrition. Similarly, about 4.7 million infants less than 6 months have moderate acute malnutrition worldwide according to Becic, Mokhtar, Wegner &

Loechl, (2014). An analysis carried out jointly by WHO, UNICEF and the World Bank showed that 32 out of 134 countries with available data on the prevalence of acute malnutrition (WHZ < -2) had a 10% prevalence or more, a threshold that depicts a "public health emergency requiring immediate intervention" (WHO, 2013 and WHO-UNICEF-The World Bank, 2012). According to WHO (2012), 55 million pre-school children were wasted in 2010 of which 40 million were regarded as having moderate acute malnutrition. As a major global health problem, childhood malnutrition contributes to increased morbidity and mortality, compromised intellectual development, suboptimal adult work capacity and perhaps increased risk of disease during adulthood (Black, et al., 2008). The WHO (2009) again contends that approximately 20% of the 7.6 million annual deaths among children less than five years can be linked to child underweight. Moderately acutely malnourished children have nutritional requirements that differ from severely malnourished children and non-malnourished children. That is to say they need increased intake of energy and essential nutrients over and above those required by their non-malnourished colleagues. In the dietary management of moderate acute malnutrition, the optimal use of locally available nutrient dense foods is recommended to improve the nutritional status of children and to prevent them from becoming severely acutely malnourished or failing to thrive (Ashworth & Ferguson, 2009). In situations where some nutrients are not sufficiently available in local foods or in cases of food shortage, caregivers may be unable to provide infants and young children recovering from moderate acute malnutrition with diets that meet their nutritional needs. The possibility of nutrition insecurity may be worsened by emergencies, droughts and or cases of displacement. Under such conditions therefore, specially formulated supplementary foods will be needed to supplement the normal diet and thus contribute to an improved intake of required nutrients

(de Pee & Bloem, 2009). The recovery of moderately acutely malnourished children has been facilitated with supplementary foods containing varying nutrients components but their efficacy and effectiveness has been suboptimal.

2.4.2.2 Severe acute malnutrition

The World Health Organization (1999) defined severe malnutrition as a weight-for-height below -3 SD (using NCHS reference) and/or the presence of oedema. According to WHO/UNICEF/SCN (2006) and WHO/UNICEF/WFP/SCN (2007), in a meeting of experts held in 2005, it was recommended to add a MUAC less than 110 mm for children aged 6 to 60 months as an independent diagnostic criterion. It is estimated that close to 19 million pre-school aged children, mainly from the WHO African Region and South-East Asia Region suffer from severe wasting (United Nations Children's Fund, 2012). It is also estimated that of the 7.6 million deaths yearly among children below five years, about 35% have been linked to nutrition related factors whiles 4.4% have been shown to be specific to severe wasting. Severe acute malnutrition is considered a major cause of child mortality across the world, accounting for around 400,000 child deaths annually (Black, et al., 2013). Again, the risk of death is estimated to be 10-fold higher relative to children with a z-score ≥ -1 (Black, et al., 2008). As of the moment, children with severe acute malnutrition are treated with special therapeutic foods, notably ready-to-use-therapeutic foods (RUTFs) or F100 and F75 milk-based diets. Data available from Malawi allude that infants and children aged 6-60 months with a weight-for-height above -3 SD also benefit from such therapeutic diets. Those who are above -3 SD (as per the NCHS reference) but are below -3 SD (as per WHO standards) are most likely to benefit from therapeutic feeding (Patel, et al., 2005).

2.4.3 Strategies to eliminate malnutrition in children

The growing population of orphaned and vulnerable children in Ghana is characterized by malnutrition and poor health. In relation to eliminating under nutrition both in emergency and non-emergency situations, dietary diversification, supplementation and food base approaches have been studied extensively. In supplementary feeding, food is distributed to add-on energy and other nutrients that are missing from the diet of those with special nutritional requirements. Supplementary foods are mostly micronutrient-fortified combinations of legumes and cereals, with corn-soy blended flour as the most commonly available food for the management of under nutrition. Corn-soy blend (CSB) is an inexpensive fortified legume-cereal combination made from locally available ingredients that is organoleptically and culturally accepted in many settings. According to Caulfield, Zavaleta, Figueroa & Zulema (1999) however, the use of CSB has had disappointing outcomes in supplementary feeding programs among vulnerable groups as a result of poor infection control. Wood and Sibanda-Mulder (2011) also opine that low micronutrient content and bioavailability, high-fiber and anti-nutritive value, low energy density and ration sharing may result in recovery rates that are less than 75% in control research trials (Matilsky, Maleta, Castleman & Manary, 2009) and as low as 24% in operational emergency settings (Navarro-Colorado, 2007). In the view of Owino (2010), there is mounting evidence to the effect that the nutritional needs of vulnerable groups cannot be met using CSB. In view of the limitations associated with CSB coupled with the fact that malnourished individuals have high nutritional requirements, the 'standard therapy' was adopted. The standard therapy was proposed by the World Health Organization in 1999 for the treatment of severe acute malnutrition in children following accumulated scientific evidence spanning the early 1960s to the late 1990s. The standard therapy method required

that severely malnourished children be fed for 3-4 weeks during recovery with milk feeds prepared by mixing dried skimmed milk, sugar and oil with a vitamin and mineral complex (F-100). An initial phase normally precedes the recovery phase, targets children who are very ill and is made up of dietary therapy with a milk-based liquid food (F-75) that contains modest amounts of energy and protein (Ciliberto, et al., 2005). According to Briend (2001), the standard therapy method was faced with challenges including being an excellent growth media for bacteria, the need to be prepared and fed under close supervision and the need to make available portable drinking water. These challenges necessitated the formulation of an improved product called Ready-to-Use Therapeutic Food (RUTF).

Matilsky, Maleta, Castleman & Manary (2009) and Patel et al (2005) argue that many studies have confirmed the supremacy of RUTF over CSB and the standard therapy in terms of better recovery rates and improved weight gain in children with severe acute malnutrition. Consequently, the effectiveness and acceptability of Ready-to-Use Therapeutic Foods (RUTFs) in treating children with SAM are well recognized. Also, the use of RUTFs in the management of moderate acute malnutrition (MAM) is regarded unsafe due to the high concentration of nutrients in the formulation. In line with this, ready-to-use supplementary foods (RUSFs) have been developed specifically to treat MAM and to be used as supplements to the traditional complementary foods. RUSFs unlike RUTFs provide less energy and the recommended daily allowance for most micronutrients in a small dose that should be combined with the local diet for managing and preventing MAM. In more recent times, it has been demonstrated that RUSF with milder nutrient concentration compared to RUTF are more effective in treating moderate acute malnutrition (Isanaka, et al., 2010; Huybergts, et al., 2012).

2.5 Assessment of nutritional status in children

As per the 3 key indicators of nutritional status assessment, the GDHS (2014) indicates that stunting, underweight and wasting among children have all improved over the last decade. The levels of stunting, wasting and underweight were reported to be 19%, 5% and 11% respectively. These rates have decreased steadily from 2003 to 2008 and then 2014. According to the 2008 GDHS report also, 28% of children less than 5 years are stunted with 10% severely stunted. The proportion of children most likely to be stunted was found to be highest among 18-23 months aged children (40%) and lowest among children age less than 6 months (4%). Also, stunting was found to be higher in rural areas (32%) relative to 21%in urban areas whiles the proportion of children less than 5 who are stunted decreased from 35% in 2003 to 28% in 2008. Stunting was also observed to be more likely (33%) among children whose biological mothers were not in the household as opposed to children whose mothers were present (28%). Again, the proportion of children less than 5 who are wasted was found to be 9%with 2% severely wasted. Wasting was found to be highest among children aged 6-8 months (29%) and least among children aged 48-59 months (3%). The Upper West (14%), Northern (13%) and Central (12%) regions were the regions where wasting was more common. Wasting among children less than 5 was also found to have declined over the past 15 years from 14% in 1993 to 9% in 2008. Similarly, 14% and 3% of children under 5 years were reported to be underweight and severely underweight respectively. Furthermore, 5% of young children were said to be overweight with the highest proportion of overweight observed among children aged 9-11 months (7%). The prevalence of overweight among children was 7%and 4% respectively in urban and rural areas.

In a study to identify the health care facilities available in orphanages as well as the nutritional status of 300 orphans aged 6-12 years in Bangladesh, Obidul Huq, Chowdhury, Roy, Formuzul Haque & Bellal Hossain (2013) reported poor nutritional status among participants. About 12.0%, 14.3% and 6.3% were found to be severely underweight, stunted and wasted respectively. Similarly, the proportion of moderately malnourished orphans were significantly high; 18.0%, 23.7% and 17.7% were also found to be moderately underweight, stunted and wasted respectively.

Nutritional status assessment has been defined in many different ways. Lee and Nieman (1996) define nutritional assessment as "the evaluation of the nutritional status of individuals or populations through food and nutrient intake and evaluation of nutrition-related health indicators". The American Dietetic Association (1994) also considers nutritional assessment as a comprehensive approach carried out by a registered dietician for defining nutritional status using medical, social, nutritional and medication histories; physical examination, anthropometric measurement, and laboratory data. Nutritional assessment has a supreme aim of improving human health by identifying individuals who are malnourished or at risk of malnutrition. Nutritional status assessment entails the interpretation of data from anthropometry, biochemical, clinical and dietary methods to identify individuals or groups who are either at risk of under or / over nutrition. The four different methods used in assessing nutritional status are usually summarized by the mnemonic "ABCD". Traditionally, nutrition status has been defined by body composition, immune competence, plasma-protein concentrations and multivariate analysis. On the basis of body composition, nutrition status assessment involves the detection of loss or gain of body components in relation to previous measurements and consequently relating the

values in a given patient to normal standards. Whiles the former is affected by error and reproducibility in measurements, the latter is dependent on normal range of values. In line with this, a person may be classified as "normal" if he or she starts off at the upper end of a normal range despite significant changes in the measured value. Therefore, there is the possibility for a person to remain in a negative nutritional status for a long time before anthropometric measurements fall below normal (American Dietetic Association, 1994; Blackburn, Bistrian, Maini, Schlamm & Smith, 1977).

Nutritional assessment systems can take the form of surveys, screening or surveillance. These systems use a variety of methods which are based on a series of anthropometric, biochemical, clinical and dietary measurements. The methods can be used either alone or more effectively in combination, depending on the objectives of the study and available resources. Studies are designed to target either the population or individual levels. Population-based nutritional assessment studies can incorporate such objectives as:

- Monitoring the progress of intervention programs
- Identifying the causes of malnutrition within the population or sub-population
- Characterizing the extent and nature of malnutrition within the population or sub-population
- Determining the overall nutritional status of a population or sub-population
- Identifying areas, populations or sub-populations at high risk of for chronic malnutrition
- Evaluating the efficacy and effectiveness of intervention programs

Nutrition status of selected populations or sub-populations can be assessed cross-sectionally by means of a nutrition survey. The information obtained from nutrition surveys can be used in allocating resources to those population subgroups in need and in the formulation of policies aimed at improving the overall nutrition status of the population. Nonetheless, cross sectional surveys are not likely to provide information on the possible causes of malnutrition needed to formulate and implement nutrition intervention programs at the population or sub-population levels.

In nutrition surveillance unlike nutrition surveys, it involves monitoring the nutritional status of selected populations or at risk sub-populations over a period of time; information is collected, analyzed and used over specified time periods. Subsequent to this, the data can be used to identify the possible causes of malnutrition (both chronic and acute), whiles allowing the design of appropriate nutrition intervention programs if required. Nutrition surveillance is also used in assessing the efficacy and effectiveness of nutrition intervention programs.

Nutrition screening is also used in identifying only at-risk individuals who require intervention. In this method, measurements of individuals are compared with predetermined cut-off points or risk levels. This is aimed at determining the proportion of individuals within the sample who are at risk for malnutrition. Screening programs are not usually as comprehensive as surveys or surveillance studies (Wasantwisut, Rosado and Gibson, 2001).

The evaluation of the nutritional status is a broad topic and therefore to assume a clinical significance, the ideal method should be able to predict whether the individual would have

increased morbidity and mortality in the absence of nutritional support. In short, can it predict the occurrence of nutrition-associated complications and thus predict outcome? Unfortunately, disease and nutrition interact so that disease in turn may cause secondary malnutrition or malnutrition may adversely influence the underlying disease. Thus, patient outcomes are multifactorial, and attempting to formulate the influence of malnutrition on outcome based on single or simple models fails to consider the many interacting factors. This complexity has been recognized in the recent recommendations by the American Dietetic Association (Jeejeebhoy, 2000; American Dietetic Association, 1994).

