EFFECTS OF IRON AND ZINC SUPPLEMENTATION ON NUTRITIONAL STATUS OF CHILDREN UNDER FIVE YEARS IN LAFIA LOCAL GOVERNMENT AREA, NASARAWA STATE NIGERIA

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FEBRUARY,2015

DECLARATION

I declare that the work in this Thesis entitled **"Effectsof Iron and Zinc Supplementation onNutritional Status of Children Under five Years in Lafia Local Government Area, NasarawaState Nigeria"** was carried out by me in the Department of Biochemistry under the supervision of Dr D. B. James and Prof. K. M. Anigo.. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously published or presented for another degree or diploma at this or other Institution.

Echoda, Anfofum Amedu	………………..	……………
	Signature	Date

CERTIFICATION

This Thesis entitled "Effects of Iron and Zinc Supplementation on Nutritional Status of Children under Five Years in Lafia Local Government Area, Nasarawa State Nigeria" by ECHODA, Anfofum Amedu (M.SC/SCI/7191/2011-2012) meets the regulations governing the award of the degree of Master in Nutrition of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

The research work is dedicated to God Almighty for His continuous guidance and to my wife Mami and children who have given me faith, love and joy.

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Most of the debts of thanks that I owe are to the Almighty God that has helped me in all my ways.

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Finally, to God be the glory.

ABSTRACT

A randomized iron and zinc supplementation trial was carried out in Lafia Local Government, Nasarawa State, Nigeria with a total of 160 children below the age of five years. They were divided into 4 groups each containing 40 respondents: the Fe-group received daily and for a 3-month period 10 mg of iron, the Zn-group 10 mg Zinc, the Fe-Zn group10mg iron + 10mg Zinc and the control group, received no supplement. Serum iron (SFe) and serum Zinc (SZn), with anthropometry were determined before and at the end of the intervention. Socioeconomic characteristics of the respondents showed that the female participants (52%) were more than male (48%), the highest number of household heads were age 30-39 (50%) while 65.5% of the mothers were between the age range of 21-30 years. Percentage changes in weight, mid upper arm circumference, MUAC, iron and zinc status were higher in groups supplemented than those that were not. There was a significant difference (P□ 0.05) in SFe among the 36-47 months age group of Fe group. Horizontal pairs (baseline versus endline) with different superscripts *b* and *a*(P<0.05) while pairs with similar superscripts a and a are not significantly different (P>0.05). Percentage change in SZn were higher in Zn-group (highest change: 19.10% in female group and 22.36% in male groups) than in Fe-Zn group (highest % change: 8.45% in male group). However, there was no significant difference (P□ 0.05) in serum concentration and weight in combined Fe & Zn supplementation. Almost half of the respondents (49.38%) had no knowledge of micronutrient supplements yet 57% caregivers who knew the importance of micronutrient supplements do not give their children. There was significant difference (P□ 0.05) in MUAC- for- age as a result of iron supplementation in females of age group less than 11months while Zn supplementation recorded significant difference (P□ 0.05) in males and females of age group 11 - 23 months. Iron and zinc supplementation recovered 12.5% severely wasted respondents in Fe- group, and reduce acute wasting by 10% in Zn- group. In conclusion, this study revealed that iron and zinc supplementation recorded a significant difference (P□ 0.05) in iron and zinc status and that single iron and zinc supplement increased weight.

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ABBREVIATIONS

CDCP	**-**	Center for Disease Control and Prevention
CS-SUNN	**-**	Civil Society Scale-Up Nutrition in Nigeria
DMT-1	**-**	Divalent Metal Transporter-1
Fe-Zn	**-**	Combined Iron and Zinc
IZA	**-**	International Zinc Association
LSROFASEB	**-**	Life Sciences Research Office, Federation of American Societies for Experimental Biology
MCV	**-**	Mean Corpuscular Volume
MUAC	**-**	Mid Upper Arm Circumference
NDHS	**-**	National Demographic and Health Survey
SFe	**-**	Serum Iron
StfR	**-**	Serum Transferrin Receptor
SZn	**-**	Serum Zinc
UNDP	**-**	United Nations Development Programme
UNICEF	**-**	United Nations Children Education Fund
WHO	**-**	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background

The prevalence of food insecurity in sub-Saharan Africa is the highest in the world, with rates as high as 30% of the population being undernourished (UNDP, 2011). The United Nations sub-committee on nutrition and the World Health Organization estimated that about two-third of children in developing countries show some degree of growth retardation due to undernutrition. Micronutrients perform essential functions in normal growth and development beginning in the earliest stages of life. About 40 nutrients which are indispensable for the maintenance of vital processes, are required in only very small amounts, for which reason they are called "micro" nutrients. The child must consume small amounts of some 13 vitamins (Vitamins A, D, E, K, C, B_{12}, thiamine, riboflavin, niacin, pyridoxine, biotin, pantothenic acid and folate) and 10 trace elements (zinc, selenium, chromium, cobalt, copper, fluorine, iron, iodine, manganese and molybdenum). These essential micronutrients fulfill a variety of special metabolic functions, some acting as cofactors in the metabolism of proteins and amino acids, lipids and /or carbohydrates and in energy production (Lander *et al*., 2008). Some others serve as the catalytic centres or as structural elements of enzymes or other macromolecules.

Micronutrients cannot be synthesized by humans and must therefore be obtained from the diet. Micronutrient malnutrition can result not only from inadequate intake but also from inadequate digestion, and absorption(Win,2015). According to Federal Ministry of Health (2013), 41% of Nigerian children under the age of five years is stunted as a result of malnutrition. Acute malnutrition level is as high as 53% in the North West, 49% in North East, and 22% in South East (Omotola, 2012). UNICEF (2013) estimated that 1.1 million children were threatened with severe acute malnutrition in the Sahel region alone (comprising of 8 states in Northern Nigeria) which is fueled by poverty, insecurity, insufficient access to food, inadequate maternal and child caring practices, poor water and sanitation, inadequate health services and flood. And that a total of 13,574 children with severe acute malnutrition (SAM) were admitted to 479 UNICEF supported Community Management of Acute Malnutrition (CMAM) sites across Northern Nigeria.

UNICEF conceptual framework (2009) shows that malnutrition occurs as a result of two immediate causes: inadequate dietary intake and diseases, but also recognizes that poverty, human and environmental resources, economic systems and political and ideological factors are basic causes. Malnutrition in developing countries has high social and economic costs, such as increased mortality and morbidity, loss of human potential, decrease in skills and qualifications, lower productivity and higher poverty rates (Ogbebo, 2014).

Pellertier *et al.,* (1995) estimated the percentage of child deaths (6-59months) which could be attributed to the potentiating effects of malnutrition on infectious disease. The results from 53 developing countries with nationally representative data on child weight-for-age indicate that 56% of child deaths were attributable to malnutrition potentiating effects. Out of about 31 widely known micronutrients, five are of public health significance in Nigeria: vitamin A, iron, iodine, zinc and folate (Umunna, 2014), Micronutrient deficiency also known as hidden hunger is a major threat to health, growth and development of infants worldwide (UNICEF, 2011). According to Umunna (2014), micronutrient deficiency has enormous consequences for economic growth and human developmentin Nigeria as the connection between suffering, death and malnutrition is manifested in poorly developed learning abilities, death from childhood illness of children under the age of five and death of young mothers at childbirth due to anaemia.

Iron deficiency is the most common single nutrient deficiency in the whole world and the common cause of anaemia (Wessling-Resnick, 2014). Preschool children and women of child bearing age are at highest risk of iron deficiency (Mei et al., 2011). Also infants- especially those born preterm or with low birthweight or whose mothers have iron deficiency are at risk of iron deficiency because of their high iron requirements due to their rapid growth (Aggett, 2012).

Common causes of iron deficiency include inadequate dietary ingestion or absorption of dietary iron to meet iron losses or iron requirements imposed by growth or pregnancy. According to Lee and Nieman (2013) a good amount of iron is lost from heavy menstruation, frequent blood donations, early feeding of cow's milk to infants, frequent aspirin use, or disorders characterized by gastrointestinal bleeding. The tendency of iron deficiency increases during periods of rapid growth particularly at infancy (and the risk is greater in premature infants), adolescence and pregnancy (Gibson, 2011). Iron deficiency has a number of consequences which include impaired body temperature regulation, impairments in behavior and intellectual performance, reduced work capacity, increased susceptibility to lead poisoning, and decreased resistance to infections (Beard, 2001). During pregnancy, iron deficiency increases risk of maternal death, prematurity, low birth weight, and neonatal mortality. During early childhood iron deficiency adversely affects cognitive, motor, and emotional development that may be only partially reversible (Lynch, 2011).

Anaemia is a haemoglobin level below the normal reference range for individuals of the same sex and age, or a haemoglobin level that is lower than two standard deviations from the mean distribution in a healthy population of the same gender and age living at the same altitude (Thomas, 2014).

Zincis found in all parts of the body and plays an important physiologic function as a component of more than 300 enzymes also influencing hormones (King, 2011). Consequently, zinc is involved in many metabolic processes, including protein synthesis, wound healing, immune function and tissue growth and maintenance. It canreduce the duration and severity of a common cold and halt diarrhoea. Severe zinc deficiency characterized by hypogonadism and dwarfism has been observed in the Middle East. Cousins (2006) has shown that reduction or cessation of growth in humans and laboratory animals is an early indication of zinc deficiency and supplementation in growth-retarded infants and children who are mildly zinc deficient can result in improved growth response.

1.2 Statement of Research Problem

Nasarawa State is generally regarded as a rural state with rate of acute malnutrition (19.9%) higher than North Central average (14.3%) (CS-SUNN, 2015). This has been made worse by the recent ethnic crisis that engulfed the senatorial district.

Micronutrient undernutrition is generally correlated with overall malnutrition, since poverty limits both the quality as well as quantity food in the diet (Horton *et al*.,2008)

Existing beliefs and practices in infant feeding, like: early introduction of sweetened palp to infants before 4-6 months; cow's milk given to children before 1 year of age; infants fed using bottle; inappropriate timing of introduction of weaning foods (either too early or too late), and the amount of weaning foods (caloric content, nutritional value) contribute to micronutrient deficiencies.

Poverty, lack of access to a variety of foods, lack of knowledge of optimal dietary practices and high incidence of infectious diseases are prevalent in children below 5 years(Chiejina,2012; NDHS, 2013)

Micronutrients deficiencies are not always clinically apparent or dependent on food supply and consumption patterns. They are associated with physiologic effects that can be life-threatening or more commonly damaging to optimal health and functioning (Tulchinsky, 2010).

Uchendu (2011) reiterated that micronutrient malnutrition is a serious childhood dietary problem in developing nations citing vitamins A and B12, iron, folic acid and zinc as preventable causes of poor childhood growth and school performance.

1.3 Justification

Childhood mortality data indicates that underfive mortality rate was higher in Nasarawa State than both North Central average and nationally (HMIS, 2014). Micronutrient deficiencies in early childhood can lower a country's Gross Domestic Product (Win, 2015).

Evidences (Bhutta *et al*., 1999; Berti et al., 2014) have shown that the most cost-effective approaches to address symptoms of micronutrient malnutrition are targeted supplementation and fortification with iron, iodine, zinc, folic acid, vitamin A, and multi-micronutrients with adequate monitoring.

In 2008, a group of internationally acclaimed economists, including five Nobel Laureates, concluded that combating the world's malnutrition problem through the provision of vitamin A and zinc ranked high among the various cost-effective solutions to the world's pressing problems (IZA, 2010). They calculated that for every dollar invested in zinc supplements, there would be a return of US $17.

Iron deficiency affects more people than any other condition, constituting a public health condition of epidemic proportions (WHO, 2003) with a devastating health consequence.

The National Food and Nutrition Policy in Nigeria which is a step in addressing the malnutrition problems of the country in its plan of action sets strategies for improving the nutritional status of all Nigerians with specific emphasis on the most vulnerable groups (NFNP, 2005). These include the reduction of undernutrition, especially among children underfive, in particular, severe and moderate malnutrition by 30% and reduction of micronutrient deficiencies, particularly which includes among others Iron deficiency Anaemia by 50%. Zinc supplementation has been associated with motor development in very low birth weight infants and more vigorous and functional activity in infants and toddlers (Black, 1998).

Scanty or no data exist on micronutrient malnutrition in children under five years in Lafia Local Government Area of Nasarawa State.

1.4 Aim and Objectives

1.4.1 Aim

- To investigate the effect of iron and zinc supplementation on the nutritional status of children under five years in Lafia Local Government of Nasarawa State

1.4.2 Specific Objectives

The objectives of this study includes

i. To determine socio-economic characteristics of caregivers of children under five years in Lafia Local Government Area of Nasarawa State.

ii. To determine the caregiver knowledge, attitudes and practices on micronutrient supplementation.

iii. To examine the effect of supplementation (Iron and Zinc) on some anthropometric parameters of the children under five years in Lafia Local Government Area of Nasarawa State.

iv. To evaluate the effect of Iron and Zinc supplementation on children under five years in Lafia Local Government Area of Nasarawa State.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Nutrition in Infants and Childhood

Requirements for macronutrients and micronutrients are higher on a per-kilogram basis during infancy and childhood than any other stage of development (Zhou *et al*., 2012). These needs are influenced by the rapid cell division occurring during growth, which requires proteins, energy and nutrients involved in DNA synthesis. According to Whitney and Rolfe (2008) an infant grows fast during the first year, and growth directly reflects nutrient intake which is an important parameter in assessing the nutritional status of infants and children. The primary food for infants during the first 12 months is either breast milk or iron-fortified formula (JADA, 2005). In addition to nutrients, breast milk also offers immunological protection in exclusive breastfeeding. At about 4-6 months, infants should gradually begin eating solid foods. Proper nutrition is required at this stage because while most adults require 25 to 30 calories per kg, a 4kg infant requires more than 100kcals/kg (430calories/day), infants 4-6 months who weigh 6kg require roughly 82kcals/kg (490calories/day). Energy needs remain high through the early formative years. Children 1 to 3 years of age require approximately 83kcals/kg (990calories/day). Energy requirements decline thereafter and are based on weight, height and physical activity (Healthy Children Org, 2014).

Appropriate nutrition in childhood is essential for physical, mental and emotional development of children through to their adult age. Children therefore become the priority population for intervention strategies (Deghan *et al*., 2005). Iron supplementation and iron therapy are currently part of the national programmes in majority of developing countries and in many industrial countries (Stoltzfus, 2001). Periodic distribution of high-dose vitamin A supplements to all children of a specified age range or targeted to high-risk groups, has been the most widely applied intervention for treatment, prevention, and control of vitamins A deficiency (VAD).

In the Copenhagen Consensus (2008), a group of world renowned economists' ranked micronutrient supplements (especially high-dose vitamin A, and therapeutic zinc supplements for children with diarrhoea) as the top international development priority. The criteria used included the benefit cost ratios as well as feasibility and sustainability of the interventions (King, 2011).

However, the diets of poor households in developing countries are lacking in many of the key vitamins and minerals (micronutrients) which are essential to keep people strong, healthy and productive. Dietary diversification, including consumption of animal products or more fruits and vegetables, can help satisfy human vitamin and mineral requirements.

2.2 Nutrition Intervention

The purpose of nutrition intervention is to resolve or improve the patient/client's nutrition problem by planning and implementing appropriate strategies that will change nutritional intake to meet the needs of the patient/client (Ozier and Henry 2011). The objective and goals of the intervention serve as the basis for measuring the outcome of the intervention and monitoring the patient/client's progress (Hoddinot *et al*., 2008).

Nutrition intervention has two basic components: planning and implementation. During planning, multiple nutrition diagnoses must be prioritized based on the severity of the nutrition problem and the potential impact the intervention will have on the problem (Mueller*et al;* 2011). The implementation of intervention is expected to target the etiology or root cause of the nutrition problem. Nutrition indicators selected for monitoring and evaluation will be the same as those used in the initial assessment of the child's nutritional status (Lee and Nieman, 2013). Every living organism has need of nutrients for growth and activity. Where these nutrients are not in adequate amount for the children, the nutritional status becomes compromised. Intervention in terms of supplementation enhances immediate impact on micronutrient status, health, and survival ability "to ensure that the individual attains optimum potential nutritional status for successful development ***in utero***; growth; learning potential; quality of life; body function; successful pregnancies; adequate milk production for baby's needs; expectation of long and healthy life; freedom from infection and resistance to diseases and response to diseases" (Eastwood, 2003).

2.3. Nutritional Status

Nutritional status of an individual is often the result of many inter-related factors. It is influenced by food intake, the quantity, quality and the physical health. The spectrum of nutritional status spread from obesity to severe malnutrition. According to Bhandari and Chihetri (2013), nutritional status is the condition of the body in those respects influenced by the diet; the level of nutrients in the body and the ability of those levels to maintain normal metabolic integrity. It is the intake of sufficient diet to maintain the composition and function of the otherwise healthyindividuals within normal range. The equilibrium can be disturbed by three processes: decreased intake, increased requirements, and altered utilization. When this disequilibrium occurs, then loss of body tissue ensues. However, lack of nutrients produces a series of metabolic changes in relation to energy and protein metabolism within hours or days of reducing nutrient intake, long before demonstrable anthropometric changes (Krebs *et al*., 2007). These functional changes predict complications better than weight loss or arm muscle circumference. For children, weight and height for age are compared with standard data for adequately nourished children. Status with respect to individual vitamins and minerals is normally determined by laboratory tests, either measuring the blood and/or urine concentrations of nutrients and their metabolites, or by testing for specific metabolic responses.

2.3.1. Nutritional Assessment of Children

Nutritional assessment in children is needed to determine their nutritional status and problems, which might occur, and if identified, to treat such problems in order to prevent them from becoming larger and threatening children's health. Lee and Nieman, (1996) have defined the nutritional assessment as "an evaluation of the nutritional status of individuals or populations through measurements of food and nutrient intake and evaluation of nutrition- related health indicators." Nutritional status cannot be defined by a single method of a nutrition assessment but rather a combination of different methods (Mascarenhas *et al*., 1998). Tools employed innutritional assessment include anthropometry, biochemical data, clinical data, dietary data, and socioeconomic demographics.

According to Gibson (1990) nutrition surveys, nutrition surveillance and nutrition screening make up the assessment systems.

(i) Nutrition surveys

This is carried out to establish baseline nutritional data and /or ascertain the overall nutritional status of the population. The nutritional status of a population may be measured by a means of a cross- sectional survey leading to identification of population at risk to chronic malnutrition (Bates*et al*., 2012). Nutrition survey cannot identify acute malnutrition or provide possible causes of malnutrition.

(ii) Nutrition surveillance

Nutrition surveillance is characterized by the continuous monitoring of the nutritional status of selected population groups (Gibson, 1990). Surveillance studies differ from nutrition surveys because the data are collected, analyzed, and utilized for a long period of time. Surveillance studies identify possible causes of malnutrition and therefore can be used to formulate and initiate intervention measures (WHO, 1976). The result of nutrition surveillance helps governments make decisions concerning priorities and disposal of resources and formulation of policies of nutrition programmes.

(iii) Nutrition screening

Malnourished individuals requiring interventions can be identified using nutrition screening. It is a comparison of individual's measurements with a predetermined risk levels or "cutoff" points (Habicht *et al*., 1982). This can be carried out at individual level or on a specific subpopulation suspected to be at risk.

2.4 Micronutrient

Micronutrients are nutrients needed in minute specific quantities in the body and are derived from food intake. These micronutrients include vitamins and minerals that are part of the various processes that allow the body to function appropriately. Getting too much or too little of these essential nutrients affects nutritional status (Thomas, 2014). Nutritional status therefore refers to whether or not the correct amounts and types of nutrients are consumed. Prolonged inadequate intake of foods rich in these micronutrients, and usually, with poor dietary quality, poor bioavailability (because of the presence of inhibitors, mode of preparation, and interactions) and /or the presence of infections result in their deficiencies. Micronutrient deficiency or hidden hunger is a major threat to health, growth and development of infants worldwide. More than 2 billion people in the world today are estimated to be deficient in key vitamins and minerals, particularly vitamin A, iodine, iron and zinc due primarily to inadequate dietary intake and are thus trapped early in life in a pattern of ill health and poor development (UNICEF, 2011).

The groups most vulnerable to micronutrient deficiencies are pregnant women, lactating women and young children, mainly because they have a relatively greater need for the micronutrients for growth and development and are more susceptible to the harmful consequences of deficiencies (Tulsi.And Muniraj,2013),

Nigeria has one of the highest rates of infant mortality in the world today (Uchendu, 2011). Nutrition interventions generally neglect the little children despite their high prevalence of malnutrition and micronutrient deficiency (Fiorentino et al., 2013). Iron, iodine and folic acid micronutrient deficiencies affect the development of brain and cognitive function of children (Bhutta *et al*., 2008). It has become pertinent to give proper attention to micronutrients , especially vitamin A, iron, iodine and recently zinc because their persistent deficiencies remain a significant public health problem in Nigeria (Onyebuchi C., 2013)

2.5 MineralIron

Iron is a mineral that is part of the protein haemooglobin which carries oxygen from the lungs throughout the body. Each haemoglobin molecule is a conjugate of a protein (globin) and four molecules of haem. A low haemoglobin concentration is associated with hypochromia, a characteristic feature of iron deficiency anaemia. Iron also helps the muscles store and use oxygen. Iron is also a part of many enzymes. Iron deficiency is a condition resulting from inadequate iron in the body and the iron requirements cannot be met by absorption from the diet such as during periods of rapid growth (infancy, adolescence), in pregnancy, during lactation,and as a result of menstrual or pathological blood loss (Ekwochi *et al*., 2013). Developing countries' diets are predominantly dominated by plant- based feds and so limit iron absorption due to their high-phytate and polyphenol contents. These result in iron deficiency, the consequences of which include:

- Delay in normal infant motor function (normal activity and movement) or mental function (normal thinking and processing skills) (Akman *et al*., 2004)
- Iron deficiency anaemia during pregnancy can increase risk for small for gestational age (preterm) babies (Scholl *et al*., 1992)' Preterm babies are more likely to have health problems or die in the first year of life than infants who are born full term and normal for gestational age. Iron deficiency can cause fatigue that impairs the ability to do physical work.
- Young children and pregnant women are at higher risk of iron deficiency because of rapid growth and higher iron needs. Among children, iron deficiency is seen most often between six months and three years of age due to rapid growth and inadequate intake of dietary iron. According to American Center for Disease Control and Prevention (1998), infants and children at highest risk are the following groups:
    - Babies who were born early or small
    - Babies given cow's milk before age 12 months.
    - Breastfed babies who after age 12 months are not being given plain, iron-fortified cereals or another good source of iron from other foods.
    - Children aged 1-5 yeais who get more than 24 ounces of cow, goat, or soymilk per day. Excess milk intake can decrease the child's desire for food items with greater iron content, such as meat or iron fortified cereals.
    - Children who have special health needs, for example, children with chronic infections.

Iron deficiency is the most prevalent micronutrient deficiency globally, affecting more than one half of the infants in developing countries (WHO, 2011). Nigeria has iron anaemia prevalence rate of 25% among children under five years (WHO, 2010),

2.5.1Iron Status

Iron functions as a component of proteins and enzymes. Almost two-thirds of the iron in the body (approximately 2.5 grammes of iron) is found in haemoglobin, the protein in red blood cells that carries oxygen to tissues, and about 15% is in the myoglobin of muscle tissue (Fulwood *et al*., 1982). Every balanced diet contains some amount of haeme and nonhaeme iron. Haeme iron is found in animal foods that originally contained haemoglobin and myoglobin, such as red meat, fish, and poultry. Nonhaeme iron is found in plant foods, such as lentils and beans, and also is provided in iron-enriched and iron- fortified foods. Haeme iron has a higher bioavailability than nonhaeme iron (Miret, 2003). Ascorbic acid, meat, poultry, and seafood canenhancenonhaeme iron absorption, whereas phytate (present in grains and beans) and certain polyphenols have some opposite effect (Hurrell and Egli, 2010). Each day the body absorbs approximately 1-2 mg of iron that the (nonmenstruating) body loses (Institute of Medicine, 2001).

2.5.2Assessment of Iron Status

There are many approaches to assessing iron status. There is no single biochemical test which can reliably be used for assessing iron status therefore models using two or more different indicators of iron status have been developed. The two most commonly used are the ferritin model and the more recently introduced body iron model. The third model is the mean corpuscular volume (MCV) model. The ferritin model (also known as the three-indicator model) uses three indicators: serum ferritin, transferrin saturation, and erythrocyte protoporphyrin (Mei *et al*., 2011). The body iron model uses two indicators: serum ferritin and soluble transferrin receptor (sTfR) (CDCP, 2012). The mean corpuscular volume (MCV) model uses MCV, transferrin saturation, and erythrocyte protoporphyrin as indicators (ESWG, 1985). Both the ferritin model and the MCV model require that at least two of the three indicators be abnormal (Cogswell *et al.*, 2009). The ferritin model tends to overestimate the presence of iron deficiency because it includes ferritin, which reflects stores in the first stage of iron depletion (Lee and Nieman., 2013). The MCV model on the other hand, includes three biochemical tests, all of which indicate altered red blood formation (LSROFASEB, 1989). Both models are capable of identifying persons in the second and third stages of iron depletion, but they may fail to distinguish iron-deficiency anaemia from other common causes of anaemia such as inflammation, acute and chronic disease, and lead poisoning, because they include erythrocyte protoporphyrin as a variable (CDCP, 2008).

Of the three models, the body iron model is considered superior because it is less affected by inflammation than are the -ferritin and the MCV models. Only two measures are used in the body iron model as compared to three in the other two. The greater simplicity of the body iron model makes it more suitable for use in areas where resources are limited and where anaemia due to inflammation, chronic disease and nutrient deficiencies other than iron are relatively common (Lynch, 2011).

2.5.3 Iron Overload

Children with normal intestinal function have very little risk of iron overload from dietary sources of iron (Aggett, 2012). Taking supplements containing 25mg elemental iron or more can also reduce zinc absorption and plasma zinc concentrations (Murray-Kolbe *et al*., 2010). Iron overload is a disorder of iron metabolism that results in the accumulation of excess iron in body tissues. Iron overload is mainly the result of haemochromatosis, which is a group of genetic diseases characterized by excessive intestinal iron absorption and deposition of excessive amounts of iron in parenchymal cells with eventual tissue damage (Powell, 2012). Organs particularly affected by haemochromatosis are the liver, heart, and pancreas, leading to the failure of these organs and possibly death. Iron overload can also result from multiple blood transfusions and excessive intake of iron from fortified foods and supplements (Cook*et al*., 2003).

2.5.4 Stages of Iron Depletion

As the body's iron stores are depleted, the risk of iron deficiency increases. Iron depletion occurs in three stages:

(a) Stage one is the depletion of iron stores which represents a state of vulnerability and not associated with any adverse physiologic effects (Adamson, 2012). At this stage low stores (reflected by decreased serum ferritin levels) are recorded for healthy persons and appear to be the usual physiologic condition for growing children and menstruating women.

(b) Stage two is early functional iron deficiency without anaemia however the adverse physiologic consequences are beginning to manifest. This stage is characterized by changes indicating insufficient iron for normal production of haemoglobin, myoglobin and iron –containing enzymes (Wood *et al*., 2006). The stage is characterized by decreased transferrin saturation and increased erythrocyte protoporphyrin levels. Erythrocyte protoporphyrin is the precursor of haemoglobin, its concentration increases when too little iron is available for the synthesis of haemoglobin. Normal subjects at this stage have low haemoglobin level but it does not showbecause it has not reached the lowest levels. Therefore haemoglobin is not a useful indicator of either of the two stages (PM, 2001).

(c) Stage three is characterized by decreased serum ferritin, transferrin saturation, haemoglobin, and MCV and increased erythrocyte protoporphyrin (Adamson, 2012).

2.5.5 Serum Ferritin

Ferritin is formed when protein apoferritin combines with iron. It is the primary store of iron in the body located in liver, spleen, and bone marrow. Approximately 30% of iron in a healthy body is in the storage form, most as ferritin and some as hemosiderin (a degradation product of ferritin) (DCP, 2012). Tissue ferritin levels and serum ferritin decrease as iron depletion progresses. Low serum ferritin concentration is a sensitive indicator of early iron deficiency. However, ferritin is an acute phase protein and its concentration increases in acute and chronic diseases thereby masking iron deficiency (Gibson, 2005).

2.5.6 Soluble Transferrin Receptor.

The measurement of soluble transferrin receptor (sTfR) has become popular because it is sensitive to the inadequate delivery of iron to bone marrowand tissue (Cook *et al*., 1990). The sTfR fragment is cleaved from the membrane bound transferrin receptor found on nearly all cells. The predominant donors of these fragments to the serum pool are the cells of the developing red cell mass – the erythroblasts and reticulocytes (Genc, *et al*., 2004). The concentration of sTfRreflectserythropoietic activity. Factors that may affect the concentration of sTfR in plasma or sera include acute or chronic inflammation and the anaemia of chronic disease, malaria, malnutrition, age and pregnancy (Skikne, 2008). Cells acquire iron when the iron transport protein transferrin forms a complex with a highly specific transferrin receptor (TfR) (Skikne, 2008)[i]

2.5.7 Transferrin, Serum Iron, and Total Iron-Binding Capacity

Iron is transported in the blood bound to transferrin, a B-globulin protein molecule synthesized in the liver. Transferrin accepts iron from the sites of haemoglobin destruction (the primary source of iron bound to transferrin), from storage sites, and from iron absorbed through the intestinal tract. It then delivers the iron to bone marrow for haemoglobin synthesis as well as other storage sites and placenta for foetalneeds. Each molecule of transferrin has the capacity to transport two atoms of iron (Cousins, 2006).

Serum iron level is a measure of the amount of iron bound to transferrin while total iron – binding capacity (TIBC) measures the amount of iron capable of being bound to serum proteins and provides an estimate of serum transferrin (Lynch 2011). Transferrin saturation is the percent of transferrin that is saturated with iron. The measure of serum iron, TIBC, transferrin saturation and serum ferritin concentration are useful in distinguishing iron deficiency from other disorders capable of causing microcytic anaemia (King, 2011).