2.5.1 Nutritional status Indicators

To make easy the interpretation of data obtained from nutritional assessment systems, raw measurements are usually combined to form indices such as weight/(height)^2 which denotes body mass index and hematocrit/red blood cell count which equals mean cell volume. It could also be related to another measure which uses reference data such as weight-for-height, weight-for-age, hemoglobin concentration in relation to age and many others. Most often, nutritional assessment indices are then converted to indicators, a term that relates to the application or use of nutritional assessment indices. Care must be taken when using the term nutritional indicators because other factors other than nutritional status have the tendency to impact the variability of the indicator. For instance, in using the proportion of low birth weight infants as an indicator for maternal nutritional status, it may only be a good nutritional indicator if a considerable proportion of its variability is indeed attributable to differences in maternal nutritional status alone, and not to other factors including but not limited to smoking during pregnancy. In choosing the appropriate nutrition index or indices or a combination of indices for a nutritional status assessment, the objectives of the study,

technical feasibility and acceptability in the collection and measurement of the parameter of interest, expected prevalence and severity of nutrient deficiency state, cost, availability of cut-offs and/or reference values and performance (sensitivity, specificity, validity, reliability and predictive value) must all be considered (Wasantwisut, Rosado and Gibson, 2001).

2.5.1.1 Anthropometry

According to Lee and Nieman (1996) anthropometry is the measurement of physical dimensions and gross composition of the body such as weight, height, head, waist and hip circumference and skinfold thickness. Anthropometric indices are used in assessing growth and body composition and are extensively used in all nutrition assessment protocols. Anthropometric measurements can be done relatively easily, quickly, and reliably with the use of calibrated portable equipment. It is an inexpensive and non-invasive measure of general nutritional status across various age groups. The use of anthropometry mainly relies on age, sex, weight and height and the measurements obtained are compared with standard values in order to make valid inferences. Growth indices based on weight-for-length and length/height-for-age have been endorsed by the WHO for assessing the nutritional status of children. These indices when combined distinguish between stunting (low length/height-for-age) and wasting (low weight-for-length) as well as underweight (low weight-for-age). Length-for-age is a more sensitive measure of the impact of nutrition intervention programs. In populations that are stunted with normal weight-for-length/height, nutrition intervention strategies may not have any impact on wasting indicators. In spite of the recommendations by WHO, weight expressed in relation to age is about the most widely employed anthropometric index in both child and maternal health clinics especially in less

developed countries due to the difficulty associated with measuring length. However, weight-for-age is inherently handicapped as it fails to discriminate between stunting and wasting and in turn undervalues the prevalence of malnutrition among stunted populations (Wasantwisut, Rosado and Gibson, 2001; WHO, 1996; Lee and Nieman, 1996).

Body mass index (BMI) is an anthropometric index of weight and height that is defined as body weight in kilograms divided by height in meters squared.

$$BMI = weight\ (kg) / height\ (m)^2$$

BMI is the commonly accepted index for classifying adiposity in adults and it is recommended for use with children and adolescents. As happens with weight-for-stature, BMI is the most extensively used screening tool to identify individuals who are underweight, overweight or obese. BMI is however not used as a diagnostic tool. BMI-for-age greater than or equal to the 95th percentile, the 85th to less than 95th percentile and less than the 5th percentile are used to identify individuals (> 5 years) who are overweight, at risk for overweight and underweight respectively. (WHO, 1996).

2.5.1.2 Biochemical assessment

Biochemical assessment includes measuring a nutrient or its metabolite in blood, faeces or urine or measuring a variety of other components in the blood or other tissues that have a relationship with nutritional status (Lee and Nieman, 1996). This can be helpful in evaluating the possibility of malnutrition. For instance, a measure of the Hb level in the blood is helpful in evaluating the possibility of iron deficiency anaemia, a measure of the level of Vitamin A in the blood is reflective of intake and reserves of Vitamin A in the body whiles a measure of the level of thiamine in urine reflects the intake of thiamine in the diet.

Biochemical assessment operates on the principle that variations in the composition and quantity of a diet is reflected by changes in the concentration of nutrients or their compounds in tissues or body fluids and/or by the appearance or disappearance of specific substances (metabolites). The measurements of these essential dietary constituents would therefore help access nutritional status. A majority of the biochemical tests (Table 2.6) available can be divided into those which detect biochemical changes that reflect metabolic alterations occasioned by nutrient deficiencies or imbalances and those which measure changes that are directly reflective of the supply of nutrients. The levels of essential dietary components in the body fluids are indicative of nutrient supply. Poor absorption, dietary deficiency, abnormal utilization or impaired transport can cause a reduction in the concentration of essential nutrients in body fluids. Consequently, measuring nutrient concentration levels can help evaluate the possibility of malnutrition even though it does not establish the existence, nor define the magnitude of nutritional disease (WHO, 1963).

Table 2.6: Biochemical studies applicable to nutrition studies

(WHO, 1963)

Nutrient deficiency	First category*	Second category
Protein	Total serum protein Serum albumin Urinary urea**	Serum protein fractions by electrophoresis Urinary creatinine per unit of time (T)
Vitamin A	Serum Vitamin A Serum carotene	
Vitamin D	Serum alkaline phosphate in young children	Serum inorganic phosphates
Ascorbic acid	Serum ascorbic acid	White blood cell ascorbic acid Urinary ascorbic acid Load test
Thiamine	Urinary thiamine (F)**	Load test Blood pyruvate Blood lactate Red blood cell hemolysate transketolase
Riboflavin	Urinary riboflavin (F)**	Red blood cell riboflavin Load test
Niacin	Urinary N-methyl-nicotinamide (F)**	Load test Urinary pyridone
Iron	Hemoglobin Hematocrit	Serum iron % saturation of transferrin
Iodine		Urinary iodine (F) Tests for thyroid function

*Urinary creatinine used as reference for expressing other urine measurements in first category

**Expressed per gram of creatinine; (F) - In a single urine specimen, preferably fasting (T) - In timed urine specimens.

2.6 Dietary assessment and nutrient deficiencies

Dietary information or evaluation in a nutritional status assessment according to Kathleen, Escott-Stump & Janice (2003) involves two main approaches or methods; daily food record/dairy and food frequency. These methods can be affected by a multitude of factors such as physical, environmental, appropriateness of food offered and social influences. Daily food record entails a documentation of dietary intake as it occurs and is mostly used in outpatient clinical settings. Food records are usually accurate if the food eaten is recorded on the same day. Food frequency questionnaire on the other hand involves a retrospective review of intake frequency; that is food consumed per day, per week or per month. The food frequency method can be used as a cross validation technique alongside a 24-hour dietary recall in order to enhance the quality of dietary data (Kathleen, Escott-Stump & Janice, 2003; Vaida, 2013)

Again, Lee and Nieman (1996) assert that dietary assessment entails surveys that measure the quantity of food consumed by an individual during the course of one and/or several days or assessing the pattern of food use during previous days and/or months. They go on to indicate that these dietary assessment methods can provide data on the intake of nutrients or specific food classes. Food composition tables and other available software programs are used in analyzing nutrient intakes of individuals or groups.

The use of dietary indices (founded on both quantitative and qualitative dietary assessment methods) can be used to fulfill various objectives depending on the kind of dietary assessment method employed. These objectives may include an assessment of the proportion of the population at risk of inadequate intake of nutrients, the pattern of food use, the use of specified foods as well as an assessment of the actual or usual intakes of

nutrients at the individual or group levels. The former information is particularly useful because it can be used to establish whether assessment using more invasive biological indices justified in a population or sub-population. As happens in some nutritional assessment protocols, dietary indices are used in unification with the ones designed to monitor knowledge, attitudes and practices (KAP) as well as reported food-related behaviors (Wasantwisut, Rosado and Gibson, 2001).

In conclusion, the literature review looked at the prevalence and determinants of anaemia and IDA among vulnerable children living in orphanages in the Tamale Metropolis. Other topical issues covered in the literature include the prevalence of hookworm infection and the relationship between anaemia status and hookworm infection, dietary diversity and its bearing on anaemia as well the different determinants of iron deficiency anaemia among children in orphanages.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

In conducting this study, several methods were employed in the process of data collection. Similarly, different techniques were also used in analyzing the collected data and in presenting the results. These methods were carefully selected to ensure that accurate and sound findings were obtained.

Biochemical assessment, a critical part of the subject under investigation, was performed in relation to the blood and faecal samples collected. Appropriate and universally accepted assays were adopted in analyzing the blood and faecal samples. The blood samples were analyzed for serum ferritin, transferrin receptor and haemoglobin concentration whiles the faecal samples analyzed for hookworm infection levels. The study also employed the food frequency and 24-hour recall, which are dietary methods consistent with and widely used in iron status evaluations. Basic anthropometric measurements (height and weight) were also carried out.

3.1 Study Area

The Tamale metropolis is one of the six (6) metropolitan assemblies in Ghana and the only one in the Northern part of the country. Tamale doubles as the capital city of the metropolis and the regional capital of the Northern region. The Tamale Metropolis is located in the central part of the Northern region and shares boundaries with Mion district to the East, East Gonja to the South, Sagnarigu District to the West and North and Central Gonja to the

South-West. Geographically, the Tamale Metropolis lies between latitude 9º16 and 9º 34 North and longitudes 0º 36 and 0º 57 West and is estimated to have a total land size of 646.90180sqkm.

Tamale, by virtue of its strategic position in the region has a market potential for local goods from the commerce and agricultural sectors from the other districts in the region. In addition to the strategic location of the Metropolis within the region, it is also better placed to benefit from markets within the West African region from countries such as Mali, Burkina Faso, Niger and Northern Togo as well as the southern part of Ghana. The metropolis has 115 communities, with most of the rural communities serving as the food basket for the metropolis (GSS, 2010; Ghana District, 2006).

3.1.1 Food Production & Consumption

Shea-fruits, mango, watermelon, Dawadawa fruit, 'Bra', 'Aleefu', 'Ayoyo', Baobab leaves among others are the main fruits and vegetables eaten by the inhabitants. 'Tuo-zaafi' (TZ) is the main staple. Cereals (maize, rice, sorghum, millet) and legumes (cowpea, groundnuts, and soy bean) are the main food crops produced by the farmers. Yam and cassava are also cultivated. Goats, chicken, sheep, cattle and guinea fowls are the main animals reared. These crops and animals are however, mostly reared in peri-urban and rural areas. The main sources of water supply are pipe borne, dam and boreholes (GSS, 2010; Ghana District, 2006).

3.1.2 Vegetation

The vegetation of the Metropolis is that of savannah woodland. Characteristically, the trees are short scattered wood lots with major tree types such as Dawadawa, Acacia, Nim, Baobab and Mahogany. The shea tree is one of the economically relevant trees available in the metropolis. It has a unimodal rainfall pattern and starts from May and ends in mid-October. Rainfall is the main source of water for agricultural activities in the Metropolis (GSS, 2010; Ghana District, 2006).

3.1.3 Occupation

According to Ghana District (2006), the main occupations of the inhabitants are predominantly trading, farming, and "office work" among others. However, the GDHS (2008) categorizes the diverse occupation of the people of Tamale into six (6) different groups; agriculture, professional/technical/managerial, sales and services, clerical, skilled, and unskilled manual work. Agriculture is the predominant occupation, with almost the people involved via the practice of subsistence farming. The agricultural sector is dominated by women in rural and peri-urban areas as well as those who have never been to school. Most of the women who have had secondary or higher education levels and those in urban areas are usually engaged in non-agricultural and sales and services occupations respectively. Not many women are into clerical and professional/technical/managerial work.

The men are mostly into agricultural and skilled manual work. Also, a lot more men than women are engaged in the clerical, professional/technical/managerial and unskilled manual work.

3.1.4 Orphanages in the metropolis

The study was conducted in the Tamale Children's Home (Nyohini) and Hands of Mercy (Anfaani) Orphanages. These selected orphanages share common objectives of serving as foster homes to least privileged and vulnerable children such as the abandoned, children of mentally ill mothers, motherless and fatherless children and missing children under the direct supervision of the Department of Social Welfare.

3.2 Study Design

A cross sectional analytical study was employed in the study. Quantitative data collection method was mainly used.