2.5.8 Erythrocyte Protoporphyrin

Protoporphyrin is a precursor of haeme. When the amount of haeme that can be produced is limited by iron deficiency protoporphyrin accumulates in red blood cells (erythrocytes). Erythrocyte protoporphyrin increases as iron depletion worsens.

2.5.8 Haemoglobin

Haemoglobin is an iron-containing molecule found in red blood cells that is capable of carrying oxygen and carbon dioxide. The amount of haemoglobin in the blood depends primarily on the number of red blood cells (Pagana and Pagana, 2010).Despite its use as a screening test for iron deficiency anaemia, isolated measurements of haemoglobin concentration or haematocrit level are not suitable as the sole indicator of iron statusbecause they tend not to become abnormal until the late stage of iron deficiency and also fail to distinguish between iron deficiency anaemia and anaemia of inflammation (Cook, 2005).

2.5.9 Haematocrit

This is also known as packed cell volume. It is defined as the percentage of red blood cells (RBC) making up the entire volume of whole blood. It can be measured manuallybycomparing the height of the whole blood in a capillary tube with the height of the RBC column after the tube is centrifuged (Cook, 2005).

2.5.10 Mean Corpuscular Volume

Mean corpuscular volume (MCV) is the average volume of the red blood cells. It is calculated by dividing the haematocrit value by the RBC count (the unit is in femtolitres). Macrocytosis (resulting from increase in MCV) is caused by deficiencies of folate or vitamin B12, chronic liver disease, alcoholism, and cytotoxic chemotherapy. On the other hand microcytosis (caused by decreased MCV) is a result of chronic iron deficiency, thalassemia, anaemia of chronic diseases and lead poisoning (Adamson, 2012).

2.6 Mineral Zinc

Zincsupplements given to short children and failure-to -thrive infants in the United States ofAmerica city of Denver improved growth (Rivera *et al.*, 2003). Trial studies concluded that zinc supplements are likely to improve the height gain of the most stunted children and improve the weight gain of those with low plasma zinc concentrations (Nguyen et al., 2012).

2.6.1 Zinc Status

Zinc is important in cellular growth, cellular differentiation and metabolism and its deficiency limits childhood growth and decreases resistance to infections. Mild to moderate deficiency is common worldwide (Black et al., 2008). Zinc supplementation has been shown to reduce the duration and seventy of diarrhoea, and to protect subsequent episodes (eLENA, 2014). Zinc participates in the synthesis, syorase, and release of the hormone insulin in the pancreas, interacts with platelets in blood clotting, affecis thyroid hormone function, and influences behavior and learning performance (Whitney and Rolfes, 2008). The micronutrient is needed to produce the active form of vitamin A. It is essential to normal taste perception, wound healing, the making of sperm, and foetal development. A zinc deficiency therefore impairs all these and other functions,underlining the vast importance of zinc supporting the body's proteins.

Intakes ofabsorbable zinc are often low in children during growth and stunting occurs nearly universally during the first 2 years of life in underpriviledged, populations (Veena *et al*., 2012). Typical clinical features, corrected by zinc supplementation, included growth retardation, delayed secondary sexual maturation (hypogonadism), poor appetite, mental lethargy and skin changes. The genetic disorders, aero dermatitis enteropathica and sickle cell diseases are associated withsuboptimal zinc status (Gibson, 1990).Diarrhoea remains a leading cause of death globally among children under five years of age. Diarrhoea contributes to nutritional deficiencies; reduced resistance to infections and impaired growth and development. Severe diarrhoea leads to fluid loss and may be life threatening, particularly, in young children.

2.6.2 Measurement of Zinc Status

The role of zinc deficiency as an important cause of morbidity and impaired linear growth has prompted the need to identify indicators of zinc status. Biochemical indicators may be used as an objective means of assessing the zinc status of a population. Serum zinc is considered the best available biomarker of the risk of zinc deficiency in populations (Joint WHO/UNICEF/IAEA/IZINCG, 2007). The rationale for the selection is that serum zinc reflects dietary zinc intake, it responds consistently to zinc supplementation, and reference data are available for most age and sex groups. To date, serum zinc is the only biochemical indicator of zinc status known to meet these criteria (Hess *et al*., 2007)

Height- or length-for-age is the best known functional outcome associated with the risk of zinc deficiency in populations (Fischer Walker and Black, 2007). The rationale for this selection is that low height-or length-for-age is often responsive to supplemental zinc; standardized methods to measure this outcome exist and are widely used; and reference data are available. Although the same may be said for weight-for-age as an indicator, height- or length- for- age is preferred because the linear growth is likely to be the primary response to increased zinc intake, whereas weight gain is likely to occur as a result of increased linear growth.

For population assessment, the recommended indicator to use is the percentage of thepopulation with serum zinc concentrations below the age/sex/time of the day-specific lower cutoff (Hess*et al.*, 2007). The recommended cutoff for children under 10 years of age is 65ug/dL (9.9umol/L) for samples collected in the morning hours in a nonfasted state (NHNES II, 2010).

2.6.3The Functions of Zinc in the Body

Zinc is an essential trace element and has a number of roles and functions in the human body. These include:

- It is an essential component/cofactor for more than 300 enzymes involved in the synthesis and metabolism of carbohydrates, lipids, proteins, nucleic acids (Tulchinsky, 2010).
- It stabilizes cellular components and membranes and so is important for cell and organ structure andintegrity.
- It is essential for cell division and is required for normal growth and development during pregnancy, childhood and adolescence (IZA, 2013).
- It is involved in DNA synthesis and the process of genetic expression (King, 2011).
- It is important for immune function (both cellular and humoral immunity).
- It is involved in wound healing and tissue repair.
- It is required for the senses of taste and smell.

Zinc plays an essential role in numerous biochemical pathways. It affects many organ systems, including skin, gastrointestinal tract, central nervous system, and immune, skeletal, and reproductive systems

2.6.4 Zinc Deficiency

Zinc deficiency affects about 2.2 billion people around the world (Prasad, 2012). Zinc deficiency can be classified as acute, as may occur during prolonged inappropriate zinc-free total parenteral nutrition; or chronic or mild, as may occur in dietary deficiency or inadequate absorption (Walker *et al*., 2013).

Zinc deficiency may manifest as acne, eczema, xerosis (dry scaling skin), seborrheic dermatitis or alopecia (thin and sparse hair) and impaired wound healing (Kumar and Clark, 2012). Severe zinc deficiency may disturb the sense of smell and taste and also feature as night blindness (Stewart-Knox *et al.*, 2005; Stewart-Knox *et al*., 2008). Deficiency of zinc in children leads to the development of respiratory infections especially pneumonia and increased incidence of diarrhoea (Prasad, 2012). There is evidence that zinc deficiency decreases hunger and results in anorexia nervosa (Suzuki *et al*., 2011). Appetite disorder can cause malnutrition. Deficiency impairs cognitive and motor function in children, and also causes delayed growth (Walker *et al.*, 2013). Incidence of difficult and prolonged labour and haemorrnhage has been documented in zinc deficient animals (Shah and Sachdev., 2006). Zinc deficiency can lead to reduced circulating testosterone, hypogonadism, and delayed puberty (Prasad, 2012).

2.6.5 Sources of Dietary Zinc

A wide variety of foods contain zinc (Institute of Medicine, 2001). Cray fish, red meat and poultry provide the majority of zinc in our diet. Other good food sources include beans, nuts, and certain kinds of sea food (such as crab and lobster), whole grains, fortified breakfast cereals, and dairy products (USDA, 2011). However, phytates which are present in whole grain breads, cereals, legumes, and other foods do bind zinc and inhibit its absorption (Wise, 1995; Sandstrom, 1997). Therefore the bioavailabilty of zinc from grains and plant foods is lower than that from animal foods.

2.6.6 Efficacy of Iron and Zinc supplementations

Iron and zinc are essential micronutrients for humor, growth, development, and maintenance of the immune system. Iron deficiency is the most important cause of nutritional anaemia and is needed for psychomotor development, maintenance of physical activity and work capacity, and resistance to infection (Stoltzfus, 2001). Zinc is involved in numerous aspects of cellular metabolism therefore it is needed for growth, protein synthesis, catalytic activity of approximately300 enzymes , wound healing and for maintenance of immune function, which enhances both the prevention of and recovery from infectious diseases (Black, 2003). Impaired growth is one of the most consistent signs of malnutrition, find although it is in itself not hazardous to health but it is associated with poverty and poor health. According to Black *et al* (2008) undernutrition remains a major issue in developing countries, being an underlying cause of 3.5 million deaths each year with over 1 billion people susceptible to zinc deficiency. Children with this deficiency are significantly more likely to experience morbidity and mortality.

Both iron and zinc deficiencies have adverse consequences for human health. Several strategies have been implemented to address iron and zinc deficiency, including supplementation and food fortification. One approach is through combined zinc and iron supplementation. However, there is concern about potential interactions between these two trace minerals. Although some pathways are unique, iron and zinc have many similar absorption and transport mechanisms and may therefore compete for absorption (Solomons and Ruz., 1997; Baqui *et al.*, 2005). Brown *et al.*, (2009) have shown that zinc supplementation had no significant adverse effects on indicators of iron and copper status. However Wieringa *et al.*, (2007) observed that supplementation with zinc significantly improved zinc status but the addition of iron to the zinc supplement significantly reduced the efficacy though iron supplementation alone, did not negatively affect zinc status. The importance of these two micronutrient deficiencies in public nutrition and their likely coexistence in infants support combined supplementation with both iron and zinc to improve cost effectiveness of interventions (Berger *et al.*, 2006). However, some trials(Dijkhuizen *et al*.,2001; Lind *et al*., 2003) show inconsistent results of the impact of association of iron and zinc supplements on micronutrient status resulting probably from nutritional status and environmental conditions that differ among different people.

2.6.7 Methods for Anthropometric Assessment

Anthropometry is the study of the measurement of the human body in terms of the body size, weight and proportions. The word 'anthropometry' is formed from two Greek words 'anthropo', meaning 'human' and 'metron', meaning 'measure' (Ulajaszek, 1994). Measures obtained from anthropometry can be sensitive indicators of health, developmentand growth in infant and children [Moore *et al.*, 1983]**.**The effect of nutrition on human growth and development has made accurate measurements of the body's dimensionsand weight indispensable to the practice of nutritional. Anthropometry methods have the additional advantage of providing information on past nutritional history which cannot be obtained with equal confidence using other assessment techniques (Gibson, 2005). Advantages and disadvantages of using anthropometry are:

2.6.7.1 Advantages

(i) Methods are precise and accurate, provided standardized techniques are used.

(ii) Procedures use simple, safe and non-invasive techniques.

(iv) Equipment required is inexpensive, portable and durable, and can be made or purchased locally.

(v) Relatively unskilled personnel can perform measurement procedures.

(vi) Methods can be used to quantify the degree of under nutrition (or over nutrition) and provide a continuum of assessment from under-to over nutrition.

(vii) Methods are suitable for large sample sizes such as representative population samples.

(viii) Methods can be used to monitor and evaluate changes in nutritional status over time, seasons, generations, etc.

(ix) Methods can be adopted to develop screening tests in situations such as nutrition emergencies to identify those at high risk.

2.6.7.2 Disadvantages

(i) The relative insensitivity to detect changes in nutritional status following inadequacy of food over short periods of time.

(ii) The inability to distinguish the effect of specific nutrient deficiencies (e.g. zinc deficiency) that affect growth in children from that due to inadequacy of food in general.

(iii) The inability to pinpoint the principal causality of under nutrition, as the poor nutritional status may be the result of factors such as repeated insults owing to infections and poor care in children.

(iv) The relative higher costs and organization required to obtain representative and quality data for the purpose of estimating numbers of undernourished.

In childhood, height (stature) and weight are the two most frequently used indicators of growth and nutritional status, while indices of weight for height, especially BMI as used as proxy for body fatness or obesity. For the children less than two years the infant stature is measured as recumbent length and height in the standing position is measured for children over two years of age. Body weight is measured with the child in underwear or in light clothing, without shoes. BMI (weight/height^2) provides guideline based on weight and height to determine underweight or overweight. There are two international growth standards which are mainly used for the screening, surveillance, and monitoring of preschool children; WHO child Growth Standards (World Health Organization) and U.S. CDCGrowth Charts (Center for Disease Control and Prevention). Both standards describe weight for age, length (or stature) for age, weight for length (or stature), and body mass index for age. The WHO recommends the application of these standards for all children worldwide, regardless of ethnicity, socioeconomic status and type of feeding (Onyango *et al.*, 2007).

Anthropometry is a practical and immediately applicable technique for assessing children's development patterns. Even though the anthropometric indicators are less accurate than clinical and biochemical techniques when it comes to assessing individual nutritional status,, it can be used as a screening device to identify individuals at risk of undernutrition, followed by a more elaborate investigation using other techniques (Gorstein and Akre, 1988). On the other side, BMI has been recommended as the most appropriate single indicator of overweight and obesity in children and adolescents (Krebs *et. al*., 2007).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was carried out in Lafia Local Government Area of Nasarawa state. Akurba, Assakyo, Azuba,Lafia and Shabu communities were involved in the study. There were farmers, traders, and civil servants. The languages of communication were majorly Eggon, English,Gwandara and Hausa. Lafia Local Government of Nasarawa State is located at Lat. $8^{o}30'$N Long. $8^{o}30'$E(www.mapofworld.com/lat_long/nigeria-lat-long.html).

3.2 Sampling Method

A systematic random sampling technique (Barreiro and Albandoz, 2001) was used to select the children that participated in this study. The housing units and the households in the communities were listed. Children below five years of age in the households were identified and given numbers, starting from number 1, every 4^{th} child was considered qualified to take part in the supplementation studies.

3.3 The sample Size of the Study

The sample size of this study was worked out with the population of children below five years in all the communities involved in the study. Sample size was calculated using the formula:

$$\textbf{Sample Size} = \frac{Z^2 X (P) X (1-p)}{C^2}$$

(Barreiro and Albandoz, 2001)

Where:

Z = 95% confidence level i.e. 1.96

P = prevalence rate in the study group compared with the population of the age group (in this study, 0.15 was used for sample size needed).

C = confidence interval (5%) or significant level of 0.05.

For the purpose of this research, the prevalence rate 15% was used (NDHS, 2013).

1.96^2 x 0.15 x 0.85

Sample Size $= \frac{1.96^2 X\ 0.15\ X\ 0.85}{0.05^2} = 195.9216$

This is approximately equals to 196 children.

3.4 Inclusion and Exclusion Criteria

The inclusion criteria include, a child below the age of 5 years, he /she was from Lafia Local Government of Nasarawa State, and he/she had a resident caregiver.

Exclusion before recruitment was on the basis of chronic disease or severe illness, severe clinical malnutrition or congenital abnormalities (Thomas, 2014) and children above 59 months. Others include children on medication or receiving supplementation and those with parasitic infections. The goal was to have 100% sampling; however 160 (more than 80%) children participated in the study due to relocation as the result of ethnic crisis that swept through the Southern Senatorial District of Nasarawa State. The survey started in the third week of November, 2014 and completed by February 2015.

3.5 Ethical Clearance

In order to conduct this research which involves children under five years and collection of blood samples, the research protocol was approved by the Ethical Committee of the Ministry of Health, Nasarawa State, Nigeria (Appendix I).