3.3 Study Population

The participants in the study were generally children between 6 months - 8 years of age living in the selected orphanages. They were further categorized into children under 5 (6-59 months) and children above 5 (5-8 years). These age groups were selected because globally, the prevalence of anaemia appears to be high and particularly worrying among children aged 6-12 months and 5-14 years in especially developing countries. Thus, children considered for this study reflected to some extent the bigger picture in relation to anaemia prevalence in children worldwide. All children within the age group specified were eligible for selection. The details of the study such as purpose, duration, risks and potential benefits and required procedures were duly explained to the managers and caregivers of the selected orphanages in a language of their choice and in terms they understood. Informed consent was obtained from managers of these orphanages.

Other children within the same age group who were not living in the orphanages were automatically eliminated from the study. In addition, orphans who were within the same age group and living at home were not included. Similarly, orphans older than 8 years were also excluded from the study.

3.4 Sampling Technique

Only two (2) orphanages (Anfaani and Nyohini) consented to taking part and therefore were enrolled into the study. A purposive sampling technique was used to select participants in the orphanages. Codes were provided for all participants in no particular order to facilitate the administration of the 24-hour dietary recall and food frequency questionnaire and in identifying the test tubes during the biochemical analysis.

3.5 Research Variables

In assessing the variables of the study, quantitative methods were largely used. The key independent variables considered in the study were anaemia or IDA as determined by Hb, serum ferritin and transferrin receptor. The dependent variables for the study included hookworm infection levels height-for-age, weight-for-height and weight-for-age and dietary diversity or intake.

3.6 Data Collection Methods and Tools

Face-to-face interviews were conducted with caregivers using a pre-tested structured questionnaire to solicit information on socio-demographic characteristics of the children and usual dietary intake. In addition, the caregivers were interviewed to gather data on

feeding and care practices, health, water and sanitation and other child nutrition-related issues. For the purpose of clarification, room was given for additional details to be provided as comments. Anthropometric indicators of weight and height or length were measured and BMI for age determined for children above 5 years. Biochemical indicators of haemoglobin, serum ferritin and transferrin receptor were also determined. Additionally, 24-hour dietary recall and food frequency questionnaires were used to obtain information on dietary intake of the children. Where possible, older participants (5-8 years) were made to sit close the respondent (caregiver) and provided some responses especially in relation to food items consumed outside of the facility. For participants < 5 years however, all questions were responded to by caregivers.

3.6.1 Blood sample collection and laboratory analysis

A qualified laboratory staff with adequate training on blood collection procedure was engaged in collecting blood samples. A soft tubing tourniquet was applied to the upper arm of the participants to enable the veins to be seen and felt. Tight fists were made which made the veins more prominent. Sterile, dry, plastic syringe of 5 ml were used with a 20 SWG disposable needle attached to it. The punctured sites were cleansed with 70% ethanol and allowed to dry and blood taken with the sterile syringe and needle. About 5 ml of blood was drawn from each subject and the blood samples collected carefully labeled with assigned codes. Ethylene Diamine Tetra-acetic Acid (EDTA) sample tubes were used for storing the blood.

Used syringes and needles were put in safety boxes and then transported to a safe and proper disposal site. Samples collected on the field were stored in cold boxes with frozen ice packs and transported to the laboratory for analysis.

Venous blood samples of children were taken for laboratory analysis. The blood samples were analyzed as soon as they were brought from the field and those that could not be analyzed that same day were stored in a fridge under a regulated temperature (4^oC to 8^oC). The blood samples collected were analyzed for full blood count in the laboratory using Sysmex KX-21N haematology analyzer manufactured by Sysmex Corporation (Japan) whiles Hb levels, Ferritin and Transferin levels were determined using immunoturbidimetric assay for the quantitative determination. Haemoglobin measurements were determined using the automated blood analyzer Mindray auto haematology analyzer BC 3000 Plus (Mindray company, Shenzhen, China).

3.6.1.1 Operating principle of Auto haematology analyzer BC 3000 and HGB measurement

The analyzer adopts the coulter principle to count WBC, RBC and PLT cells and to draw their corresponding histograms (Kubota, 2003). The haemoglobin concentration (HGB) is obtained by the colorimetric method. The results of the other parameters (HCT, MCV, MCH, MCHC) are derived from these. The Coulter method of sizing and counting particles is based on measurable changes in electrical impedance produced by nonconductive particles suspended in an electrolyte. A small opening (aperture) between electrodes is the sensing zone through which suspended particles pass. In the sensing zone each particle displaces its own volume of electrolyte. Volume displaced is measured as a voltage pulse; the height of each pulse being proportional to the volume of the particle.

The quantity of suspension drawn through the aperture is precisely controlled to allow the system to count and size particles for an exact reproducible volume. Several thousand particles per second are individually counted and sized with great accuracy. This method is independent of particle shape, colour and density (Tsuruda, et al., 1999).

HGB was determined by the colorimetric method. The WBC/HGB dilution was delivered to the WBC bath where it was bubble mixed with a certain amount of lyse, which converts haemoglobin to a haemoglobin complex measured at 525 nm. A lead emitting diode (LED) was mounted on one side of the bath and a beam of light emitted, which passed through the sample and a 525nm filter, and then was measured by a photo-sensor mounted on the opposite side. The signal was then amplified and the voltage measured and compared to the blank reference reading (readings taken when there is only diluent in the bath). The HGB was calculated per the following equation and expressed in g/dl (Tsuruda, et al., 1999).

$$HGB(g/dl) = constant * log\ 10\ (\frac{Blank\ photocurrent}{samplephotocurrent})$$

3.6.1.2 Iron indices

The iron indices; serum iron, ferritin and transferrin were determined using the Flexor XL analyzer (Vital Scientific, Netherlands). All the reagents for the biochemical assay were obtained from Fortress diagnostics (United Kingdom).

The Flexor XL is an automatic chemistry analyzer, used in combination with reagents for the in-vitro diagnostic measurement of analytes in samples of serum. The Flexor XL auto analyzer is designed as a stand-alone system with all components fitted in one unit.

3.6.1.2.1 Transferrin receptor

This is an immunoturbidimetric assay for the quantitative determination of transferrin in human serum. The serum sample (2µl) was added to a buffer reagent (250µl) and incubated for 5 minutes, after which an anti-Transferrin antibody reagent (50µl) was then added. The anti-Transferrin antibodies react with the antigen in the sample to form an antigen/antibody complex (Chen, XiaO, Xu, Agree & Yu, 2013). Following agglutination, the absorbance of the complex formed was then measured turbidimetrically at 340nm using the Flexor XL analyzer.

3.6.1.2.2 Serum ferritin

This is an immunoturbidimetric assay for the quantitative determination of serum ferritin. Latex coated with anti- human ferritin is agglutinated when they react with serum that contains ferritin. The agglutination is proportional to the concentration of the ferritin in the sample and is measured by turbidimetry at 650nm. Serum sample (100µl) was added to a buffer reagent (800µl), and a latex reagent (200µl) was then added. Following agglutination, the absorbance of the sample which is proportional to the concentration of ferritin in the sample was measured turbidimetrically at 650nm using the Flexor XL analyzer.

Reference or cut-off values for serum ferritin and transferrin receptor (sTfR >8.3 mg/L) were determined and adopted from the manufacturer of the assay used. Serum ferritin cut-off values of <12 µg/L and <15 µg/L (unadjusted) and <30 µg/L (adjusted for high infection pressure areas which reflects depleted iron stores in the presence of infection)

were used to indicate depleted iron stores in children less than 5 years and those above 5 years respectively as recommended by WHO/CDC (2005). According to the WHO/CDC (2005), adjusting the cut-off that defines iron deficiency usually to <30 µg/L is one way of accounting for the increase in ferritin levels caused by inflammation. As proposed by Beguin (2003), the combined use of the concentration of serum TfR and ferritin in log (serum TfR/ferritin) ratio was calculated since that is believed to be most useful in identifying iron deficiency in individuals with or without infection. This parameter has been further corroborated by Punnonen, Irjala, & Rajamaki (1997) in which several possibilities of combining serum transferrin and ferritin parameters were exploited and a conclusion reached to the effect that the use of the sTfR/log ferritin ratio (TfR-F index) significantly improved the diagnostic efficiency, even in areas with a high infection pressure. To this end, an internationally accepted cut-off value for TfR-F index of >5.6 (adopting sTfR of >8.3 mg/L and ferritin of <30 µg/L) was used to define deficiency of iron stores according to Phiri et al (2009).

3.6.2 Parasitological Examination (Stool Routine Examination)

Stool specimens were collected according to WHO standard protocol. They were examined microscopically using direct and formalin-ether concentration methods (WHO, 1991). Stool samples were collected into labeled, leak-proof, and clean plastic stool containers and brought to the laboratory immediately. Direct microscopy of the smears in saline (0.85% NaCl solution) and Lugol's iodine was performed for the detection of ova, larvae, trophozoites, and cysts of intestinal parasites (Cheesbrough, 2005). Additionally, a concentration procedure that involved mixing the stool samples with formalin, treating with ether, and centrifuging was employed. The layers of ether, formalin, and debris were

discarded, and the residues were observed microscopically for the presence of intestinal parasites (WHO, 1991; Cheesbrough, 2005)

3.6.3 Anthropometric measurements

UNICEF electronic scale and an infantometer were used to take weight and height/length of participants aged (6-59) months respectively with the help of their caregivers. Birth certificates and or postnatal cards were used to ascertain the ages in months of study subjects. However, in circumstances where such required documentation was unavailable, ages were confirmed by probing the caregivers. Weight-for-height, height- for-age and weight-for-age were used as the main indicators to assess nutritional status of the participants using the WHO reference standards (WHO, 2006). The nutritional status of children aged 5-8 years was determined by employing BMI for age. All measurements were taken in triplicates and average of the three readings recorded as the true value.

3.6.3.1 Weight measurements

Electronic digital scale (Uniscale) was used for weighing. Weight measurement was guided by the standard measurement protocol for measuring weight, adapted from WHO expert committee report, 1995. The Uniscale was placed on a leveled ground and the digital reading made to assume "zero" by passing the foot across the surface of the screen. Participants who were above 23 months and able to stand without any problem were made to stand on the scale without sandals, their hands hanging down by their side whiles their head looked straight. On the other hand, participants below 23 months who were unable to stand alone were weighed using an automatic mother—child adjustment. The caregiver was

instructed to stand on the scale, the weight was eliminated and the child given to her to obtain the child's weight. All readings were taken to the nearest 0.1kg.

3.6.3.2 Height or length measurements

Height was measured without shoes to the nearest 0.1cm using an infantometer. Participants who were less than 24 months or below 80cm had their lengths taken whiles those above 23 months or more than 80cm had their heights taken. In both cases however, measurement was done with a measurer and an assistant. All the steps involved in taking height measurement were duly followed.

For length measurements the infantometer was placed on a flat floor. Children below 24 months were made to lie flat and in the center of the board with their heads held gently against the immovable head board. Their knees were pressed firmly but gently against the board and the movable foot piece placed firmly against their heels. Reading was taken immediately to the nearest 0.1cm. Measurements were taken in triplicates and average of the three readings recorded as the true value.

For measuring height, the infantometer was placed upright and in a stable position. The child's feet were placed flat and together in the center of and against the back and base of the board. The legs were made straight and the heels and calves held against the hoard. The child was made to look straight and head piece was lowered on top of the child's head. The head piece was pressed gently on the child's hair and reading taken immediately to the nearest 0.1cm. Measurements were taken in triplicates and average of the three readings recorded as the true value.

3.6.4 Dietary intake assessment

The 24-hour dietary recall method together with a food frequency questionnaire was used to gather information on participants' dietary intake. All participants were given unique codes which were referred to during the 24-hour dietary recall and food frequency interview sessions. For both age categories (under 5s and above 5), caregivers responded to the 24-hour dietary as well as the food frequency questionnaire since the children could not have provided full details of food consumed. Participants who were available during the interviews were invited to sit next to the interviewee in order to ensure that they were properly identified and referred to. The food intake during the last 24 hours was recorded in order to obtain the information regarding the intake of calories, proteins, iron, vitamin A and vitamin C. Initially, structured questionnaires were used to collect information on all the foods consumed by each participant at home, school (for participants of school going age and who are in school) and elsewhere guided by specific probes. Detailed information concerning the description of each food (whether the specified food was fresh, boiled, smoked or steamed) was gathered from caregivers. The food frequency method was also used as a cross validation technique along with 24 – hour diet recall to enhance the quality of dietary data. For a particular food item, the frequency of intake (daily, once, twice, 3 – 4 times a week, weekly, fortnightly, monthly or occasionally) were recorded.

3.7 Data analysis

The results from the biochemical assessment were entered into SPSS version 22 and analyzed whereas anthropometric data was analyzed using Epi-info software version 3.4.1. Data from the dietary intake were also presented in tabular form. Chi square and binary logistic regression analyses were used to measure the relationship between iron deficiency

anaemia and predictor factors in the study. A p-value of less than 0.05 was set to determine any statistical significant differences.

In defining nutritional status, stunting, underweight and wasting were defined by cut-offs for HAZ, WAZ, and WHZ at < -2 z-scores respectively. Descriptive statistics enabled results to be reported as means and their standard deviations or frequencies, proportions and percentages.

3.8 Quality control

Five (5) research assistants with previous experience in data collection were recruited and trained on the data collection protocols and tools. Ahead of the commencement of data collection, the questionnaire was piloted among other children of the same age group living in nearby communities to test its responsiveness and its capacity to collect the required information. In ensuring data quality, precautions were taken to ensure that accurate data were recorded. In the process of data collection, instruments were calibrated, measurements were taken in multiples and standardized methods used. Also, in reducing the incidence of human error during data entry, the use of detailed labels to avoid confusion and proper documentation of anything that can be misinterpreted by another researcher were employed. Spread sheets were properly designed whiles data entry was done by two clerks to check for accuracy and consistency. As regards cross-checking and validating data, codes were double-checked for out-of-range values. Data was also checked for completeness.

3.9 Ethical considerations

The managers of the orphanages were informed in writing to seek their permission to carry out the study. Meetings were organized to explain the methods and goal of the study to the managers or caretakers. In line with this, consent forms detailing the purpose and intentions of the study were given to managers or caretakers who were able to read to append their signatures and a copy each kept by the researcher and orphanage. The content of the consent form was read out (those who cannot read) in a local language understood by the management and signature or thumbprint obtained. The consent processes were documented through the use of consent forms. Permission was also obtained from the Tamale Metropolitan Health Directorate as well as the Northern Regional Directorate of Social Welfare through official writing (Appendix I). An application was also made to the University for Development Studies' Institutional Review Board (IRB) in respect of the study.

3.10 Methodological Limitations

One of the major limitations of this study was the unavailability of literature on the levels of anaemia of orphans in general as well as those living in orphanages. Also, the number of children in the study was not enough to provide power for the statistical determinations. It is possible that many differences and/or associations were not statistically significant for this.

Again, although the study gathered information on the food consumption patterns of participants, it failed to determine or estimate the dietary intakes in relation to the recommended dietary allowances.

CHAPTER FOUR

RESULTS

4.0 Introduction

The results as presented in the various sections below provide a detailed description of the findings in relation to the objectives of the study. It begins with a general overview of the socio-demographic characteristics of participants in section 4.1 as captured by Table 4.1. Section 4.2 and the accompanying table attempt to provide answers to the prevalence of anaemia and IDA among study participants as indicated in specific objective 1. Section 4.3 also summarizes the findings on the prevalence of hookworm infection among participants as reflected by specific objective 2 and explores the hookworm infection status in relation to anaemia status of children. Again, section 4.4 presents findings on dietary diversity assessment and the relationship between DD and IDA (specific objective 3). Similarly, results on the relationship between nutritional status and IDA (specific objective 4) are captured by section 4.5. Finally, section 4.6 presents results bordering on the determinants of IDA among study children as indicated in objective 5.

4.1 Socio-demographic characteristics

The study was initially scheduled to take place in four (4) orphanages across the Tamale Metropolis. One orphanage declined to participate whiles another had just 1 child. Therefore the remaining two facilities were the only ones enrolled onto the study.

More than 3/4 (49) of the participants (79%) were within the ages 6-59 months whiles those 60+ months (5-8 years) accounted for 21.0%. In relation to the sex of participants, 61.3%

and 38.7% were males and females respectively. The mean age of participants was 35.87±29.17 months with a minimum and maximum age of 8 and 96 months respectively. Details of the socio-demographic characteristics are presented in Table 4.1 below.

Table 4.1: Socio-demographic Characteristics

Variable	Frequency	Percentage
Age Group		
6-24 months	36	58.1
25-59 months	13	21.0
60+ months	13	21.0
Total	**62**	**100**
Sex		
Male	38	61.3
Female	24	38.7
Total	**62**	**100**

(Field work, 2016).

4.2 Prevalence of Anaemia/IDA among children in the study

In measuring the prevalence of anaemia among the children (Table 4.2), the level of haemoglobin (Hb) was employed. In this regard, an Hb ≥ 11g/dL and Hb = 10-10.9 g/dL indicated normal and mild anaemia respectively. Also, moderate and severe anaemia were indicated by Hb = 7-9.9 g/dL and Hb < 7 g/dL respectively. Over half of the participants (53.2%) were found to be anaemic. Out of those found to be anaemic, 14 (22.6%) were mildly anaemic whereas 30.6% were moderately anaemic. However, none of the participants was severely anaemic. After adjusting serum ferritin levels to <30 μg/l, about 32 participants had ferritin concentration less than the adjusted cut off and were therefore deemed to have iron deficiency (ID) whiles the remaining 30 participants had values greater

than the cut off. Inferably, combining the Hb and ferritin cut-offs, the prevalence of Iron Deficiency Anaemia (IDA) among participants in the orphanages stood at 22.6% (Hb <10.9 plus serum ferritin <30 µg/l).

Table 4.2: Prevalence of anaemia among children in the study

Variable	Frequency	Percentage
Levels of Anaemia (Hb)		
Normal (Hb ≥ 11g/dL)	29	46.8
Mild (Hb = 10-10.9 g/dL)	14	22.6
Moderate (Hb = 7-9.9 g/dL)	19	30.6
Severe (Hb < 7 g/dL)	0	0.0
Total	**62**	**100**
Iron Deficiency Anaemia (Hb <10.9 plus serum ferritin <30 µg/l)		
IDA	14	22.6
No IDA	48	77.4
Total	**62**	**100**

(Field work, 2016).

4.2.1 Relating Socio-demographic characteristics to IDA status in the study children

The relationship between socio-demographic characteristics and IDA status of the children is presented in Table 4.3 below.

Table 4.3: Socio-Demographic Determinants of Iron Deficiency Anaemia

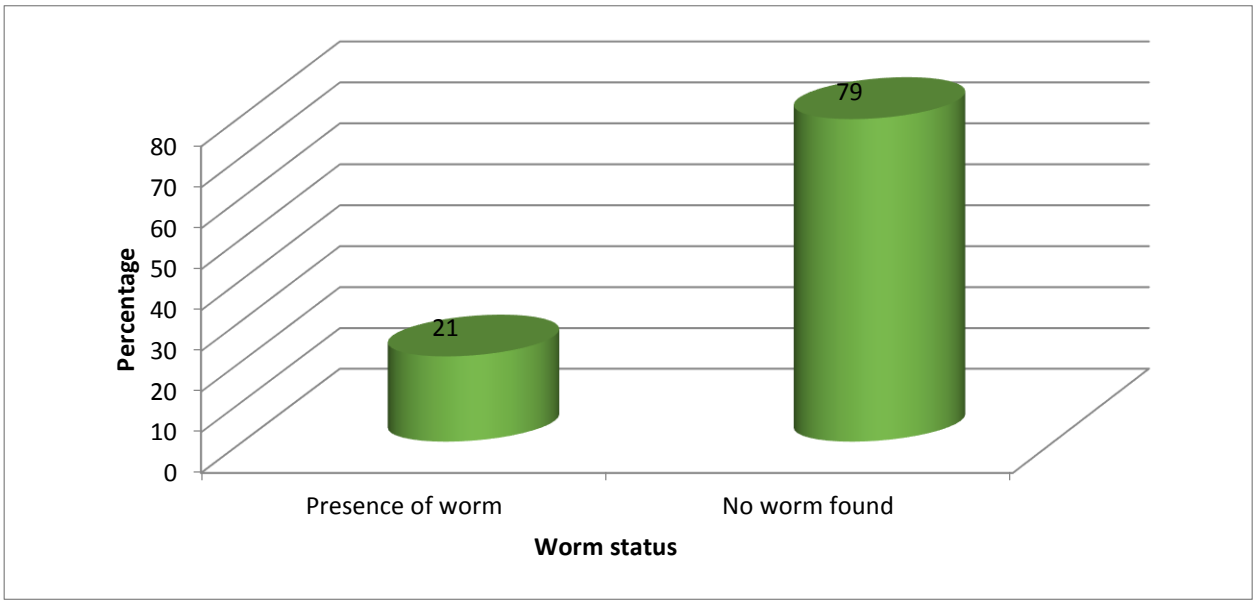
Variable	N	IDA		Chi-square	p-value
		Yes n (%)	No n (%)		
Age					
6-24 months	36	8 (22.2)	28 (77.8)	1.706	0.426
25-59 months	13	3 (30.0)	10 (70.0)		
60+ months	13	3 (30.0)	10 (70.0)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Sex					
Male	35	11 (31.4)	24 (68.6)	3.123	0.077
Female	27	3 (11.1)	24 (88.9)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Sick of Malaria					
Yes	9	2 (22.2)	7 (77.8)	0.136	0.709
No	53	12 (22.6)	41 (77.4)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		

(Field work, 2016).

The results show that IDA was more likely to be associated with the 25-59 month olds (30%) and 60+ month olds (30%) than the 6-24 month olds (22.2%) but the differences were not significant (p=0.426). In terms of the gender, males (31.4%) were more likely to have IDA than females (11.1%) though the difference was not also significant (p=0.077). Furthermore, children with malaria (22.2%) were as likely to have IDA as those without malaria (22.6%).

4.3 Hookworm Infestation among the study children

Relative to the critical role of hookworm infection in the subject of investigation, the hookworm status of the orphans was also analyzed. Over ¾ of the participants (79%) were found to have no worms while less than ¼ (21%) presented with worms (Figure 4.1).



(Field work, 2016).

Figure 4.1: Prevalence of Hookworm Infestation

4.3.1 Relating Hookworm infestation with Anaemia/IDA status of study children

Table 4.4 below summarizes anaemia and IDA statuses of participants in relation to the presence or otherwise of hookworms.

Table 4.4: Hookworm infestation in relation to anaemia and IDA status

Variable	N	Anaemia Status		Chi-square	p-value
		Anaemic n (%)	Normal n (%)		
Worm present	13	10 (76.9)	3 (23.1)	3.710	0.054
No worm	49	23 (46.9)	26 (53.1)		
Total	**62**	**33 (53.2)**	**29 (46.8)**		
Variable	**N**	**IDA Status**		**Chi-square**	**p-value**
		IDA	**Normal**		
Worm present	13	5 (83.3)	1 (16.7)	8.219	0.004
No worm	49	9 (16.1)	47 (83.9)		
Total	62	**14 (22.6)**	**48 (77.4)**		