3.6 Data Collection

The community leader (the “Sangari”) was contacted and the researcher was invited to address the assembly of the different ethnic, trade and religious representatives. The purpose was to convey the desire to carry out the study in their domains and what their children stood to benefit from the study. Every Friday, this group of elders pays homage to the palace of the ‘Sangari’ and this provided the right opportunity for nutrition education and advocacy (Plate 3.1), as well as distribution of information letter to each parent titled ‘consent form’(Appendix III) which were thoroughly explained to them through interpreters. The caregiver (or parent) signed the Informed Written Consent section of the Consent Form and returned to the researcher before the child was screened for eligibility. The caregiver then provided the necessary information required in the questionnaires.

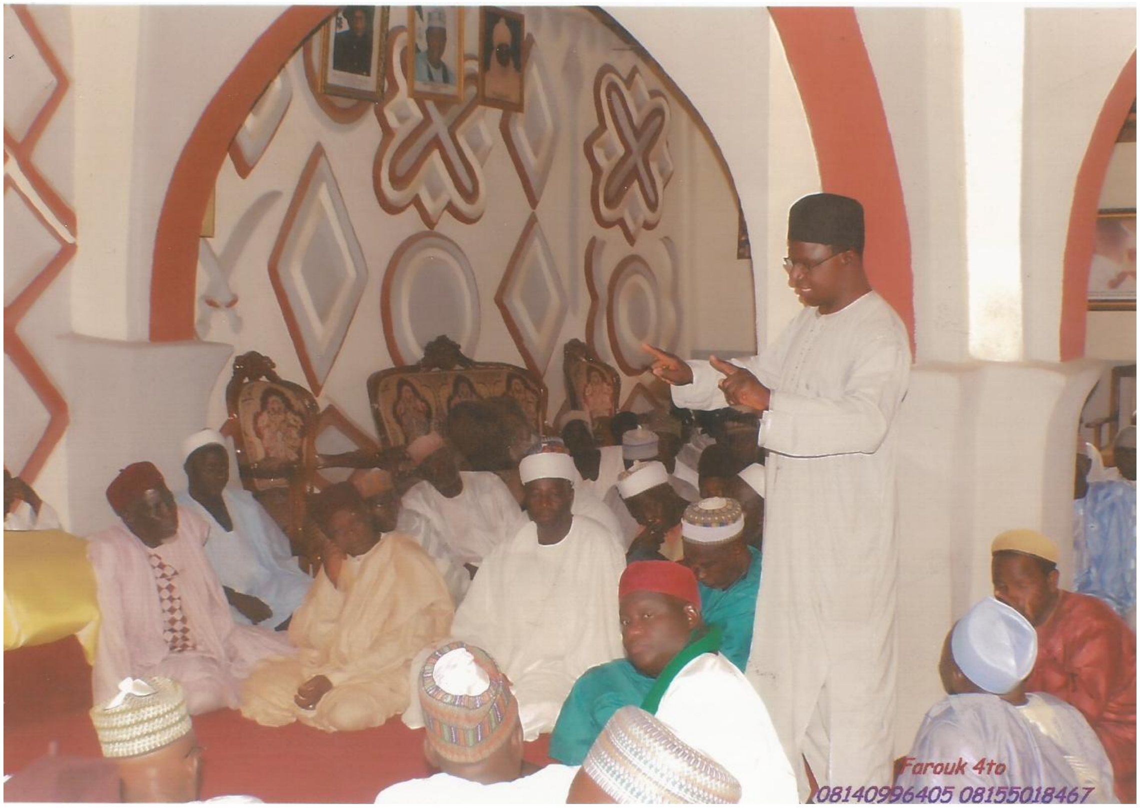

Plate 3.1: Researcher meeting with the 'Sangari' and community representatives.

The study was carried out within the period of ninety (90) days. One hundred and sixty (160) children were recruited for the study with 83 females (51.87%) and 77 males (48.13%) but two (2), representing 1.25% were not able to complete the study due to ethnic crisis that engulfed the area. The children were divided into four groups, each containing forty children from ages less than eleven to less than five years of both sexes.The iron group (Fe-group) received daily and for 3-month period 10 mg of iron, the zinc group (Zn-group) 10 mg zinc, the iron and zinc group (Fe-Zn group) 10 mg iron + 10 mg zinc and the Control group (unsupplemented). Serum ferritin (SF) and zinc (SZn) and anthropometry were measured before and at the end of the supplementation.

Trained assistants measured weight and height at baseline and at the end of the study. Each assistant was responsible for the same group of children all along the study. Length (also referred to as recumbent length) was obtained with the subject lying down, in a supine or face-up position for children up to 24 months or those who could not stand erectly without assistance. The measuring device has a stationary headboard and a movable footboard that are perpendicular to the headboard and measured to the nearest 0.1cm (Moore and Roche, 1983). When twomeasures were different by more than 0.3mm, length was again measured in triplicate. Stature, or standing height was measured for respondents 2-5years of age using a measuring stick fastened to a wall and a right-angle headboard for reading the measurement. Each measure was taken in triplicate and length/stature calculated as the mean of the three measures. Infants were weighed naked on a baby scale with a precision of 10g (Seca, Germany). Children who can stand without assistance were weighed on a platform electronic scale that is accurate to 100 g (0.1 Kg)

Non-fasting blood samples were collected in the morning between 0800 and 0010, at baseline and after 12 weeks, at the end of the supplementation period. At each sampling, 3 ml venous blood was drawn using a zinc-free vacuum system. Serum was separated by centrifugation at 3000 r.p.m. for 10 minutes at 4oc. Aliquots of serum was stored at 2-8^{0}C until analysis of serum ferritin (SF) and zinc (SZn)

3.7 Instruments

The data required to accomplish the objectives of the nutritional status of children under five years were derived from three nutritional assessment components: Socioeconomic and demographic characteristics (health knowledge, attitudes and food habit); anthropometric measurements (weight, mid upper arm circumference, MUAC, weight- for – age, weight-for- height; and MUAC- for-age); and biochemical analysis (Iron status and Zinc status at baseline and at endline).

Plate 3.2: The researcher with Phlebotomists taking blood samples of the respondents

Three methods were used to collect information during the study. These include:

(i) Questionnaires

Questionnaires were administered to the parents/caregivers of the children underfive that participated in the study. Interpreters were used for those who could not communicate in English**.** The questionnaires collected information on socioeconomic demographic characteristics, attitude and practice of supplement intake, cooking and eating habit, and reasons for intake of micronutrient supplement by the under-five (Appendix II).

(ii) Anthropometry

Indicators employed include weight-for-age and mid upper arm circumference (MUAC).

(iii) Biochemical Assessment

Iron status and zinc status assessments of children underfive were carried out before and after supplementation

3.8 Food Habit Attitude and Health Knowledge Survey Procedure

The Food Intake and Health Knowledge Survey were carried out using questionnaires (Appendix II). The questionnaire was divided into six sections that provide information on social status, household composition, dietary, cooking and eating habits, attitudes and practices of intake of multivitamin supplements and reasons for the intake of micronutrient supplements by children under five years. The questionnaires were administered to every caregiver, and the contents interpreted to the natives who could not read. After the completion of the questionnaire by each caregiver, the blood sample of the child was taken.

3.9 Anthropometric measurements

Anthropometric measurements used in this study were weight and mid upper arm circumference of children below five years of age using the techniques suggested by WHO (1995).

The effect of nutrition on human growth and development has made accurate measurement of the body's dimensions and weight indispensable to the practice of nutritional assessment (Lee and Nieman, 2013). Anthropometric measures can be used to evaluate nutritional status, whether it be obesity caused by overnutrition or emaciation resulting from protein-energy malnutrition.

Measurement of Weight

Infants were weighed on a sica scale that is accurate to within 10g (0.01 kg). The diaper used on the pan was in place when the zero adjustments were made on the scale. The infant was set lying down in the middle of the pan (Moore and Roche, 1983). The average of two weighings was recorded numerically in the infant's file to the nearest 10g.

Children who could stand without assistance were weighed on a platform electronic scale that was accurate to 100 g (0.1 kg). The respondent was made to stand still in the middle of the scale's platform without touching anything and with the body weight equally distributed on both feet (Mei and Grummer-Strawn, 2011). The weight was read to the nearest 100 g (0.1 kg). The average of two successive measurements was immediately taken and recorded in the child's file to the nearest 100 g (0.1 kg).

Measurement of Mid Upper Arm Circumference (MUAC)

The subject was made to stand with the left arm hanging loose.The top of the shoulder (acromion) and the Point of the elbow (olecranon process) were located (the distance between the two points was measured and the mid-point identified). Using a MUAC tape, the circumference of arm at the mid-point was measured without pulling the tape tightly. It was just fitted comfortably round the arm.

3.10 Biochemical Assessment

A team of paediatricians from Paediatric Department, DalhatuAraf Specialist Hospital, Lafia were the phlebotomists used to obtain blood samples from the children. The blood samples collected from each respondent were3 ml venous blood drawn using a zinc-free vacuum system. Serum was separated by centrifugation at 3000 r.p.m. for 10 minutes at 4^{0}C at Dalhatu Araf Hospital, Lafia. Aliquots of serum were stored at -30^{0}C from the designated communities. The serawere separated and tightly stored at $2\text{-}8^{0}$C and taken to the laboratory of Ahmadu Bello University, Zaria Sickbayfor analyses.

3.9.1. Quantitative Determination of Iron

Principle

The iron is dissociated from the complex of serum ferritin and soluble transferrin in a weakly acidic medium. The liberated iron is reduced into the bivalent form by means of ascorbic acid. Ferrous ions react with FerroZine to give a coloured complex and the absorbance was taken at 562nm using a spectrophotometer.

$$\text{Transferrin } (Fe^{3+})_2 + e \xrightarrow{\text{Ascorbic acid}} Fe^{2+} + \text{Transferrin}$$ (Young, 2001)

$$Fe^{2+} \xrightarrow{\text{FerroZine}} \text{Coloured complex}$$

The intensity of the colour formed is proportional to the iron concentration in the sample.

Procedure

The test procedure was shown in table 3.1. Working reagent was obtained by dissolving the contents of the tube containing the reductant (ascorbic acid) in the bottle of the buffer (acetate pH 4.9). This was capped and mixed gently to dissolve the contents.The reduced Iron reacts with ferrozine, (a colourant) to produce a coloured complex. The intensity of the colour is proportional to the concentration of iron in the sample.

Table 3 1: Test Procedure for Iron Analysis

	WR Blank	Calibrator	Sample Blank	Sample
WR (ml)	1.0	1.0	1.0	1.0
R 3 (drops)	1	1	-	1
Distilled water (μL)	200	-	-	-
Calibrator (μL)	-	200	-	-
Sample (μL)	-	-	200	200

$$\text{Iron } (\mu g/dL) = \frac{(A)\ Sample - (A)\ Sample\ Blank}{(A)\ \text{Standard}} \text{x } 100 \text{ (calibrator concentration.)}$$

(A)sample = absorbance of sample; (A) sample blank = absorbance of working reagent;

(A) standard = absorbance of iron aqueous primary standard (100 µg/dL).

Conversion Factor: µg/dL x 0.179 = µmol/L (Young, 2001)

3.9.2. Quantitative Determination of Zinc

Principle

The colorimetric test was carried out directly without deproteinization of the sample. At pH 8.2 in a buffered media, zinc reacts with the specificcomplexant NITRO-PAPS, forms a stable coloured complex. The colour intensity is proportional to the amount of zinc present in the sample (Burtis *et al*., 1999).

Reagents composition includes Borate Buffer (pH 8.2), NITRO-PAPS and zinc primary standard (200 µg/dL). Spectrophotometer was used to measure the coloured complex at 578nm

Procedure

The test procedure was shown in table 3.2. Working reagent was obtained by dissolving 2g of ascorbic acid powder (a reducing acid) in one volume and concentration of the borate buffer. This was capped and mixed gently to dissolve the contents. The working reagent so obtained has a shelf life of 30 days when stored at 2-8^{o}C without contamination.

Table 3.2: Test Procedure for Zinc Analysis

	Blank	Standard	Sample
WR (mL)	1.0	1.0	1.0
Distilled water	50	-	-
Standard (μL)	-	50	-
Sample (μL)	-	-	50

The contents were mixed and the absorbance read (A_1) of the sample against the blank. Then the following were added:

	Blank	Standard	Sample
R2 (μL)	100	100	100

These were mixed and the absorbance of sample and standard read (A_2) against blank.

$$\frac{(A_2 - A_1)\ \text{Sample}}{(A_2 - A_1)\text{Standard}} \text{x} \quad 200\ \text{(Standard concentration)}$$

(µg/dL Zinc in the sample)

(Young, 2001)

(A_2)Sample = absorbance of sample; (A_1) = absorbance of working reagent;

Standard = Zinc primary standard 200 µg/dL

Conversion factor: µg/dLx0.153 =µmol/L

3.1.5 Data Analysis

Anthropometric data analysis was carried out using WHO software (WHO Anthro 2007) which was used as a tool for nutritional assessment of children under 5 years old. This software was developed to facilitate application of the WHO Child Growth Standards in monitoring growth and motor development in individuals and populations of children up to 5 years of age. The software derives nutritional status informationfor WAZ, WHZ, and MAZ.

3.1.7 Statistical Analyses

The principal objective of the analysis was to access the efficacy of the single or combined iron and zinc treatment on biochemical and anthropometrical outcomes and changes between baseline and end point. Comparison of treatment groups (Fe, Zn, Fe+Zn, Control) for end point values and/or changes between baseline and end point was performed by analysis of variance (ANOVA) and independent t-test.

CHAPTER FOUR

4.0 RESULTS

4.1 Socioeconomic and Demographic Characteristics of the Respondent Caregivers in Lafia Local Government of Nasarawa State (LLGNS)

Socioeconomic and demographic characteristics of the respondents' caregivers in Lafia Local Government of Nasarawa State are presented in Table 4.1 and Figure 4.1. The results revealed the participation of 83 (52%) females and 77 (48%) males in the study. Half (50%) of the household heads were in the 30-39 years age group and only 16 (10%) were above fifty years while 65.5% of the mothers were in the 21-30 years age group with only 2.5% above 41 years of age.Nearly half (49%) of the mothers attained secondary education as their highest educational qualification and 23% had no formal education. Civil servants form the bulk of the respondents (38%) followed by the farmers (32%). The estimated annual income of majority of the household heads (31%) falls within N50, 000.00 to N100, 000.00 with about 29% earning greater than N200, 000.00 annually. Figure 4.1 shows the disaggregation of the children by age and sex which indicates that there were five age groups with the females forming a greater percentage(53.33%) in the <11 months age group than males (46.67%) but more males (53%) in the 48-59months age group than females (47%). The age grouping is adopted from the Nigeria Demographic and Health Survey (NDHS) 2013.