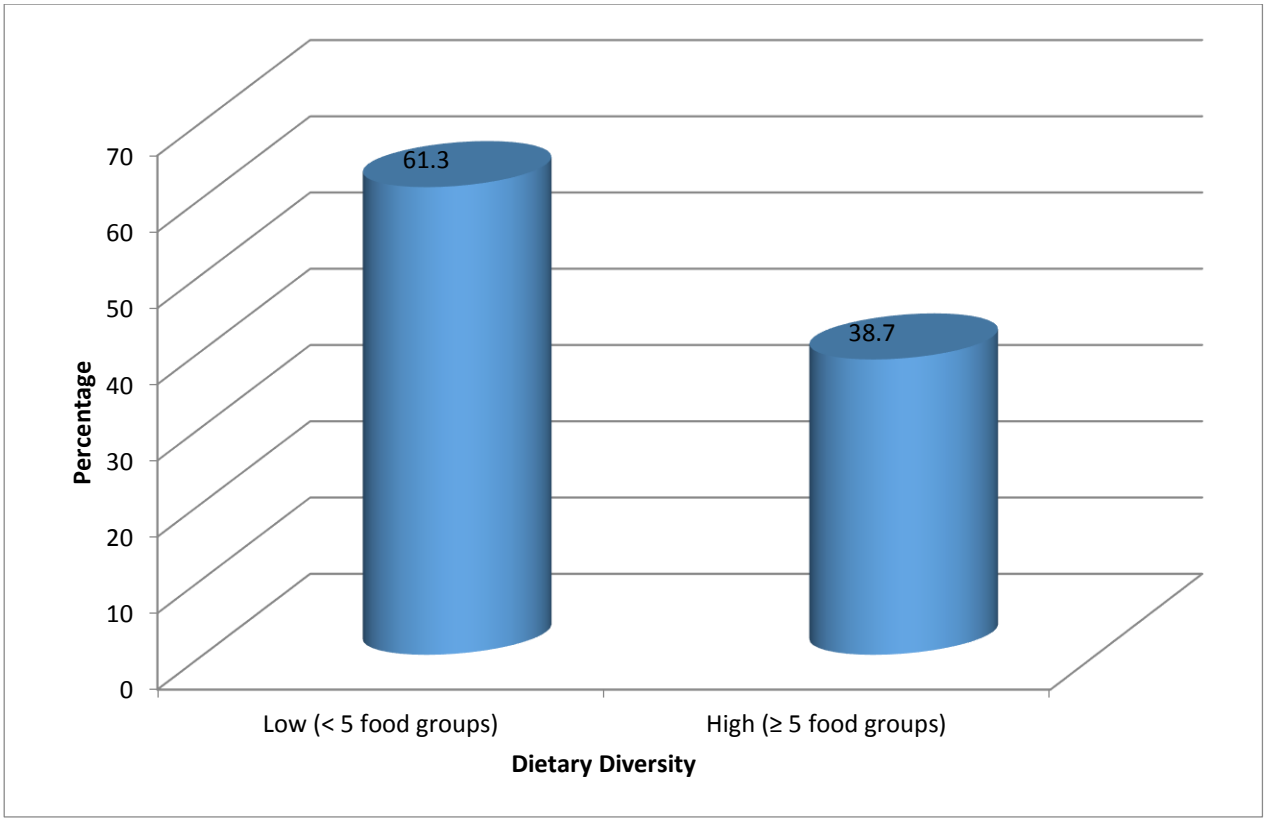
(Field work, 2016).

Anaemia was found to be significantly more present among children with worm infestation compared to those without worm infestation (76.9% versus 46.9%, p=0.054). Similarly, IDA was significantly more likely among children with worm infestation compared to those without worm infestation (83.3% versus 16.1%, p=0.004).

4.4 Food Consumption and Dietary Diversity among study children

Collectively, the FFQ and the 24-hour dietary recall methods generated information that allowed the assessment of the degree to which participants consume food groups rich in iron and other nutrients in their daily meals. This clearly paved way to relate the IDA status of participants to their dietary intake.

In relation to the number of food groups consumed within the week each child was classified as having high or low dietary diversity (DD) which could reflect their nutrient intake. Participants who consumed foods from less than five (5) food groups per week were considered as having low DD whiles those who consumed foods from five (5) or more food groups were considered as having high DD. Subsequently, more than half (61.3%) of the participants assessed for food intake had low DD whereas 38.7% had high DD (Figure 4.2). The mean for dietary diversity score was 4.52±2.28 with a minimum and maximum score of 1 and 9 respectively.



(Field work, 2016).

Figure 4.2: Dietary diversity among study children

4.4.1 Relating Food consumption, Dietary Diversity and IDA among study children

The consumption of iron-rich foods, vitamin-A rich foods, tea leaf, the number of times of food consumption per day and dietary diversity scores were related to IDA in the study population and the results are presented in Table 4.5 below.

Table 4.5: Food consumption, Dietary Diversity and IDA among study children

Variable	N	IDA		Chi-square	p-value
		Yes n (%)	No n (%)		
Consumption of Iron-Rich Foods					
Yes	31	3 (9.7)	28 (90.3)	4.723	**0.030**
No	31	11 (35.5)	20 (64.5)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Consumption of Vitamin A-rich Foods					
Yes	31	8 (25.8)	23 (74.2)	0.203	0.652
No	31	6 (19.4)	25 (80.6)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Consumption of Tea Leaf					
Yes	34	6 (17.7)	28 (82.3)	1.077	0.296
No	28	8 (28.6)	20 (71.4)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Number of times of food consumption per day					
Adequate	19	4 (21.9)	15 (78.1)	0.117	0.723
Inadequate	43	10 (23.3)	33 (76.7)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Dietary Diversity					
Low	37	9 (24.3)	28 (63.7)	3.041	0.090
High	25	5 (20.0)	20 (80.0)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		

(Field work, 2016).

Among those children who consumed iron-rich foods, 9.7% had IDA (Table 4.5) and for those who did not consume iron-rich foods 35.5% had IDA. This difference was shown to be significant (p=0.030). Regarding the consumption of vitamin-A rich foods, 25.8% of the children were reported to have IDA while 19.4% who did not consume vitamin-A rich foods had IDA. However, the difference in this case was not statistically significant (p=652). In terms of tea leaf beverage consumption, 17.7% of consumers as opposed to 28.6% of non-consumers were more likely to have IDA , but this difference was also not statistically significant (p=0.296). When the number of times of food consumed per day was classified as adequate (3 times or more daily) or inadequate (less than 3 times per day) it was shown that 21.9% of those who had adequate consumption also had IDA whilst

23.3% of those who had inadequate consumption had IDA (p=0.723). As per DD, 24.3% of children with low DD as opposed to 20.0% with high DD were more likely to have IDA although the difference was not significant (p=0.090).

4.5 Nutritional status of children in the study

An evaluation of the nutritional status and estimation of spread of malnutrition among the children is presented in Table 4.6 using cut-offs for z-scores for weight-for-age (WAZ), weight-for-height (WHZ) and height-for-age (HAZ). A large proportion of the children were considered underweight (41.9%) with 33.8% and 8.1% being moderately (WAZ<-2) and severely underweight (WAZ<-3) respectively. Similarly, out of 20.1% of children who were identified to be wasted, 16.2% and 4.8% were moderately (WHZ<-2) and severely wasted (WHZ<-3) respectively. Furthermore, about 32.3% were classified stunted with 24.2% and 8.1% being moderately (HAZ<-2) and severely stunted (HAZ<-3) respectively.

Table 4.6: Nutritional status of children in the study

Variable	Frequency	Percentage
Underweight (WAZ)		
Normal	36	58.1
Moderate	21	33.8
Severe	5	8.1
Total	**62**	**100**
Wasting (WHZ)		
Normal	49	79.0
Moderate	10	16.2
Severe	3	4.8
Total	**62**	**100**
Stunting (HAZ)		
Normal	42	67.7
Moderate	15	24.2
Severe	5	8.1
Total	**62**	**100**

(Field work, 2016).

4.5.1 Relating Nutritional Status to IDA among children in the study

The nutritional status of children in the study in terms of underweight, wasting and stunting levels were related to IDA and the results are presented in Table 4.7.

Though children who were underweight were more anaemic with IDA {25.0%) than their normal counterparts (20.1%), the difference was not significant (p=0.272). Similarly, IDA was more likely but not significantly so to be found in those who were stunted (27%) than those who were normal (16.0%) (p=0.123). Wasted children were also less significantly (p=0.940) shown with IDA than their normal counterparts (21.7% vs 23.1%, p=0.940).

Table 4.7: Bivariate Analysis of Nutritional Status and IDA

Variable	N	IDA Status		Chi-square	p-value
		IDA n (%)	No IDA n (%)		
Underweight					
No	38	8 (20.1)	30 (79.9)	1.206	0.272
Yes	24	6 (25.0)	18 (75.0)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Stunting					
No	25	4 (16.0)	21 (84.0)	2.373	0.123
Yes	37	10 (27.0)	27 (73.0)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		
Wasting					
No	39	9 (23.1)	30 (76.9)	0.006	0.940
Yes	23	5 (21.7)	18 (78.3)		
Total	**62**	**14 (22.6)**	**48 (77.4)**		

(Field work, 2016).

4.6 Determinants of IDA among children in the study

Different co-variates were examined in relation to the IDA status of children in the study using a binary logistic regression model. These factors included the consumption of iron-rich foods, consumption of vitamin-A rich foods, consumption of tea leaf and number of times of food consumption per day, dietary diversity, worm infestation, malaria, haemoglobin levels, age and sex of the children. The outcome of the regression analysis is shown in Table 4.8.

After controlling for socio-demographic characteristics (age and sex) and other co-variates in the analysis, worm infestation was found to be the only significant predictor (p=0.042) of IDA among children in the study.

Compared to those without worm infestation, children with worm infestation were about 7.7 times likely to suffer from IDA (AOR=7.65, 1.074-54.482, p=0.042) (Table 4.8).

Table 4.8: Determinants of IDA among children using binary logistic regression modeling

	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for Exp(B)	
							Lower	Upper
Iron-rich foods	-0.084	1.25	0.004	1	0.947	0.92	0.079	10.649
VitA-rich foods	-0.532	1.58	0.113	1	0.736	0.588	0.027	13.009
DDS	-0.805	0.908	0.785	1	0.375	0.447	0.075	2.652
Tea leaf intake	24.299	17006.66	0	1	0.999	3.57E+10	0	-
Age	0.777	0.619	1.575	1	0.209	2.176	0.646	7.327
Frequency of food intake	-23.17	17006.66	0	1	0.999	0	0	-
Sex	1.557	0.821	3.593	1	0.058	4.742	0.948	23.71
Worm infestation	2.035	1.002	4.127	1	**0.042**	7.651	1.074	54.482
Constant	-7.667	4.245	3.263	1	0.071	0		

(Field work, 2016).

CHAPTER FIVE

DISCUSSION

5.0 Introduction

In this chapter, the results of the study are discussed in relation to existing literature. Where possible, the required literature was cited to show either a convergence or divergence in opinion in the interpretation of the results. In general, all results were discussed with supporting literature. Finally, the inferences emanating from the discussions have also been presented.

5.1 Prevalence of anaemia and IDA among children in the study

The prevalence of anaemia as determined by the haemoglobin level among the study children was quite high by all standards (53.2%), which according to the WHO is at the level where it can be considered as a public health problem. This prevalence rate is comparable to that reported in a study by GSS (2011) among children 6-59 months (57%) in Ghana. However, since the children in the latter study were not living in orphanages, it could only be inferred that the factors accounting for their level of anaemia may not be very different from those in this study population. However, the level of anaemia seen in this study is in sharp contrast to those reported in the GDHS of 2008 (78%) and 2014 (66%) for children within this age group, but comparatively, it may give the impression of a better status for children in this study. This is probably borne out by the fact that the anaemia in this study population has mostly been mild and moderate without any report of severe anaemia. Nevertheless, the prevalence rate of 53.3% confirms the assertion that anaemia is

a severe public health problem in nearly all developing countries and therefore needs mitigation.

In this study also, IDA prevalence was found to be on the high side (22.6%), with more than half of the study population with iron deficiency, which means that the proportion of children with IDA is about half of those with anaemia. This conforms to the assertion by Fernando (2008) that 50% or more of all anaemia are said to have IDA. This is again bolstered by Stoltzfus (2001) where she asserts that the number of people affected by iron deficiency is mostly higher than those with anaemia, and adds that it is likely that any population affected by anaemia is to some degree attributed to iron deficiency. In this same vein, it is observed that iron deficiency may have contributed greatly to the anaemia levels observed.

5.2 Factors associated with IDA among children in the orphanages

On a global scale, the major causes of anaemia are iron deficiency; other nutritional deficiencies, malaria, helminth infections, chronic infections such as HIV/AIDS, reproductive causes, and genetic conditions (Galloway, 2003). The fact that anaemia prevalence in this study persists at moderate to severe levels according to internationally accepted standards primarily reflects the difficulty of meeting the dietary iron needs of individuals. Additionally, it could also be a reflection of a mix of other causative factors as indicated by Galloway (2003). Nevertheless, a lack of adequate dietary iron intake, which is a major nutritional issue in developing countries, has been shown to be central to the development of iron deficiency and IDA. This assertion is further amplified by Hall, Bobrow, Brooker & Jukes (2001) who add that iron deficiency, the most common form of

micronutrient deficiency, is caused by inadequate diet and infection, particularly hookworm and malaria.

According to a study by GSS (2011), close to half of the anaemia problem was linked to dietary practices, particularly the low consumption of iron rich food sources, a finding which resonates with that of this study. Furthermore, the high prevalence of anaemia as reported in this study may be supported by the findings of Rosado et al (2010), who showed that anaemia is most likely the most identified consequence of micronutrient deficiencies among different populations in the world. This level of anaemia as seen among children in the orphanages could be blamed in part on the lack of access to good diet, ineffective care and or unhygienic practices as often happens in most orphanages.

In assessing the dietary intake, most participants were found to have consumed foods from an average of 4 food groups. It does demonstrate to some extent that children in these orphanages have access to food. This observation is sustained by both Vyok (2011) and Aldous (1962) who showed that orphans' accessibility to food can be likened to that of other local children. However, access to food by children in orphanages does not guarantee adequate nutritional intake owing to poorly planned menus as suggested by Lucas (2000) and Frank and Klass (1996). This has been confirmed by an observation in this study showing, for instance, the frequent consumption of tea, vegetables and starchy carbohydrates as a constant feature of the menu. The typical eating pattern in the orphanages revealed a largely grain and vegetable based diet, which although relatively high in total iron content, was very low in absorbable iron due to the presence of high levels of phytates and polyphenols (Wasantwisut, 2001).

The children in this study were also offered foods rich in vitamin A and iron which they consumed. Nevertheless, apart from the iron-rich foods (p=0.030) none of the foods consumed showed any significant association with IDA. Consumption of iron-rich foods, however, was shown to be protective of IDA. This significant association could be attributed to the provision of animal source foods as part of the menu in the orphanages.

From the bivariate analysis (Table 4.7), no significant differences in IDA (p=0.090) was observed between participants deemed to have low and high dietary diversity. This could mean that there was no increase in the range and nutritional quality of foods consumed on a regular basis in the orphanages or in other wards the variety of foods consumed was limiting, which may lead to nutritional deficiencies. This may reaffirm the case of poorly planned menus owing to the lack of adequate knowledge on nutrition and child care practices by caregivers of these orphanages.

In order to be effective in improving iron intake in such vulnerable groups, dietary diversification activities must be geared towards expanding dietary variety and quality through increased consumption of animal source foods, which by and large would lead to an overall improvement in nutritional status.

In this study, the prevalence of underweight (41.9%) and stunting (32.3%) among children under 5 years living in the orphanages were found to be comparable to those in a study by Panpanich, Brabin, Gonani & Graham (1999), which sought to compare the health and nutritional status of children living in orphanages and orphans living with families and non-orphaned children in Malawi. Nonetheless, significant variation in the prevalence of

wasting was observed between this study (20.1%) and the 9.7% reported by Panpanich, Brabin, Gonani & Graham (1999).

Also, Sadik (2010) reported prevalence rates for severe stunting (10%) and severe wasting (15%) in a study to investigate the dietary needs of orphanage children in Ghana, which mimics that in the current study. This is closely in conformity with yet another study by Obidul Huq, Chowdhury, Roy, Formuzul Haque & Bellal Hossain (2013) who investigated the healthcare facilities available in orphanages and the nutritional status of orphans (6-12 years) in Bangladesh.

Compared to the GDHS (2014) however, there are significant differences in prevalence rates than in this study, with the GDHS indicating lower rates; underweight (11%), stunting (19%) and wasting (5%) respectively. The remarkable disagreement between these 2 studies could be attributed to the fact that unlike this study, the GDHS focused generally on children under 5 years and not mainly orphans in the same age category.

According to the WFP (2009), in Ghana, lack of access to food was only significantly related to wasting, which directly results from acute reduced energy intake due in part to either a worsening diet or inability to absorb ingested nutrients. Stunting, which is a reflection of chronic malnutrition, was more strongly linked with wealth of the household. Inspite of this, the causal factors could change depending on the location. For instance, in the savannah zone, wasting was mostly determined by disease (diarrhea and fever). On the other hand, stunting was mainly occasioned by a lack of access to food at the household level (poor and borderline food consumption). Stunting generally occurs as a result long term, structural shortcomings at the household and community levels. Given this

relationship therefore, inadequate diet which is characteristic among the poor populations in this part of the country could present long lasting and irreversible effects on the mental and physical development of children. Further to this, diarrhea, lack of deworming medication and unsafe sanitation facilities were found to be significantly associated with stunting levels.

Generally, it can be inferred that the seemingly high prevalence of malnutrition in the understudied orphanages and other orphanages as outlined in literature point to a certain convergence in opinion that most orphanages are characterized with malnutrition and poor health. Indeed, this is corroborated by an observation made by www.globalgiving.org in which they opine that the growing population of orphaned and vulnerable children in Ghana is typified by malnutrition and poor health. This trend, they assert could be due to the fact that most of the caregivers in these homes lack the required basic knowledge to meet the health care and nutritional needs of these orphans. This observation is further shared in a study by IRIN (2009), which revealed that even though orphans have access to more material goods relative to their community peers, only about 30% of an orphanage's funds actually go to child care. Again, this is reinforced in both Aldous (1962) who contend that orphan's access to material support supersede that of other locals. According to FAO (2005), the nutrition status of individuals is influenced by the environment, tradition and practices within the household and the community. Good care practices including eating habits, home health practices and hygienic practices at the level of the household ensure that healthcare and food resources made available to individual members result in optimal growth, survival and development.

Overall, the seemingly high malnutrition and IDA prevalence rates reported in this study could be attributed to the fact that most orphanages are typified by a lack of access to adequate health care services and rising fertility rates that result in overcrowding in these orphanages, thus causing a reduction in the food resources available to the children. This position is strongly shared by UNICEF (2007). Again, even where children have access to food resources, adequate nutritional intake is not guaranteed due to possibility of poorly planned menus

5.3 Determinants of Iron deficiency anaemia among children in the orphanages

Apart from contribution to the cause of iron deficiency and IDA, these could be exacerbated through excessive blood loss as a result of infections. Whilst malarial infection leads to anaemia through the destruction of red blood cells by the malaria parasites, hookworms and schistosomes being the most common helminthes cause significant blood loss in the host, which leads to iron deficiency and anaemia. This study has shown that though malaria was not likely to be significantly associated with anaemia, hookworm infection was a major issue among the study population. Indeed, close to ¼ (21%) of the participants presented with these worms, which resonates with the statement espoused by the World Health Organization (2007a) in which it is estimated that the prevalence of parasitic infections in Ghana is between 2% and 78%. It also ties in with the fact that over a billion people worldwide, including children are known to be infected with hookworms and may also give credence to the fact that IDA is one of the most frequently observed manifestations of hookworm infection as reported by Hotez, et al (2004) and Roca & Balanzó (2006). Quite clearly, the reported 21% hookworm infestation levels observed from the study could once

again be attributed to lack of routine deworming activities in the orphanages which calls for the need to strengthen and maintain such activities.

Different indicators have been noted to have a link with iron deficiency anaemia, however, only worm infestation was observed to significantly impact anaemia and IDA, and clearly hookworm infections emerged as the strongest predictor of IDA. According to Diemert (2006), hookworm infection is mainly manifested clinically as iron deficiency anaemia and constitutes a major public health issue around the world. This finding is also consistent with positions espoused by both Hotez, et al (2004) and Roca & Balanzó (2006) in which iron deficiency anaemia was seen to be one of the most frequently observed manifestations of hookworm infection. This could also imply that deworming activities are not probably carried out as routinely as they ought to be and perhaps due also to low intake of iron rich foods or non-availability of iron from the foods consumed owing to high levels of iron inhibitors.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

The conclusions chapter presents the highlights of the key findings and discussions recounting from the inferences and linkages within the findings. Based on the conclusions pertinent recommendations are made.

6.1 Summary of Main Findings

The study set out to determine the prevalence and predictors of IDA among children (6 months – 8 years) living in 2 orphanages in the Tamale Metropolis. The study collected and analyzed data on food consumption/dietary intake and care practices in the orphanages and conducted anthropometric and biochemical assessments.

This study adopted a comprehensive method that employed the recommended 'ABCD' of nutritional status evaluations. The key findings of the study are summarized below;

- Over half of the participants (53.2%) were found to be anaemic with 22.6% and 30.6% being mildly and moderately anaemic respectively. No case of severe anaemia was found.
- The prevalence of Iron deficiency anaemia was determined to be 22.6% in the understudied orphanages
- The study revealed that hookworm infection was a major issue at the orphanages since close to ¼ (21%) of the participants presented with worms.

- Iron deficiency anaemia was found to be more among orphans with worm infestation compared to those without worm infestation (76.9% versus 44.9%, p=0.04).
- Among those children who consumed iron-rich foods, 9.7% had IDA (Table 4.5) and for those who did not consume iron-rich foods 35.5% had IDA. Consumption of iron-rich foods was significantly more likely to protect against IDA (p=0.030)
- A large proportion of the children were considered underweight (41.9%), stunted (32.3%) and wasted (16.2%). However there were no significant associations between these rates of malnutrition and IDA.
- After controlling for age, sex and other covariates, only worm infestation was found to be a predictor of IDA among orphans in the study (AOR, 7.651, 95% CI = 1.074-54.582, p=0.042). Relative to those without worm infestation, orphans with worm infestation were about 7.7 times likely to suffer from iron deficiency anaemia.

6.2 Conclusions

Overall, the study established that malnutrition was rife in among the study population and the causes may be ascribed to the consumption of diets limiting in quality as well as from poor care and health practices in the orphanages. Although the consumption of iron-rich foods was seen as protective of IDA, perhaps the frequent consumption of foods such as tea and high starchy carbohydrates may negate the beneficial effects of these iron-rich diets.

Among the various determinants of IDA, worm infestation was strongly predictive of IDA. The findings may suggest that malnutrition and IDA are rife in these orphanages. In view of these findings, a combined strategy employing routine deworming, proper hygienic practices and dietary diversification and modifications are strongly recommended to tackle

the issue of malnutrition and IDA in the orphanages. Again, anaemia prevention and control measures should be maintained and strengthened since it continues to be a public health problem among Ghanaian children. The study, although failed to measure the knowledge of caregivers, agrees to some extent with other findings that suggest that caregivers in institutionalized care lack the requisite knowledge to provide for the nutritional needs of children in such places in the light of seemingly high proportion of underweight children and high level of anaemia.

It is expected that the findings will not only add to the scarce data but also will form the basis of developing and implementing a rigorous nutrition education and training program for institutionalized care in Ghana.

6.3 Recommendations or Future Directions

Based on the findings of the study, the following are recommended;

- Managers and care providers of orphanages should ensure that inmates are routinely dewormed. This is necessary as worm infestation was seen to be the main predictor of iron deficiency anaemia among participants.
- The department of social welfare and managers of orphanages should provide periodic nutrition education and training to caregivers to enable them meet the nutritional demands of the different children in the orphanages.
- The need to strengthen monitoring and supervision of orphanages by institutions that have oversight responsibility.

- Further research should be dedicated to the nutritional and health assessments of children in orphanages and institutionalized care in Ghana.

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APPENDICES

Appendix I: Survey Questionnaire

Orphanage Manager/Caretaker's Informed Consent

Title: Predictors and prevalence of Iron Deficiency Anaemia among children living in orphanages in the Tamale metropolis

The above document describing the benefits, risks and procedures for the research titled "*Predictors and prevalence of iron deficiency anaemia among children living in orphanages in the Tamale Metropolis*" has been duly read and explained to me. I have been given the opportunity to have any questions about the research answered to my satisfaction. Taking part in this academic undertaking is therefore my choice. I know that I may decide to pull out at any time or pull my inmates out at any time. I agree to participate voluntarily.

…… ……..……

Date Name of facility/orphanage

……..…….

Signature/thumbprint of respondent

……..

Signature/thumbprint of witness

……. ……

Date Name of interviewer

……..

Signature of interviewer

A. Orphanage Manager/Caretaker Questionnaire

IDENTIFICATION	CODE
Name of facility/orphanage…… Town/City……..…….. Region……. Rural ☐ Urban ☐	☐ Facility code
Name of respondent …… Contact number ……... Name of referenced child……. Child's age ……... Child's sex: Male ☐ Female ☐	☐ Child's code
Interviewer ……. Date:	

Section one of the questionnaire is a KAP survey that seeks to assess the knowledge, attitude and practices of managers or caregivers of orphanages as regards children aged 6 months-8 years. It will attempt to gather information on the feeding and care needs of the target group and where to access this information. The other sections will obtain information on anthropometric details, dietary intake, sanitation and hygiene, as well as clinical information.