Table 4.1 Socioeconomic and Demographic Characteristics of the Respondents Caregivers of Children Under Five Years

Variable	Frequency	Percentage (%)
Age of Household Head (Years)		
20-29	24	15
30-39	80	50
40-49	40	25
50 and above	16	10
Age of Caregivers (Years)		
10-20	15	9
21-30	105	65.5
31-40	36	23
41 and above	4	2.5
Mothers educational status		
No formal education	37	23
Primary education	42	26
Secondary education	78	49
Tertiary education	3	2
Primary occupation of Household		
Farming	32	32
Trading/Business	51	20
Civil service	61	38
Artisan	9	6
Others	7	4
Estimated Annual Income of Households		
<₦50,000.00	38	24
₦50,000.00 to N100,000.00	49	31
₦100,000.00 to 200,000.00	26	16
Greater than N200,000.00	47	29

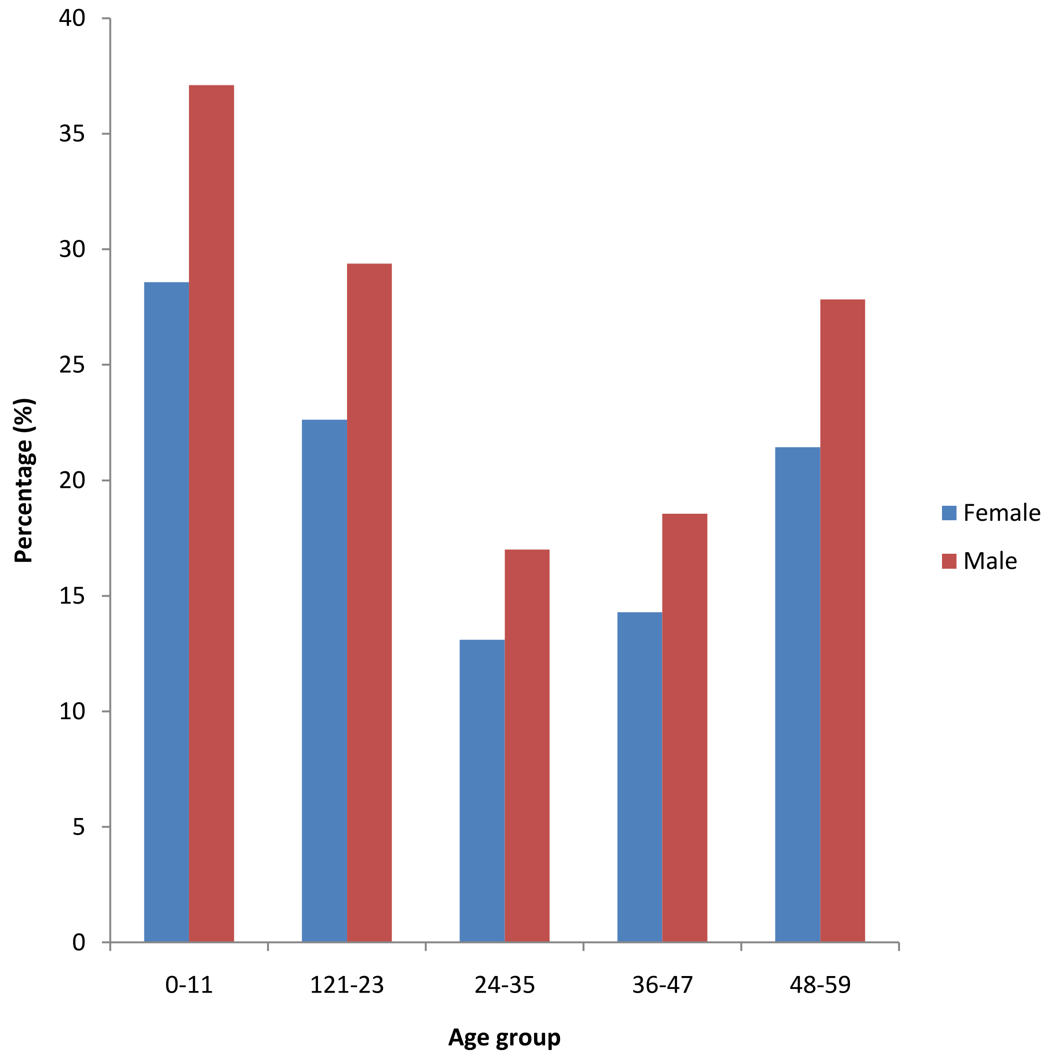

Figure 4.1: Children Respondents by Age Group (Months)

4.2 Knowledge, Attitudesand Practiceson Micronutrients and Supplementationof the Caregivers Respondents

The knowledge, attitudes and practices on micronutrients and supplementation of respondents are shown in Table 4.2. Majority of the respondentscaregivers (29.38%) preferred maize as their stable food and 26.25% chose yam. However, majority of the respondents (61.25%) attributed inadequate food in their households due to lack of money, therefore most of them (49.38%) saved their leftover food for later consumption. More than half of the respondentscaregivers (54.38%) dehulled the maize before converting into flour to improve the aesthetic value. About half the respondents (49.38%) had no knowledge of micronutrient supplements.However, 57% of care givers that knew the importance of the micronutrient supplements do not give their children.

Table 4.2: Knowledge, Attitudes and Practices on Micronutrients and Supplementation by the Caregivers

Variable	Frequency	Percentage (%)
Preferred staple foods		
Yam	42	26.25
Cassava	38	23.75
Maize	47	29.38
Rice	33	20.63
Reasons for inadequate food in household		
There is no one to cook till night	10	6.25
Not enough money to buy food	98	61.26
Too many children in the household to feed	40	25.00
Others	12	7.50
Maize dehulled before use		
	34	21.25
Enhances palatability		
Improves the aesthetic value	95	54.38
Removes hindrances to digestibility	11	6.88
Provides feeds for domestic animals	20	12.50
Importance of micronutrients		
Supplement nutrients are contents of food	6	6.25
Boost blood levels of minerals and vitamins	21	13.13
Prevent and cure diseases and illness	54	33.75
No idea	79	49.38
Give multivitamins/supplements to children		
Less than 12 months	46	28.75
13-36 months	45	28.13
After 36 months	12	7.50
Do not give	57	35.63

4.3 Effect of Iron Supplementation on Weight, and Mid Upper Arm Circumference (MUAC) of Children Under Five Years in Lafia Local Government of Nasarawa State (LLGNS).

The effects of iron supplementation on weight and MUAC of the children below five years in LLGNS are presented in Tables 4.3 and 4.4 respectively. Percentage changes in weight and MUAC showed higher values in the groups supplemented when compared with group that was not supplemented..

The result showed that iron supplementation caused the highest percentage change (33.79%) in weight of females among the female age group less than 11 months followed by 12-23 months' age group with 28.89% (Table 4.3). The 48-59 months' age group recorded the least percentage change (13.61%) in weight among the female age groups. The male age group of less than 11 months recorded the highest percentage change in weight (36.67%) among the males and the least value of 10.40% in the 48-59 months' age group. There was a significant difference (P<0-05) between the means of the baseline and endline of weight in both sexes below 11 months of age.

The mid upper arm circumference (MUAC) measured after supplementation of the children below 5 years showed the highest percentage change (22.38%) in the females of age group less than 11 months, followed by the 12-23 months' age group with percentage change of 19.05%.The age group 36-47 months had the least change in MUAC (0.83%).The males of less than 11 months age group recorded the highest percentage change (19.33%) and 48-59 months had the least (1.90%). There was a significant difference (P<0-05) between the means of the baseline and endline of MUAC only in females group below 11 months of age.

Table 3: Effects of Iron Supplementation on Weight (Kg) of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
				FEMALE			
< 11	24	7.17±0.390[b]	15.28±1.95[a]	6.17±1.60[a]	6.20±0.62[a]	33.79	0.13
12 – 23	19	7.30±0.50[b]	12.78±0.15[a]	9.20±2.12[a]	9.34±1.75[a]	28.89	0.74
24 – 35	11	11.18±1.38[a]	14.35±1.62[a]	10.00±0.10[a]	10.20±0.00[a]	28.82	1.82
36 – 47	12	11.00±0.00[a]	13.50±1.54[a]	13.07±2.15[a]	12.94±1.92[a]	20.83	- 1.08
48 – 59	18	17.00±1.41[a]	19.45±2.00[a]	13.33±3.40[a]	13.97±3.51[a]	13.61	3.56
				MALE			
< 11	21	6.95±1.75[b]	14.65±2.00[a]	6.10±0.00[a]	6.25±0.05[a]	36.67	0.71
12 – 23	13	10.88±0.93[a]	13.28±2.41[a]	8.50±1.50[a]	8.65±1.06[a]	18.46	1.15
24 – 35	11	-	-	10.67±0.94[a]	10.80±0.93[a]		0.64
36 – 4	12	12.00±0.00[a]	13.50±0.00[a]	11.75±1.48[a]	12.07±1.31[a]	12.50	2.67
48 – 59	20	16.80±1.93[a]	18.88±2.47[a]	15.00±1.87[a]	14.20±3.58[a]	10.40	- 4.00

Horizontal pairs (baseline versus endline) with different superscripts are significantly different (P<0.05) while pairs with similar superscripts are not significantly different (P>0.05); N = Number of Participants; α = 5% (One-Way ANOVA).

Table 4: Effects of Iron Supplementation on MUAC of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
				FEMALE			
< 11	24	10.10±0.46 [b]	15.47±0.17 [a]	11.63±0.29 [a]	11.75±0.27 [a]	22.38	1.50
12 - 23	19	10.20±1.00 [a]	13.82±0.28 [a]	13.45±0.13 [a]	13.66±0.53 [a]	19.05	1.11
24 - 35	11	10.83±0.53 [a]	11.53±0.16 [a]	11.60±0.00 [a]	11.70±0.00 [a]	6.36	0.91
36 - 47	12	13.30±0.00 [a]	13.40±0.00 [a]	10.90±0.47 [a]	10.99±0.28 [a]	0.83	0.75
48 - 59	18	9.30±0.12 [a]	9.52±0.12 [a]	12.80±0.50 [a]	12.60±0.14 [a]	1.22	- 1.11
				MALE			
< 11	21	10.87±1.01 [a]	14.93±0.40 [a]	11.80±0.50 [a]	11.70±0.42 [a]	19.33	- 0.48
12 - 23	13	9.53±1.18 [a]	10.33±0.25 [a]	11.30±0.00 [a]	11.60±0.40 [a]	6.15	2.31
24 - 35	11	-	-	9.78±0.44 [a]	9.65±0.75 [a]	-	- 1.18
36 - 47	12	11.60±0.00 [a]	12.00±0.00 [a]	11.95±0.50 [a]	11.95±0.27 [a]	3.33	0.00
48 - 59	20	12.58±0.21 [a]	12.96±0.62 [a]	12.10±0.37 [a]	12.20±0.20 [a]	1.90	0.50

Horizontal pairs (baseline versus endline) with different superscripts are significantly different (P<0.05) while pairs with similar superscripts are not significantly different (P>0.05); N = Number of Participants; α = 5% (One-Way ANOVA).

4.4 Effect of Zinc Supplementation on Weight (Kg), and MUAC of Underfive Children in LLGNS

The effects of zinc supplementation on weight and MUAC of children less than 5 years are presented in Tables 4.5 and 4.6 respectively. The groups that were supplemented with zinc for three months showed higher percentage changes in weight and MUAC when compared with groups not supplemented. Among the female age groups, the respondents in the age group less than 11 months registered the highest percentage change in weight (34.42%) as a result of zinc supplementation followed by 12-23 months' age group with 29.31%. The least percentage change in weight (21.94%) was recorded in the 48-59 months age group. The male age group that showed the highest percentage change (37.73) was the 24-35 months' age group. Eleven months' age group had a percentage change of 30.05% in weight as a result of zinc supplementation. The age group 36-47 months produced the least percentage change in weight (13.33%). However, there was no significant difference ($P < 0.05$) between the means of the baseline and endline of any age group.

Percentage change in MUAC among the female age groups had the highest value (23.21%) in 12-23 months age group. The least percentage change was observed in 48-59 months age group. The male group of age 12-23 months registered the highest percentage change in MUAC (25.62%) as the result of zinc supplementation followed by the less than 11months' age group (13.62%). The least percentage change was seen in 48-59 months' age group (3.80%). There were significant differences ($P < 0.05$) between the means of the baseline and endline of females below 11 months and males between 12-23 months and 36-47 months.

Table 5: Effects of Zinc Supplementation on Weight (Kg) of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	4.98±1.39 [a]	13.24±1.20 [a]	6.17±1.60 [a]	6.20±0.62 [a]	34.42	0.13
12 - 23	19	9.61±5.09 [a]	15.18±2.65 [a]	9.20±2.12 [a]	9.34±1.75 [a]	29.31	0.74
24 - 35	11	12.00±0.00 [a]	15.20±0.00 [a]	10.00±0.10 [a]	10.20±0.00 [a]	29.09	1.82
36 - 47	12	15.67±0.47 [a]	19.00±1.42 [a]	13.07±2.15 [a]	12.94±1.92 [a]	27.75	- 1.08
48 - 59	18	19.33±2.98 [a]	22.78±1.94 [a]	13.33±3.40 [a]	13.97±3.51 [a]	21.94	3.56
MALE							
< 11	21	8.20±0.00 [a]	11.10±0.00 [a]	6.10±0.00 [a]	6.25±0.05 [a]	30.05	0.71
12 - 23	13	13.48±3.41 [a]	16.83±1.17 [a]	8.50±1.50 [a]	6.65±1.06 [a]	25.77	1.15
24 - 35	11	10.55±0.45 [a]	14.70±0.60 [a]	10.67±0.94 [a]	10.80±0.93 [a]	37.73	0.64
36 - 47	12	22.50±2.70 [a]	24.10±1.71 [a]	11.75±1.48 [a]	12.07±1.31 [a]	13.33	2.67
48 - 59	20	16.64±5.20 [a]	19.94±5.15 [a]	15.00±1.87 [a]	14.2±3.58 [a]	16.50	- 4.00

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; $\alpha = 5\%$ (One-Way ANOVA).

Table 6: Effects of Zinc Supplementation on MUAC of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	11.33±0.51 [b]	14.71±0.37 [a]	11.63±0.29 [a]	11.75±0.27 [a]	14.08	1.50
12 - 23	19	10.46±1.13 [a]	17.87±1.40 [a]	13.45±0.13 [a]	13.66±0.53 [a]	23.21	1.11
24 - 35	11	12.40±0.00 [a]	13.80±0.00 [a]	11.60±0.00 [a]	11.70±0.00 [a]	12.73	0.91
36 - 47	12	11.40±0.00 [a]	12.73±1.89 [a]	10.90±0.47 [a]	10.99±0.28 [a]	11.08	0.75
48 - 59	18	9.13±0.45 [a]	10.10±0.39 [a]	12.80±0.50 [a]	12.60±0.14 [a]	5.39	-1.11
MALE							
< 11	21	10.20±0.00 [a]	11.10±0.00*	11.80±0.50 [a]	11.70±0.42 [a]	13.62	-0.48
12 - 23	13	9.13±0.45 [b]	12.46±0.11 [a]	11.30±0.00 [a]	11.60±0.40 [a]	25.62	2.31
24 - 35	11	11.00±0.85 [a]	11.95±0.05 [a]	9.78±0.44 [a]	9.65±0.75 [a]	8.64	-1.18
36 - 47	12	2.50±0.86 [b]	13.33±0.41 [a]	11.95±0.50 [a]	11.95±0.27 [a]	6.92	0.00
48 - 59	20	11.73±0.69 [a]	12.49±0.24 [a]	12.10±0.37 [a]	12.20±0.20 [a]	3.80	0.50

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; α = 5% (Independent t-Test).

4.5 Effect of Combined Iron and Zinc Supplementation on Weight (Kg) and MUAC (cm) of Underfive Children in Lafia Local Government, Nasarawa State

The effect of combined iron and zinc supplementation on weight and MUAC of children below five years are presented in Tables 4.7 and 4.8 respectively. The result showed that the groups supplemented have higher percentage changes in weight and MUAC than the group that was not supplemented. The percentage change in weight as a result of combined iron and zinc supplementation among the female respondents showed the highest value (7.55%) in the 24-35 months' age group followed by the 12-23 months age group (6.21%). The least value (1.67%) was recorded in 48-59 months' age group. In the group not supplemented, the respondent females of 48-59 months' age group had the percentage change in weight(3.56%) that was higher than those of the corresponding male and female age groups including the 12-23 months' age group of the males that were supplemented. Among the male respondents, 36-47 months' age group registered the highest percentage change in weight (8.00%) followed by 24-35 months' age group (2.31%). There were no significant differences between the means of the baseline and endine of weight in any age group in both sexes.

Combined iron and zinc supplementation in the females produced the highest percentage change in MUAC (5.93%) among the 48-59 months' age group. The least percentage change (1.42%) was recorded in the 24-35 months' age group. The male age group that manifested the highest percentage change in MUAC (6.36%) was 24-35 months followed by the 48-59 months' age group with4.65%. The least percentage change (2.00%) was observed in less than 11months' age group. There was a significant difference ($P < 0.05$) between the means of the baseline and endline of MUAC in males of age group 48-59 months only.

Table 7: Effects of Combined Iron and Zinc Supplementation on Weight (Kg) of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
				FEMALE			
< 11	24	9.12±3.48 [a]	10.32±3.48[a]	6.17±1.60 [a]	6.20±0.62 [a]	5.00	0.13
12 - 23	19	10.40±3.01 [a]	11.58±1.88 [a]	9.20±2.12 [a]	9.34±1.75 [a]	6.21	0.74
24 - 35	11	8.60±1.98 [a]	9.43±1.98 [a]	10.00±0.10 [a]	10.20±0.00 [a]	7.55	1.82
36 - 47	12	12.50±1.50 [a]	12.94±1.92 [a]	13.07±2.15 [a]	12.94±1.92 [a]	3.67	- 1.08
48 - 59	18	12.00±2.35 [a]	12.30±2.35 [a]	13.33±3.40 [a]	13.97±3.51 [a]	1.67	3.56
				MALE			
< 11	21	6.52±1.52 [a]	7.81±1.52 [a]	6.10±0.00 [a]	6.25±0.05 [a]	6.14	0.71
12 - 23	13	9.15±2.75 [a]	9.45±1.25 [a]	8.50±1.50 [a]	6.65±1.06 [a]	2.31	1.15
24 - 35	11	10.00±1.00 [a]	10.70±1.00 [a]	10.67±0.94 [a]	10.80±0.93 [a]	6.36	0.64
36 - 47	12	12.00±0.00 [a]	12.96±1.68 [a]	11.75±1.48 [a]	12.07±1.31 [a]	8.00	2.67
48 - 59	20	13.67±3.30 [a]	14.20±3.10 [a]	15.00±1.87 [a]	14.2±3.58 [a]	2.65	- 4.00

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; α = 5% (Independent t-Test).

Table 8: Effects of Combined Iron and Zinc Supplementation on MUAC of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	10.33±0.15 [a]	10.97±0.07 [a]	11.63±0.29 [a]	11.75±0.27 [a]	2.67	1.50
12 - 23	19	13.20±0.45 [a]	13.64±0.08 [a]	13.45±0.13 [a]	13.66±0.53 [a]	2.32	1.11
24 - 35	11	12.30±0.10 [a]	12.64±0.09 [a]	11.60±0.00 [a]	11.70±0.00 [a]	1.42	0.91
36 - 47	12	14.10±0.09 [a]	14.20±0.19 [a]	10.90±0.47 [a]	10.99±0.28 [a]	1.67	0.75
48 - 59	18	13.15±0.38 [a]	13.93±0.25 [a]	12.80±0.50 [a]	12.60±0.14 [a]	5.93	-1.11
MALE							
< 11	21	13.78±0.49 [a]	14.20±0.30 [a]	11.80±0.50 [a]	11.70±0.42 [a]	2.00	-0.48
12 - 23	13	11.15±0.61 [a]	11.64±0.24 [a]	11.30±0.00 [a]	11.60±0.40 [a]	3.76	2.31
24 - 35	11	12.80±0.42 [a]	13.50±0.00 [a]	9.78±0.44 [a]	9.65±0.75 [a]	6.36	-1.18
36 - 47	12	12.98±0.36 [a]	13.33±0.31 [a]	11.95±0.50 [a]	11.95±0.27 [a]	2.92	0.00
48 - 59	20	11.47±0.12 [b]	12.40±0.08 [a]	12.10±0.37 [a]	12.20±0.20 [a]	4.5	0.50

Horizontal pairs (baseline versus endline) with different superscripts are significantly different (P<0.05) while pairs with similar superscripts are not significantly different (P>0.05); N = Number of Participants; α = 5% (Independent t-Test).

4.6 Effect of Iron Supplementation onIron Status and Zinc status of Underfive Children in LLGNS

The effects of iron supplementation on iron status and zinc status of children below five years are presented in Tables 4.9 and 4.10 respectively. Percentage changes in iron status of the supplemented respondents were significantly higher when compared with the group that was not supplemented. The female respondents had the highest percentage change (38.83%) of iron concentration in 12-23 months' age group followed by 24-35 months' age group with 36.00%. The least percentage change in iron status (22.00%) among the female age groups occurred in the less than 11 months. The male age group 12-23months registered the highest percentage change in iron status (35.15%) the least percentage change occurred in 48-59 months' age group (Table 4.9). There was a significant change ($P < 0.05$) in the means of baseline and endline of iron status of females 36-47 months age group only.

The highest percentage change in zinc status (4.79%) as a result of iron supplementation among the females occurred in the age group 12-23 months followed by those less than 11 months with 3.79%. The least percentage change was observed in 36-47 months' age group.The highest percentage change in zinc status within the male respondents (7.62%) was recorded by the 12-23 months' age group followed by that of 36-47 months' age group (6.67%) with the least value (0.95%) revealed in 48-59 months' age group. There was no significant difference ($P < 0.05$) between the means of baseline and endline of zinc status in any age group of both sexes.

Table 9: Effects of Iron Supplementation on Iron Status (μmolL^{-1}) of Under-Five Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	23.14±4.13 [a]	28.42±7.87 [a]	28.63±3.31 [a]	26.52±5.06 [a]	22.00	-8.79
12 - 23	19	9.09±3.44 [a]	16.48±0.08 [a]	18.55±3.65 [a]	18.65±5.13 [a]	38.83	0.53
24 - 35	11	25±2.26 [a]	28.96±9.27 [a]	27.5±0.00 [a]	27.67±0.00 [a]	36.00	1.55
36 - 47	12	11.11±0.00 [b]	14.91±0.00 [a]	37.72±3.41 [a]	37.82±4.32 [a]	31.67	0.83
48 - 59	18	17.8±7.29 [a]	23.81±3.57 [a]	22.28±3.32 [a]	21.28±2.62 [a]	22.28	5.56
MALE							
< 11	21	17.58±11.37 [a]	21.81±3.94 [a]	22.8±5.23 [a]	23.28±3.20 [a]	23.67	0.62
12 - 23	13	29.37±5.48 [a]	33.94±9.14 [a]	30.38±7.15 [a]	30.67±3.53 [a]	35.15	2.23
24 – 35	11	-	-	39±3.69 [a]	39.22±4.48 [a]	-	2.00
36 – 47	12	16.13±0.00 [a]	20.11±0.00 [a]	25.4±4.93 [a]	25.42±2.44 [a]	33.17	2.17
48 – 59	20	10.8±9.28 [a]	15.09±4.65 [a]	37.68±5.87 [a]	37.79±2.11 [a]	21.45	0.55

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; α = 5% (Independent t-Test).

Table 10: Effects of Iron Supplementation on Zinc Status (µmolL^{-1}) of Underfive Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	9.84±3.47 [a]	10.75±9.60 [a]	9.92±2.03 [a]	9.94±6.99 [a]	3.79	0.08
12 – 23	19	8.54±0.23 [a]	9.45±0.00 [a]	11.44±4.82 [a]	11.68±5.41 [a]	4.79	1.26
24 – 35	11	11.03±5.27 [a]	11.26±2.28 [a]	11.98±0.00 [a]	12.00±0.00 [a]	2.00	0.18
36 – 47	12	10.69±0.00 [a]	10.86±6.00 [a]	12.15±5.57 [a]	11.90±2.03 [a]	1.42	-2.08
48 – 59	18	7.89±1.80 [a]	8.41±1.02 [a]	8.41±1.17 [a]	8.11±0.38 [a]	2.89	-1.67
MALE							
< 11	21	8.99±1.44 [a]	9.69±2.02 [a]	10.08±4.36 [a]	10.09±1.36 [a]	3.33	0.05
12 – 23	13	10.92±5.09 [a]	11.91±5.79 [a]	9.94±8.22 [a]	9.74±1.83 [a]	7.62	-1.54
24 – 35	11	-	-	8.27±5.11 [a]	8.33±2.33 [a]	-	0.55
36 – 47	12	7.03±0.00 [a]	7.83±0.00 [a]	9.92±3.94 [a]	9.96±3.24 [a]	6.67	0.33
48 – 59	20	7.89±2.91 [a]	8.08±5.76 [a]	9.25±8.33 [a]	9.26±0.70 [a]	0.95	0.05

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; $\alpha = 5\%$ (Independent t-Test).

4.7 Effect of Zinc Supplementation on Iron Status and Zinc Status of Underfive Children in Lafia Local Government, Nasarawa State

The effects of zinc supplementation on both irons and zinc status of children below five years are shown on Tables 4.11 and 4.12 respectively.The result showed that percentage change in iron and zinc status in supplemented respondents were higher when compared with the group that was not supplemented. Supplementation with zinc created the highest increase in percentage change (8.05%) in iron status of female respondents among the 12-23 months age group. Next to this was the change observed in 36-47 months' age group (6.75%) and the least change (4.36%) was seen in the 24-35 months' age group. The male respondents showed the highest percentage change (10.58%) in the 36-47 months' age group with the 48-59 months' age group recording the least (4.10%). There was no significance difference ($P < 0.05$) between the means of baseline and endline of iron status in any of the age groups of both sexes.

The highest percentage change in zinc status among the females (19.10%) was noted in the 12-23 months' age group and this was followed by the age group less than 11 months. The age group 36-47 months recorded the least percentage change (6.25%) among the females. The male respondents percentage change in zinc status peaked (22.36%) in 24-35 months' age group. The 36-47 months' age group also showed a high percentage change (18.92%) while the least value was noticed in the age group less than 11 months (Table 4.12). There was no significance differences ($P< 0.05$) between the means of baseline and endline of zinc status of any age group and sex.

Table 11: Effects of Zinc Supplementation on Iron Status (µmolL^{-1}) of Underfive Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg) Baseline	Test (Kg) Endline	Control (Kg) Baseline	Control (Kg) Endline	Percentage Change (%) Test	Percentage Change (%) Control
FEMALE							
< 11	24	23.00±3.54 [a]	24.26±12.01 [a]	28.63±3.31 [a]	30.63±5.06 [a]	5.25	0.46
12 – 23	19	22.97±4.28 [a]	24.50±11.48 [a]	18.55±3.65 [a]	28.55±5.13 [a]	8.05	2.21
24 – 35	11	8.33±0.00 [a]	8.81±0.00 [a]	27.50±0.00 [a]	27.67±5.13 [a]	4.36	1.55
36 – 47	12	18.77±8.89 [a]	19.58±6.52 [a]	37.72±3.41 [a]	39.86±4.32 [a]	6.75	1.17
48 – 59	18	22.62±3.85 [a]	23.18±7.03 [a]	22.28±3.32 [a]	22.28±2.62 [a]	3.11	0.56
MALE							
< 11	21	7.98±0.00 [a]	8.75±0.00 [a]	22.80±5.23 [a]	32.84±3.20 [a]	4.10	0.19
12 – 23	13	15.45±7.28 [a]	16.31±7.28 [a]	30.38±7.15 [a]	30.52±3.53 [a]	6.62	1.15
24 – 35	11	18.17±0.62 [a]	18.67±0.62 [a]	39.00±3.69 [a]	32.40±4.48 [a]	4.55	1.64
36 – 47	12	23.61±2.62 [a]	24.88±2.04 [a]	25.40±4.93 [a]	25.42±2.44 [a]	10.58	0.18
48 – 59	20	31.64±5.43 [a]	32.95±9.52 [a]	37.68±5.87 [a]	37.79±2.11 [a]	6.55	0.05

Horizontal pairs (baseline versus endline) with different superscripts are significantly different (P<0.05) while pairs with similar superscripts are not significantly different (P>0.05); N = Number of Participants; α = 5% (Independent t-Test).

Table 12: Effects of Zinc Supplementation on Zinc Status (μmolL^{-1}) of Underfive Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	9.36±15.30 [a]	13.56±14.91 [a]	9.92±2.03 [a]	10.76±6.07 [a]	17.50	3.50
12 - 23	19	8.52±12.21 [a]	12.15±12.06 [a]	11.44±4.82 [a]	11.68±5.41 [a]	19.10	2.32
24 - 35	11	7.62±0.00 [a]	9.69±0.00 [a]	11.98±0.00 [a]	12.30±0.00 [a]	9.73	0.91
36 - 47	12	9.55±7.71 [a]	10.30±8.51 [a]	12.15±5.57 [a]	12.56±2.03 [a]	6.25	3.42
48 - 59	18	8.36±5.52 [a]	10.84±7.43 [a]	8.41±1.17 [a]	8.41±0.38 [a]	13.78	1.67
MALE							
< 11	21	8.82±0.00 [a]	11.18±0.00 [a]	10.08±4.36 [a]	10.11±1.36 [a]	13.76	0.14
12 - 23	13	10.9±5.93 [a]	12.98±7.34 [a]	9.94±8.22 [a]	12.94±1.83 [a]	16.00	1.54
24 - 35	11	9.99±1.63 [a]	12.45±1.72 [a]	8.27±5.11 [a]	9.33±2.33 [a]	22.36	0.55
36 - 47	12	8.34±7.13 [a]	10.91±7.37 [a]	9.92±3.94 [a]	9.96±7.24 [a]	18.92	1.17
48 - 59	20	9.79±6.79 [a]	12.96±12.13 [a]	9.25±8.33 [a]	10.86±0.70 [a]	15.85	3.05

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; α = 5% (Independent t-Test).

4.8 Effects of Combined Iron and Zinc Supplementation on Iron Status and Zinc Status of Underfive Children in Lafia Local Government, Nasarawa State

The effects of combined iron and zinc supplementation on iron status and zinc status of children below five years of age are shown on Tables 4.13 and 4.14 respectively. Combined iron and zinc supplementation to the female respondents produced the highest percentage change in iron status (7.63%) among the age group less than 11 months. The 12-23 months' age group had the least percentage change of 2.21%. Among the male age groups supplemented, 12-23 months recorded the highest percentage change (10.92%) in iron status and 24-35 months had the least (2.36). There was no significance difference ($P < 0.05$) between the means of the baseline and endline of iron status in all the age groups of both sexes.