1	Do you know anything about how to feed children in the following age groups? ***(If no skip to Q7)***	**Age group** / **1. Yes** / **2. No** / **3. Other** 0-6 months 7 months to under 2 years 2-under 5 years 5-8 years
2	What do you know about the needs of children 0-6 months? ***(Circle as they are mentioned, multiple answers permitted)***	1. Initiate breastfeeding within 1hr of delivery 2. No water for first 6 months 3. Exclusive breast feeding for 6 months 4. Breastfeed on demand 5. Give baby colostrum (the first yellow milk a mother produces 6. Allow baby to suckle long at one breast for food and water 7. Others (specify)…….
3	What do you know about the needs of the children aged 6-23 months regarding feeding? **(*Circle as they are mentioned, multiple answers permitted)***	1. Introduce complementary foods at 6 months 2. Feed child a range of foods from all groups 3. Give frequent small meals 4. Cook separately for baby without harsh spices, eg. Pepper 5. Be patient and encourage child to eat during feeding time 6. Continue breastfeeding until child is 2 years 7. Others (specify)…….
4	What do you know about the needs of the children aged above 2 years and under 5 years regarding feeding? ***(Circle as they are mentioned, multiple answers permitted)***	1. Eat variety of meals prepared from all group of foods 2. Eat fruits between meals 3. Eat fruits with meals 4. Eat fruits and/or vegetables of variety of colours 5. Others (specify)……..
5	What do you know about the needs of the children aged between 5 and 8 years regarding feeding? ***(Circle as they are mentioned, multiple answers permitted)***	1. Eat variety of meals prepared from all group of foods 2. Eat fruits between meals 3. Eat fruits with meals 4. Eat fruits and/or vegetables of variety of colours 5. Others (specify)……..
6	Who/where did you receive this information concerning 6-8 years	1. Health worker/health facility 2. Teacher/school staff/school 3. Community volunteer 4. Child 5. Family member, specify… 6. Friend 7. Radio 8. Television

	(Circle as they are mentioned, multiple answers permitted)	9. Church/mosque 10. Myself 11. Don't remember 12. Others (specify)……
7	If all the food we eat in Ghana were placed together into one basket, would you be able to group them according to their functions ***(If no, skip to Q10)***	1. Yes 2. No

8	Name the food groups you know ***(Circle as they are mentioned, multiple answers permitted)***	1. Body building/protein foods such as milk, meat, chicken, eggs 2. Energy given/carbohydrates and fats such as kenkey, yam, banku 3. Protective/fruits and vegetables such as mangoes, carrots, nkotomire, aleefu, kenaf 4. Nuts and Legumes/beans, peas, lentils, nuts 5. Other (specify)…….
9	Who or where did you hear about food groups from? ***(Circle as they are mentioned, multiple answers permitted)***	1. Health worker /health facility 2. Teacher/school staff/school 3. Community volunteer 4. Child 5. Family member 6. Friend 7. Radio 8. Television 9. Church/mosque 10. Others (specify)…….…… 11. Myself 12. Don't remember
10	What are some examples of foods that mainly help children to grow well?	1. Meat (beef, mutton, pork, rabbit, bush meat) 2. Poultry (chicken, guinea fowl, duck) 3. Eggs (all souces) 4. Dairy (milk, cheese, yorghut) 5. Legumes (beans , groundnuts,) 6. Fish (Herring, tuna, mackerel, tilapia) 7. Other (specify)…… 8. Don't know 9. Wrong (specify)……..
11	What are some examples of foods that mainly provide energy for work?	1. Cereals and grains (maize, sorghum, rice) 2. Roots and tubers (cassava, yam, cocoyam, plantain, sweet potato, irish potato) 3. Fats and oil (coconut oil, palm oil, soya oil, olive oil) 4. Other (specify)……. 5. Don't know

12	What are some examples of food which protects us from diseases?	1. Fruits (watermelon, pineapple, mango, banana, orange, tangerine, pea) 2. Vegetables (okro, garden eggs, tomatoes , carrots, green beans, onions, spring onions) 3. Leaves (lettuce, cabbage, nkontomire) 4. Other (eg, fruit juice) 5. Don't know
13	What do you think would happen when a school child does not eat body building foods such as meat, fish, chicken, milk, in the amounts they need? ***(Do not read answers – multiple options allowed)*** ***(4-8 years)***	1. Weight loss 2. Low energy/weakness/low physical activity 3. Frequent illness 4. Slowed growth rate 5. Poor performance at school 6. Anaemia (low blood) 7. Poor vision 8. Goiter 9. Sore mouth/bleeding gums 10. Skin problems 11. Don't know 12. Death 13. Other (specify)…….……
14	What do you think would happen when a school child does not eat energy providing foods such as kenkey, rice, fufu, plantain, palm oil, coconut oil, in the amounts they need? ***(Do not read answers – multiple options allowed)*** ***(4-8 years)***	1. Weight loss 2. Low energy/weakness/low physical activity 3. Frequent illness 4. Slowed growth rate 5. Poor performance at school 6. Anaemia (low blood) 7. Poor vision 8. Goiter 9. Sore mouth/bleeding gums 10. Skin problems 11. Don't know 12. Death Other (specify)……..……

15	What do you think would happen when a school child does not eat protective foods such as mango, banana, pawpaw, kontomire, alefu, in the amounts they need? ***(Do not read answers – multiple options allowed)***	1. Weight loss 2. Low energy/weakness/low physical 3. Frequent illness 4. Slowed growth rate 5. Poor performance at school 6. Anaemia(low blood) 7. Poor vision

		8. Goiter 9. Sore mouth/bleeding gums 10. Skin problems 11. Don't know 12. Death 13. Others (specify)…….
16	How many times in a week should a school going child eat fruits? ***(4-8 years)***	1. Once 2. Twice 3. Thrice 4. Four time 5. Five times 6. Six times 7. Everyday 8. Never 9. Don't know 10. Others (specify)……..
	Do you usually consider any of the following factors when sharing meals at the orphanage? ***Ask respondent to rank factors she does***	

17	***consider when sharing meals in order of importance. Indicate ranking beside factor, eg. Status-1, gender-2, appetite-3, etc. Only rank for those indicated as yes***	No	Yes	Rating	
					Gender
					Physiological state (eg. sick)
					Appetite/capacity for food
					Don't know
					Food preference
					Age
18	Would you provide a child one less meal at home on days when she/he eats a free meal at school?	1. Yes 2. No 3. Don't know			
19	How can we ensure the safety of your food in the orphanage? ***(choose all that apply)***	1. Select wholesome food 2. Cook food well before eating 3. Wash fresh food under running water before use 4. Wash fresh vegetables under running water before use 5. Serve cooked food hot 6. Buy cooked food hot 7. Buy food which is served on raised platforms 8. Dish cooked food with a serving utensil and not bare hands 9. Vendors should dish cooked food with utensils and not bare hands 10. Keep food covered 11. Buy cold food such as yorghurt, ice cream, chilled or frozen 12. Use clean utensils 13. Separate uncooked food from cooked foods 14. Don't know 15. Others (specify)…….			

B. Anthropometry/Health/Sanitation/Other Care Practices

<table>
<tr><td>20</td><td>Height/length of child</td><td>…… cm</td></tr>
<tr><td>21</td><td>Weight of child</td><td>…… kg</td></tr>
<tr><td>22</td><td>Has this child (name/code) had a recent weight loss?</td><td>1. Yes 3. Don't know
2. No</td></tr>
<tr><td>23</td><td>Is the child on any special diet?</td><td>1. Yes. If yes, specify……
2. No</td></tr>
<tr><td>24</td><td>Does the child have good appetite?</td><td>1. Yes
2. No</td></tr>
<tr><td>25</td><td>Does the child have any problem with?

(Tick appropriately)</td><td>
<table>
<tr><th>Condition</th><th>1. Yes</th><th>2. No</th></tr>
<tr><td>Swallowing</td><td></td><td></td></tr>
<tr><td>Chewing</td><td></td><td></td></tr>
<tr><td>Nausea</td><td></td><td></td></tr>
<tr><td>Diarrhea</td><td></td><td></td></tr>
<tr><td>Vomiting</td><td></td><td></td></tr>
<tr><td>Constipation</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>26</td><td>Is this child (code) on any vitamin/mineral supplement?</td><td>1. Yes. If yes list……
2. No</td></tr>
<tr><td>27</td><td>How many times does the child bath in a day? (confirm from child if available and can talk)</td><td>1. …….. times (fill)
2. When necessary
3. Others (specify)……</td></tr>
<tr><td>28</td><td>Does the child have a room to him/herself? (Observe and comment where necessary)</td><td>1. Yes. Comment …….
2. No</td></tr>
<tr><td>29</td><td>If no, how many share a room?</td><td>1. 1-2
2. 3-4
3. Above 5</td></tr>
<tr><td>30</td><td>Does the child (code) sleep under an insecticide treated net?</td><td>1. Yes ……..
2. No</td></tr>
<tr><td>31</td><td>Did the child sleep under an insecticide treated net last night? (Observe and comment)</td><td>1. Yes

2. No</td></tr>
<tr><td>32</td><td>Has the child had malaria in the period preceding the survey?</td><td>1. Yes
2. No. If No skip to 34</td></tr>
</table>

33	How long ago did this happen?	1. 1-3 days ago 2. 4 - 6 days ago 3. Others (specify)……
34	Has the child been dewormed?	1. Yes 2. No. If No skip to 37
35	When was the last time he/she dewormed?	1. ……. day (s) ago 2. …….. week (s) ago 3. …… month (s) ago 4. Don't know 5. Others (specify) ……
36	How often does he/she take dewormers?	1. Monthly 2. Every 2 months 3. Every 3 months 4. Every 6 months 5. Every 12 months 6. Others (specify)……..
37	How does the child access health care?	1. Clinic 2. Drug peddlers 3. Hospital 4. Licensed chemical sellers 5. Health post/center 6. Herbalist 7. Others (specify)……..

C. Clinical Assessment

CHARACTERISTICS	PRESENT	ABSENT	COMMENTS
(1) Hair • Shiny • Loss of colour • Fir			
(2) Skin • Paleness • Dry • Oedema			
(3) Lips • Cheilosis (swollen) • Angular stomatitis			
(4) Eyes • Pale conjunctiva • Bitot spot • Dryness of Eyes			
(5) Gums • Swelling • Bleeding • Redness • Good pink colour			
(6) Tongue • Swollen • Xerophtalmia • Deep redness			
(7) Teeth • White • Dental caries • Pain • Crowding.			
(8) Others			

D: 24-Hour Dietary Recall

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
1	Did (CHILD'S NAME/CODE) drink anything from a bottle with a nipple yesterday or last night?	YES.....1 NO .....2 DON'T KNOW 9	
2	Now I would like to ask you about liquids or foods (CHILD'S NAME/CODE) had yesterday during the day or at night. Did (CHILD'S NAME/CODE) drink/eat:	READ THE LIST OF LIQUIDS (A THROUGH E, STARTING WITH "BREAST MILK"). YES NO DK	
	A. Breast milk?	……..…1 2 9	
	B. Plain water?	……..…1 2 9	
	C. Commercially produced infant formula?	……..…1 2 9	
	D. Any fortified, commercially available infant and young child food" [e.g. Cerelac?	……..…1 2 9	
	E. Any (other) porridge or gruel?	……..…1 2 9	
3	How many times did (CHILD'S NAME/CODE) eat solid or semi-solid food or soft foods other than liquids yesterday during the day or at night?	1 time……..1 2 times……2 3 times……3 4 or more times……4	
4	Now I would like to know whether (CHILD'S NAME/CODE) have had foods from the following groups yesterday during the day or at night. Did (NAME) drink/eat:	PLEASE FILL OUT THE FOLLOWING TABLE WITH THE ANSWERS TO THE QUESTIONS BELOW:	
	GROUP 1: CEREALS	**YES NO DK**	
	Any fortified, commercially available infant and young Child food (e.g. Cerelac)?	……1 2 9	
	Any (other) porridge or gruel?	……1 2 9	
	Bread, noodles, biscuits, any other food made from millet, sorghum, maize, rice, wheat	……1 2 9	
	GROUP 2: WHITE TUBERS AND ROOTS	**YES NO DK**	