The percentage change of zinc status in female respondents that were supplemented was highest (8.45%) in the 24-35 months' age group and least in 48-59 months. The male age group 12-23 months registered the highest percentage change (8.08%) and 36-47 months age group had the least percentage change in zinc status after supplementation with combined iron and zinc (Table 4.14). There was no significance difference ($P < 0.05$) between the means of baseline and endline of all the groups of both sexes.

Table 13: Effects of Combined Iron and Zinc Supplementation on Iron Status (μmolL^{-1}) of Underfive Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
FEMALE							
< 11	24	23.14±4.13 [a]	24.94±6.09 [a]	28.63±3.31 [a]	26.52±5.06 [a]	7.63	0.38
12 - 23	19	9.09±3.44 [a]	27.59±13.82 [a]	18.55±3.65 [a]	30.55±5.13 [a]	2.21	0.52
24 - 35	11	25.00±2.26 [a]	21.81±2.27 [a]	27.50±0.00 [a]	27.67±0.00 [a]	5.00	1.55
36 - 47	12	11.11±0.00 [a]	29.80±0.00 [a]	37.72±3.41 [a]	32.12±4.32 [a]	3.25	1.33
48 - 59	18	17.80±7.29 [a]	24.63±6.68 [a]	22.28±3.32 [a]	21.38±12.62 [a]	3.94	0.56
MALE							
< 11	21	17.58±11.37 [a]	34.74±14.82 [a]	22.80±5.23 [a]	18.89±13.20 [a]	4.33	1.38
12 - 23	13	29.37±5.48[a]	34.40±4.70 [a]	30.38±7.15 [a]	30.89±13.53 [a]	10.92	1.62
24 - 35	11	-	16.92±1.92	39.00±3.69 [a]	32.15±4.48 [a]	2.36	0.45
36 - 47	12	16.13±0.00 [a]	28.72±6.85 [a]	25.40±4.93 [a]	17.40±2.44 [a]	6.50	0.67
48 - 59	20	10.80±9.28 [a]	32.80±11.73 [a]	37.68±5.87 [a]	38.98±2.11 [a]	2.43	1.45

Horizontal pairs (baseline versus endline) with different superscripts are significantly different (P<0.05) while pairs with similar superscripts are not significantly different (P>0.05); N = Number of Participants; α = 5% (Independent t-Test).

Table 14: Effects of Combined Iron and Zinc Supplementation on Zinc Status of Underfive Children in Lafia Local Government, Nasarawa State

Age Group (Months)	N	Test (Kg)		Control (Kg)		Percentage Change (%)	
		Baseline	Endline	Baseline	Endline	Test	Control
				FEMALE			
< 11	24	9.36±15.30 [a]	10.84±3.29 [a]	9.92±11.03 [a]	10.10±6.97 [a]	6.33	0.50
12 - 23	19	8.52±12.21 [a]	8.77±7.25 [a]	11.24±12.82 [a]	12.18±5.41 [a]	5.42	2.32
24 - 35	11	7.62±0.00 [a]	9.33±9.30 [a]	12.20±0.00 [a]	12.30±0.00 [a]	8.45	2.91
36 - 47	12	9.55±7.71 [a]	8.86±0.00 [a]	12.15±5.50 [a]	12.30±2.03 [a]	8.08	1.25
48 - 59	18	8.36±5.52 [a]	9.46±3.66 [a]	8.11±11.17 [a]	8.60±0.38 [a]	4.17	1.06
				MALE			
< 11	21	8.82±0.00 [a]	9.36±5.29 [a]	10.08±4.36 [a]	10.18±1.36 [a]	3.38	0.48
12 - 23	13	10.90±5.93 [a]	9.38±6.37 [a]	12.74±8.22 [a]	9.04±1.83 [a]	8.08	0.77
24 - 35	11	9.99±1.63 [a]	10.57±6.80 [a]	9.27±5.11 [a]	11.63±2.33 [a]	6.00	1.45
36 - 47	12	8.34±7.13 [a]	8.55±6.90 [a]	9.82±13.94 [a]	9.11±7.24 [a]	2.92	1.58
48 - 59	20	9.79±6.79 [a]	11.91±4.87 [a]	10.25±8.32 [a]	9.26±0.70 [a]	4.75	0.05

Horizontal pairs (baseline versus endline) with different superscripts are significantly different ($P<0.05$) while pairs with similar superscripts are not significantly different ($P>0.05$); N = Number of Participants; α = 5% (Independent t-Test).

4.9 Nutritional Status Based on Weight-for-Age of Children Underfive in Lafia Local Government, Nasarawa State

At the baseline, 7.5% were severely underweight (z-scores< -3SD) in Fe-group, 18% in Zn-group and 9% in Fe-Zn- group (Appendix IV). At the end of 3 months daily supplementation, all the children in the severe underweight category were fully recovered (Figure 3). Overweight increased as the result of the supplementation in Fe-group from zero to 7.5% severe overweight (z-scores > +3SD), Zn-group from 5% to 12.5% and Fe-Zn group from zero to 15%. The result shows that the male groups' response to the supplementation resulted in the overweight increase in Fe-group (Table 14).Moderate underweight (z-scores<-2SD) and mild underweight (z-scores<-1SD) in the test groups were fully recovered at the end of the supplementation but mild, moderate and severe underweight of 10%, 10% and 2.5% respectively remained in the Control group. The highest percentage change in mildoverweight (z-scores>+1SD) occurred in Fe-group from 12.5% to 40% and Zn- group recorded the highest percentage change in moderate overweight (z-scores>+2SD) from zero to 35%.The Fe-Zn group registered the highest percentage change (12.5%) of the severely overweight.

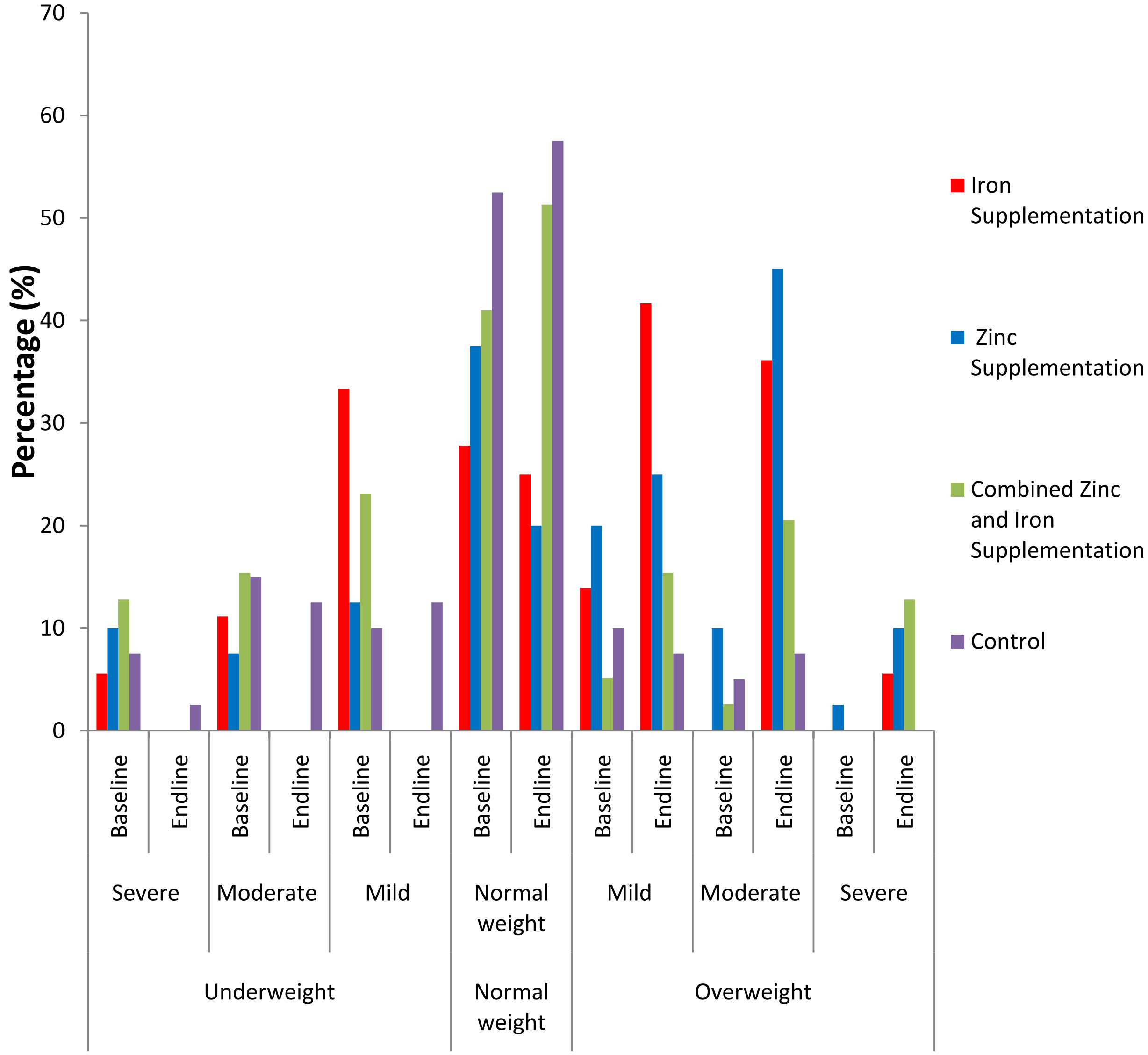

Figure 4.2: Nutritional Status Based on Weight-for-Age of Underfive Children in Lafia Local Government, Nasarawa State

4.10 Nutritional Status Based on MUAC-for-Age of Underfive Children in Lafia Local Government, Nasarawa State

This study recorded prevalence of severe wasting with MUAC-for age < 110mm (z-scores < -3SD) at recruitment (23% in Fe-group, 23% in Zn-group, and 47.5% in Fe-Zn-group.) among children under five years (AppendixIV). At the end of 3 months supplementation the children were fully recovered. Moderate wasting (z-scores <-2SD)decreased (47.5% to 7.5% in Fe-group, 30% to 10% in Zn- group and 25% to 2.5% in Fe-Zn- group) at the end of the study and no child remained mildly wasted (z-scores <-1SD) in the Fe-group.

4.11 Nutritional Status Based on Weight-for-Height of Underfive Children in Lafia Local Government, Nasarawa State

Atrecruitment 5% of the respondents in Fe-group were severely wasted (z-scores < -3 SD) and were mainly males (Appendix V). Fe-group also recorded 20% moderately wasted (z-scores < -2 SD) respondents and acute wasting (z-scores < -1 SD) in 12.5%. At the end of 3 months supplementation,, the severely wasted respondents were fully recovered, the moderately wasted were reduced from 20% to 5% and acutely wasted decreased from 12.5% to 5%. Acute wasting of 10% observed in Zn-group at baseline was reduced to 2.5% and 15% in Fe-Zn group decreased to 5%.The Control group showed an increase in acute wasting from 15% to 20%.

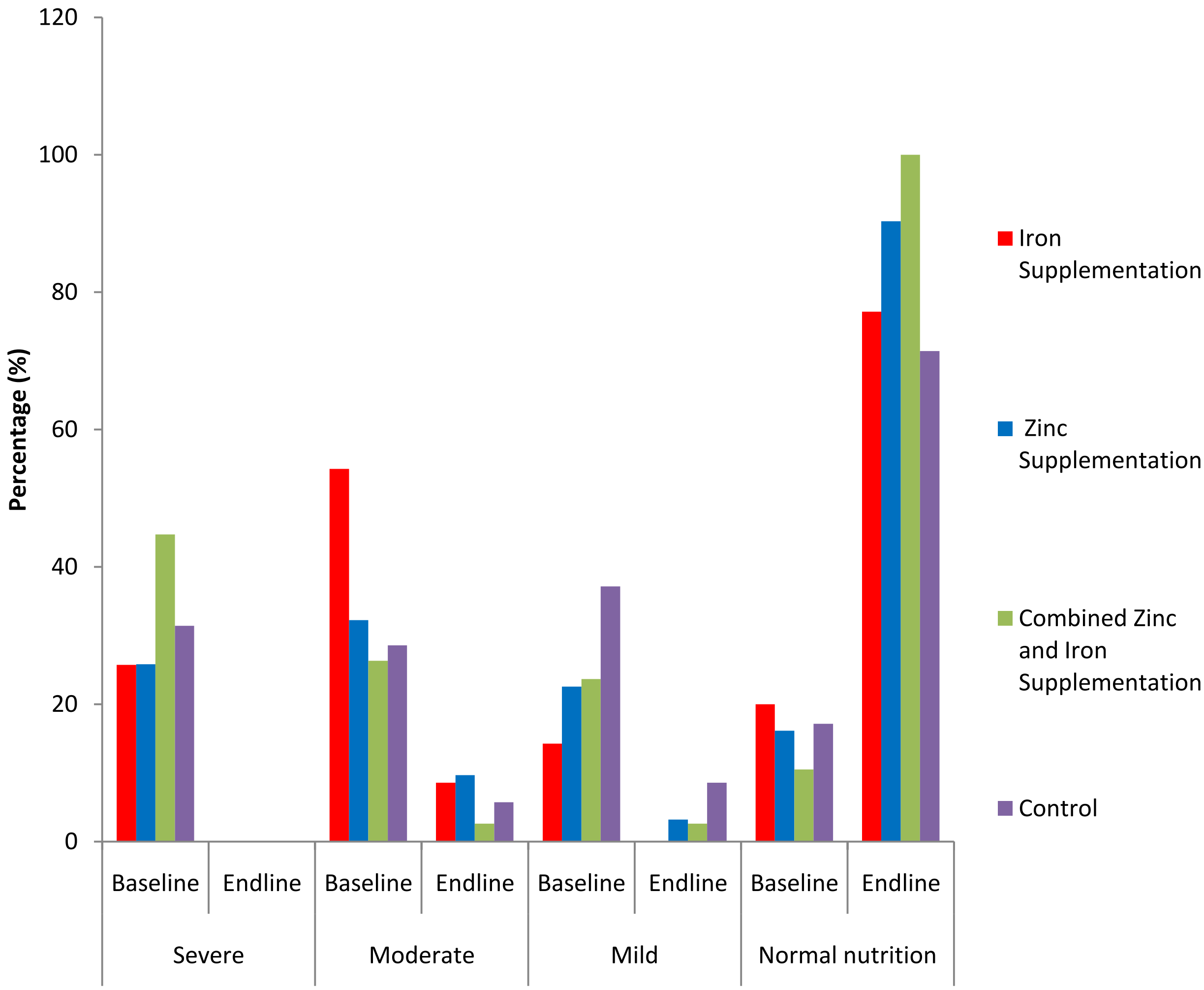

Figure 4.3: Nutritional Status Based on Muac-for-Age of Underfive Children in Lafia Local Government, Nasarawa State