	White potatoes, white yams, manioc, cassava, or any other foods made from roots?				
	GROUP 3:MILK AND MILK PRODUCTS	**YES**	**NO**	**DK**	
	Commercially produced infant formula?	……1	2	9	
	Milk such as tinned, powdered, or fresh animal milk?	……1	2	9	
	Cheese, yogurt, or other milk products?	……1	2	9	
	GROUP 4: VITAMIN A RICH VEGETABLES	**YES**	**NO**	**DK**	
	A. Pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside?	……1	2	9	
	B. Any dark green leafy vegetables?	……1	2	9	
	C. Ripe mangoes, papayas or (INSERT ANY OTHER LOCALLY AVAILABLE VITAMIN A-RICH FRUITS)?	……1	2	9	
	D. Foods made with red palm oil, palm nut, palm nut pulp sauce?	……1	2	9	
	GROUP 4: OTHER FRUITS/VEGETABLES	**YES**	**NO**	**DK**	
	E. Any other fruits or vegetables like oranges, grapefruit or pineapple?	……1	2	9	

GROUP 5: EGGS	**YES**	**NO**	**DK**	
F. Eggs?	……1	2	9	
GROUP 6: MEAT, POULTRY, FISH	**YES**	**NO**	**DK**	
G. Liver, kidney, heart or other organ meats?	……1	2	9	
H. Any meat, such as beef, pork, lamb, goat, chicken, or duck?	……1	2	9	
I. Fresh or dried fish or shellfish?	……1	2	9	
J. Grubs, snails, insects, other small protein food?	……1	2	9	
GROUP 7: LEGUMES/NUTS	**YES**	**NO**	**DK**	
K. Any foods made from beans, peas, lentils, or nuts?	……1	2	9	
GROUP 8: OILS/FATS	**YES**	**NO**	**DK**	
L. Any oils, fats, or butter, or foods made with any of these?	……1	2	9	
M. CHECK 93A – 93S: HOW MANY FOOD GROUPS (GROUPS 1-8 IN ABOVE TABLE) HAVE AT LEAST 1 'YES' CIRCLED?	Number of Group ☐			
GROUP 9: OTHER FOODS	**YES**	**NO**	**DK**	
N. Tea or coffee?	……1	2	9	
O. Any other liquids?	……1	2	9	

P. Any sugary foods, such as chocolates, candy, sweets, pastries, cakes, or biscuits?	……1 2 9	
Q. Any other solid or soft food?	……1 2 9	
5. How many times did (NAME/CODE) eat solid, semi-solid, or soft foods other than liquids yesterday during the day or at night? IF CAREGIVER ANSWERS SEVEN OR MORE TIMES, RECORD "7" WE WANT TO FIND OUT HOW MANY TIMES THE CHILD ATE ENOUGH TO BE FULL. SMALL SNACKS AND SMALL FEEDS SUCH AS ONE OR TWO BITES OF MOTHER'S OR SISTER'S FOOD SHOULD NOT BE COUNTED. LIQUIDS DO NOT COUNT FOR THIS QUESTION. DO NOT INCLUDE THIN SOUPS OR BROTH, WATERY GRUELS, OR ANY OTHER LIQUID. USE PROBING QUESTIONS TO HELP THE RESPONDENT REMEMBER ALL THE TIMES THE CHILD ATE YESTERDAY	NUMBER OF TIMES ☐ DON'T KNOW……9	

Frequency codes:

1- Daily
2- 4-5 times per week
3- 3-4 times per week
4- 1-2 times per week
5- Occasionally
6- Rarely

E: 7-Day Food Frequency Questionnaire

Has name/code eaten (food item) for the past 7 days?

Food Item	1. Yes 2. No	Daily	4-5 times/week	3-4 times/week	1-2 times/week	Occasionally	Rarely
CEREALS							
White maize koko							
Seasoned Millet (hausa) koko							
Tom brown							
Weanimix							
Rice water							
Cerelac							
Tapioka							
Bread							
Kenkey							
Banku/etew/akple							
Yakayeke							
Tuo zaafi							
Corn-boiled/roasted							
Rice(boiled/fried)							
Sorghum/Wheat							

WHITE TUBERS AND ROOTS **Food Item**	**1. Yes** **2. No**	**Daily**	**4-5 times/week**	**3-4 times/week**	**1-2 times/week**	**Occasionally**	**Rarely**
White yam							
White potato							
LEGUMES/NUTS							
Cassava							
Beans							
Manoic							
Cowpeas							
Others (plaintain)							
Bambara beans							
Soya beans							
Groundnuts (roasted/boiled/raw)							
Groundnut soup							
Kulikuli							
Koose							
Tigernuts							
VITAMIN A RICH FRUITS & VEGETABLES							
Pumpkin							
Carrots							
Squash							
Sweet potato (yellow or orange)							
Ripe mangoes							
Pawpaw							
Red palm oil/palm nut/palm nut pulp sauce							

Kontomire							
Cassava leaves							
Spring onions							
Lettuce							
OTHER FRUITS & VEGETABLES							
Orange							
Mango							
Grape fruits							
Guava							
Onions							
Shea fruits							
Pineapple							
Water melon							
Cabbage							
Garden eggs							
Okro							
Moringa leaves							
Tomatoes							
Bra (kenaf leaves)							
MEAT/POULRTY/FISH							
Liver/Kidney/Heart							
Beef							

Pork							
Lamb							
Goat							
Chicken							
Duck							
Fresh/Dried fish/ Shellfish							
Grubs							
Snakes							
Insects							

MILK & MILK PRODUCTS							
Tinned milk (Ideal, Carnation, Peak, Nunu, etc)							
Powdered milk (Nido, Peak, cowbell,Nunu)							
NAN 1/NAN 2							
Fresh animal milk							
Lactogen 1							
Lactogen 2							
OTHER FOODS							
Tea (tea leaves)							
Milo							
Coffee							
Zimcom (millet)							
Other……..							
Other……..							

Food Item	**1. Yes 2. No**	**Daily**	**4-5 times/week**	**3-4 times/week**	**1-2 times/week**	**Occasionally**	**Rarely**
Other…….							
Chocolates							
Pie							
Cakes							
Biscuits							
Candy							
Sweets							
Other……..							
Other……..							
OILS AND FATS							
Butter/Margarine							
Shea butter							
EGGS							
Eggs							

Appendix II: Introductory Letters

UNIVERSITY FOR DEVELOPMENT STUDIES

(School of Medicine and Health Sciences)

Tel: 03720-93295

P.O. Box 1883
Tamale, Ghana

Our Ref: UDS/CHD/099/12
Your Ref:

Date: 13/03/2015

Department of Allied Health Sciences

THE DIRECTOR
TAMALE TEACHING HOSPITAL
PUBLIC HEALTH LABORATORY
TAMALE.

Dear Sir,

LETTER OF INTRODUCTION

I write to introduce to you **MR. KAMAL-DEEN DJABAKU,** a student of the Department of Allied Health Sciences, School of Medicine and Health Sciences of the University for Development Studies**.**

He is carrying out a survey in your institution titled: **"Prevalence and Predictors of Iron deficiency anemia among orphans between "0 to 8 years" living in orphanages in the Tamale Metropolis."**

Kindly assist him to collect the appropriate data to answer his research questions.

Thank you.
Yours sincerely,

Dr. Robert Kuganab-Lem
(Head of Department)

UNIVERSITY FOR DEVELOPMENT STUDIES

(School of Medicine and Health Sciences)

Tel: 03720-93295

P.O. Box 1883
Tamale, Ghana

Our Ref: UDS/CHD/099/12
Your Ref:

Date: 13/03/2015

Department of Allied Health Sciences

THE METROPOLITAN DIRECTOR
OF HEALTH SERVICE
TAMALE.

Dear Sir,

LETTER OF INTRODUCTION

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He is carrying out a survey in your institution titled: **"Prevalence and Predictors of Iron deficiency anemia among orphans between "0 to 8 years" living in orphanages in the Tamale Metropolis."**

Kindly assist him to collect the appropriate data to answer his research questions.

Thank you.
Yours sincerely,

Dr. Robert Kuganab-Lem
(Head of Department)

GHANA HEALTH SERVICE

In case of reply the number
And date of this
Letter should be quoted
My Ref No. PHL/GHS/NR/

PUBLIC HEALTHLABORATORY
TAMALE TEACHING HOSPITAL
P.O. BOX TL 16
TEL: MOB: +233 244571559

17th April , 2015.

INTRODUCTORY LETTER

The Tamale Public Health Laboratory is a zonal facility in charge of the three regions of the north. It is ranked a four star laboratory by the African Society for Laboratory Medicine (ASLM), a subsidiary of WHO/AFRO Stepwise Laboratory Quality Improvement Process Towards Accreditation. It is one of a few facilities in Africa which have achieved a four star status.
In view of the above, all processes and procedures in the laboratory are carried out by certified competent and well motivated staff, guided by the policies covering same.

MR. KAMAL-DEEN DJABAKU, a student of the Department of Allied Health Sciences of the University for Development Studies has expressed interest in partnering our facility to carry out a study in your institution titled **'Prevalence and Predictors of Iron deficiency anaemia among orphans between 0 to 8 years living in orphanages in Tamale Metropolis'.**
Our role is to professionally take blood samples aseptically into both EDTA tubes and serum separators. A maximum of 1ml of blood sample into each of these tubes from recruited individuals will be enough for both full blood count and serum feritin estimations. In addition to that, faecal samples will be taken from these individuals for parasitological examination.

I wish therefore to assure you that, all these procedures will be carried out professionally under the principles of quality assurance; and that, the confidentiality of the test results is guaranteed
Thank you.

MR ABASS ABDUL-KARIM
DEPUTY HEAD
PUBLIC HEALTH LAB

Abass Abdul-Karim
SBMS, QM/Deputy Head
MPHIL, PGD, BSc

GHANA HEALTH SERVICE

OUR CORE VALUE

1. People Centered
2. Professionalism
3. Team work
4. Innovation
5. Discipline
6. Integrity

METRO. HEALTH DIRECTORATE
GHANA HEALTH SERVICE
P.O. BOX TL. 1191,
TAMALE

metropolitanhealthdirectorate@gmail.com

30TH March, 2015

Tel: 233 - 71: 23765
Fax: 233 - 71: 23765

My Ref No: .....
Your Ref No: .....

THE REGIONAL DIRECTOR
SOCIAL WELFARE DEPARTMENT
TAMALE

LETTER OF INTRODUCTION
MR.KAMAL-DEEN DJABAKU
MASTERS STUDENT UDS

As Part of the partial fulfillment to the award of Masters Degree in the University, students are supposed to take field studies or research.

The above has chosen Tamale Metropolis to carry out a survey **"Prevalence and Predictors of Iron Deficiency Anemia among Orphans Between "0 to 8 years" Living in Orphanages in the Tamale Metropolis."**

I would be very grateful if you could permit him to carry out the survey in the various Orphanages in the Metropolis.

Thank you.

DR. FRANCIS SOAH ALI
(METROPOLITAN DIRECTOR OF HEALTH SERVICES)

Cc: MR KAMAL-DEEN DJABAKU

DEPARTMENT OF SOCIAL WELFARE

In case of reply the number and date of this letter should be quoted

REPUBLIC OF GHANA

P.O. Box 57
Tamale, N/R
Tel: 0372022728

Our Ref: DA.1/Vol.8/32

Your Ref:.....

Date: 23rd April, 2015

PERMISSION TO CONDUCT RESEARCH ON ORPHANAGES BETWEEN 0-8 YEARS LIVING IN ORPHANAGES IN TAMALE METROPOLIS

Mr. Kamal-Deen Djabaku, a Masters student of University of Development Studies [UDS], as part of his partial fulfillment to the award of Master's Degree has decided to conduct a research on the "Prevalence And Predictors Of Iron Deficiency Anemia Among Orphans Between 0-8 Years Living In Orphanages In Tamale Metropolis".

The research, it is hoped, will bring to light issues instrumental to addressing the health needs of the orphans in the orphanages.

In the light of the above development, Mr. Kamal-Deen Djabaku, is hereby given permission to conduct the research on the orphans with the support and technical assistance of staff of the Ghana Health Service.

Consequently, by virtue of this letter the Supervisors of the homes/orphanages are to allow the researcher and the team of health workers undertake the research.

Thank you.

PROSPER KWASI OYEH
AG. REGIONAL DIRECTOR

ALL SUPERVISORS OF ORPHANAGES
IN TAMALE METROPOLIS