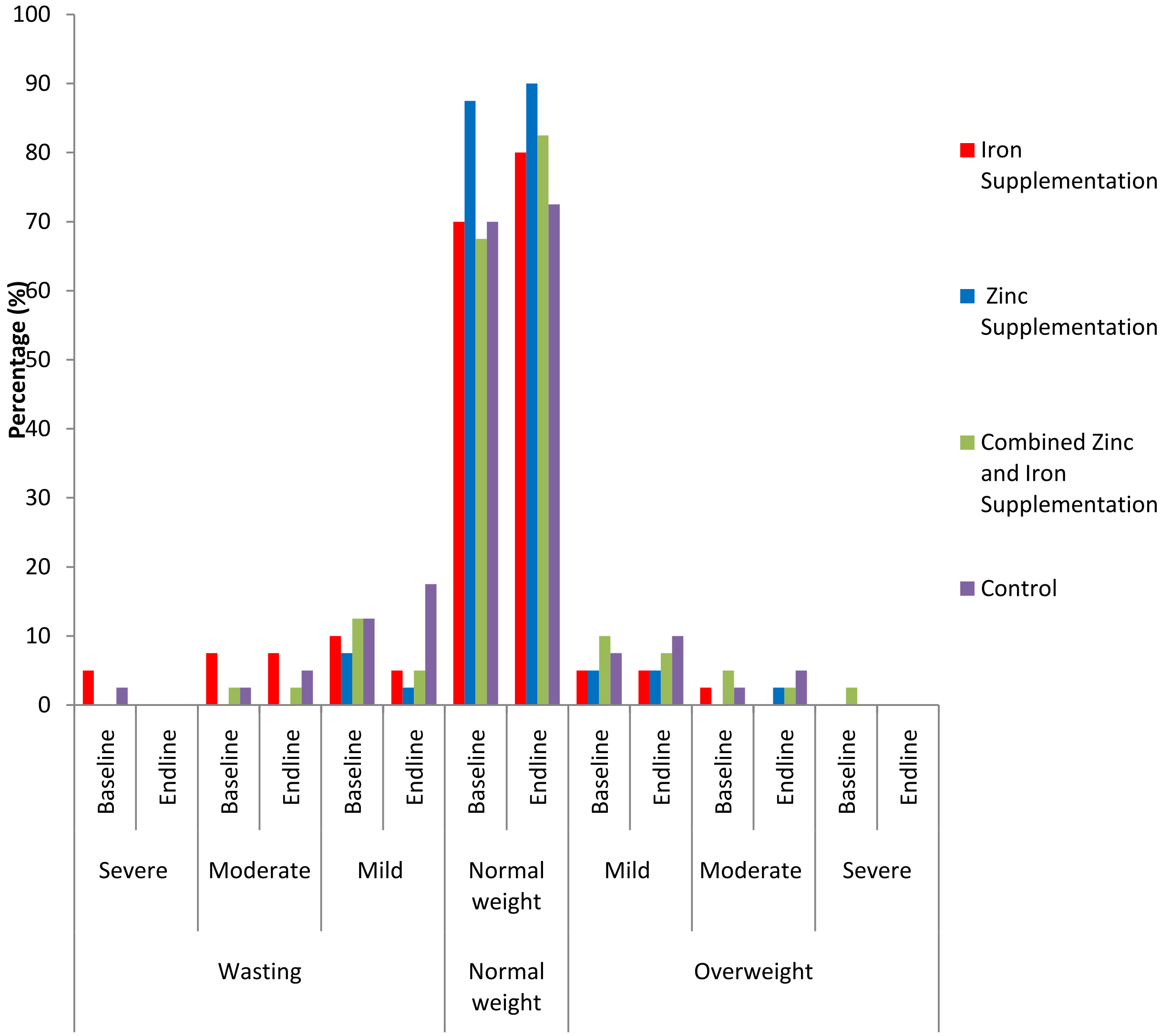

Figure 4.4: Nutritional Status Based on Weight-for-Height of Underfive Children in Lafia Local Government, Nasarawa State

CHAPTER FIVE

5.0 DISCUSSION

This study provides an overview of the current nutrition status of children under five years in Lafia Local Government Area Nasarawa state. The respondents in this study represent five different age groups, gender and locations from different social backgrounds. Despite the security challenges in Nasarawa south senatorial district, questionnaires administered yielded a response rate of 91%. Some selected socio-economic and demographic characteristics of the households studied are discussed.

This study has shown that poor feeding practices do adversely affect the health and nutritional status of children. Exclusive breastfeeding was not taken seriously by many caregivers (40%) (HMIS,2014).Early breast suckling stimulates the release of prolactin, which helps in the production of milk, and oxytocin, which is responsible for the ejection of milk. A good number of the respondents caregivers (48%) discarded colostrum thereby preventing optimal infant feeding and protection. Only one quarter of children were breastfed within one hour of birth. Majority of the newborns (67%) were given something other than breast milk before six months thereby exposed the .babies to the risk of infection.

The data presented in this study tend to highlight nutritional deficiencies in the underfive year population, where consequences include high mortality and losses of cognitive development. But nutrition in children below 5 years depends critically on nutrition of their caregivers. When maize had become the preference of many residents (29.38%)as the choice staple food, different products are derived from it. Plant-based complementary foods like 'akamu' often contain high levels of phytate, a potent inhibitor of iron, zinc and calcium absorption (Gibson *et al*., 2010). It is made from refined flour of milled maize which lost most of the vitamins and minerals during milling (USAID, 1998). The majority depend on plant-based complementary foods (e.g. Akamu) that are insufficient to meet needs for certain micronutrients. This is in tandem with WHO and UNICEF reports (1998) that a high prevalence of stunting in rural West Africa with nutritional indicators particularly bad in children aged 12-24 months is typical for young children in rural Africa where bulky weaning diets with low micronutrients and low energy density prevail (Muller *et al*., 2003).Iron and zinc content is particularly very low in tubers and refined cereals, fruits and vegetables because of their high-phytate content (Gibson *et al*., 2010). These are the main weaning foods of more than half (61.21%) of the population of children below 5 years in Lafia Local Government of Nasarawa State.

Most of the respondents (34.38%) processed the maize to obtain refined flour that enhances the aesthetic nature of the food products. A study by Moeser *et al,* (2001) supports this practice, that corn processed to remove poorly digestible fibre fraction provides more digestible nutrient, than corn grain. As a result degrermed, dehulled corn reduces faecal and nitrogen excretion, thus providing a means to reduce nutrient excretion.

This study also showed that lack of knowledge of micronutrient deficiency is a major contributor to childhood morbidity and mortality. The dietary practice of many households studied revealed poverty and food insecurity. The majority of the respondents (61.26%) categorically accepted that there is not enough money to buy food and not to think of adding supplements to whatever they could afford. It was thereforeconvenient for 49.38% of the respondent caregivers to save left over foods and later warm them for consumption instead of giving the remnants to domestic animals. This is in tandem with the work of Bhandari *et al* (2013) that children can receive micronutrients from fresh foods, food fortification, and direct supplementation but cooked, fermented, refrigerated foods lose their micronutrients with time. And that poverty, lack of access to different typesof foods, and lack of knowledge of efficient dietary practices contribute to poor nutritional status of the underfive year children.Therefore for cooked food to be kept overnight, many micronutrients become nonavailable.

Population with poor resources like the area studied generally consume monotonous diets that are predominantly cereal based and include few or no animal products, vegetables, or fruits(Hurrell *et al*., 2005). Moreover, many of the households (48.38%) in the study had no idea of micronutrients and their works and among the few that have the idea, only 28.75% give multivitamins before 1 year. Many households (35.63%) do not give any other supplements or multivitamins to the children as long as they could eat the adult food, some as early as from 4 months.However Aggett (2012) reported that full-term infants have a risk of becoming iron deficient at 6 to 9 months unless they obtain adequate amounts of bioavailable iron outside their mothers. Failure to give these indispensable micronutrients to the infants and pre-shool-age children reduces their cognitive and psychomotor growth and their resistance to infections. According to Demellof (2001) and Black *et al*, (2011), those born preterm or with low birth weight or whose mothers have iron deficiency are at risk of iron deficiency because of their high iron requirements due to their rapid growth.

Household is defined in this study as persons living together in the same housing unit cooking and eating together from the same pot with one recognizable adult as head. Many households in this study (46%) depend upon protected wells and rain water as sources of drinking water. This may be in agreement with reports of WHO and UNICEF (2010) but a few (13%) have access to piped source of water and borehole. For this purpose water must be fetched from a source that is not immediately accessible to the household and this can be contaminated during transport or storage (NDHS 2014). This can compromise nutritional status.

Sanitation facilities including method of waste disposal are far from being adequate as only few households 29.9% have access to improved toilet system (that is available to household members only). A good number of the respondent caregivers (7%) defecate in the bush and the majority (51.5%) use pit latrines. Poor waste disposal system can cause diarrhoea in children thereby compromising their health status. The standard of sanitation and methods of waste disposal were better in households with educated members.

Educational level of the household members is an important social characteristic that links to factors which determine health seeking behaviors. The educational level of mothers particularly is an important factor in reproductive behaviors and children's health status. In this study however, as high as 23% of the mothers have no formal education, 26% with primary education and the majority, (49%) have secondary education. Mother's education is said to be inversely related to the child's risk of dying (NDHS, 2013). The study has shown that children under five years born to these mothers of low income, that do not have education, lack the health attention received by children of mothers that have attained education.

It has been estimated that 39% of Nigerian (34.5% NasarawaState) children less than 5 years old are stunted (HAZ < -2) and 21% (19.9% Nasarawa State) severely stunted (NDHS, 2013). This study encountered high prevalence (45%) of stunting and wasting (WHZ<-2) at the time of recruitment. The nutritional indicators were particularly bad in children aged 12-23 months which is a true reflection of (i) poor complementary foods that could not meet the nutritional requirements of the rapidly growing child and (ii), infectious diseases.

Given the low intake of animal products in the study area, existence of high prevalence (60%) of iron deficiency and zinc deficiency in infants and preschool children was manifested. It has shown that supplementation with iron and zinc is an effective method of combating the deficiencies. The pattern of observed percentage increase in weight is greatest between 9-24 months. This could be attributed to the age group being within the fastest growing period of life and availability of all necessary nutrients reduces underweight. These supplements complement the constantly decreasing provision from the mother thereby meeting all the conditions for successful growth. The result of iron and zinc supplementation in this study is consistent with the work of Berger et al, (2006).This study has shown that combined iron and zinc supplementation positively influenced the percentage change in weight of children without significant differences between the female and the male age groups. The differences in nutritional status of children at the baseline result from the different households, environments, knowledge and attitude of the caregivers and these may account for the different results (Lind *et al*., 2004).

Previous trials(Domellof *et al*., 2002; Lonnerdal and Hernell*.*, 2010;) have suggested that boys have lower iron levels and serum iron (SFe) in infancy, possibly putting them at increased risk of iron deficiency but in this study we found few differences in the main outcomes between boys and girls as the increased risk of iron deficiency was present in both sexes. One possible explanation for the gender differences may be the higher growth rate of boy infants leading to increased iron requirements (Domellof et al., 2002).

At recruitment 37.5% of the children in Fe-group were anaemic with low weight (using classification of Slon, 2006) but fully recovered with increased weight after the three months (90days) iron supplementation. Interestingly the number of children who experienced side effects from the supplementation was low and this must have contributed to the high compliance of 98%. This is consistent with the works of Thibault *et al.*,(2000), Roy and Ennis,(2000) with Togolese children, and de Silva *et al*.,(2003) with Sri Lanka children.The percentage change in weight could be attributed to rapid catch up growth when low birth weight infants were supplemented with iron and zinc(Berglund, 2012).A contributory factor to the positivepercentage weight change in this group could alsobe the improvement in appetite that comes with iron supplementation (Stoltzfus *et al*., 2004) that enable them to eat more. In contrast, a meta-analysis of 27 iron supplementation trials to children below five years of age showed no overall percentage change in weight (Ramakrishman *et al*., 2009). What is more of concern is that four trials have suggested a negative effect on weight when analyzing iron replete infants (Sazawal et al., 2006). A recent study reveals that iron is also an essential nutrient to pathogens i.e. bacteria, fungi and viruses. Iron supplementation can increase the risk of infections (Domellof, 2010)as demonstrated by a large iron supplementation trial in Zanzibar that had to be terminated due to increased risk of severe malaria infection in supplemented infants (Sazawal, *et al*., 2006). Studies carried out on Indonesian infants revealed that iron supplementation has no effect on body composition of Mexican preschoolers (Rosado *et al*., 1997). Children randomized to iron have slightly lesser weight gain (Pasricha *et al*., 2013). These diverging results possibly depend on the time, duration and severity of iron deficiency / iron deficiency anaemia or the time, duration and dosage of supplementation (Berglund, 2012).It is also evident from this study that there is higher anaemia prevalence in boys than in girls in the Control group at the end of the 3 months.

Positive effect of iron supplementation manifested using MUAC (Mid upper arm circumference). The Fe-group recorded at recruitment 25% severe wasting (MUAC < 110mm) but they all recovered at the end of the 90 day supplementation. This can be attributed to the fact that iron is needed at this crucial growth period as an essential component of haemoglobin and myoglobin, required for normal cellular functioning, and synthesis of hormones and connective tissues (Agget, 2012). The increment in percentage change in weight could be as a result of iron resolution of infection through reduction in morbidity (de Silva *et al*., 2003).

Children aged below 5 years are a group at high risk of iron and zinc deficiencies. Breastfed infants who do not receive iron-rich complementary foods by 6 months of age can quickly become iron deficient (Lynch, 2003).Iron depletion is more rapid in low-birth-weight infants than in normal weight infants (Allen, 2002). In this study, the underfive children typically consume little meat or animal product, iron and zinc deficiencies were therefore common. There is not yet a global policy for daily supplementation, but zinc has been shown to reduce the incidence of diarrhoea and pneumonia (Bhutta *et al*., 1999) and is now one of the micronutrients of the World Health Organization’s guidelines for the treatment.

Iron supplementation resulted in higher percentage change in SFe of childrenin all the age groups in this study and reduced prevalence of anaemia.There was a higher percentage change in SFe of the children supplemented with iron alone when compared with the SFe of children in the Control group. This is in tandem with Pasricha*et al*.,(2013) in the study of effect of daily iron supplementation on health in children aged 4-23 months asserted that iron supplementation significantly increased SFe and reduced the prevalence of anaemia in 42,306 children in 35 studies. Similarly,Berger *et al*(2006) observed that increase in SFe doubled in rural Vietnamese children supplemented with iron alone and iron deficiency almost cleared whereas the prevalence of iron deficiency doubled in infants who did not receive iron. In their work with children from Colombo Sri Lanka, de Silver *et a*l (2003) reported that iron supplementation cleared anaemia, improved SFe and also reduced morbidity due to upper respiratory tract infections.

The effect of iron supplementation on SZn in this study agrees with the work of Berger *et al*(2006) on Vietnamese infants but in contrast with Dijhuizen *et al*(2001) who recorded no difference in plasma SZn between children who received iron and zinc supplements and children who received zinc alone after 6 months of supplementation to Indonesian infants. However, Untoro *et al* (2005) also worked with some Indonesian infants and reported that a greater percentage of infants who received daily iron (32.8%) than of those who received placebo (15.6%) were zinc deficient (<10.7 umol/L) after 6 months of supplementation.

In the current study, zinc supplementation showed high percentage change in weight of the children in Zn-group. The positive effect of zinc supplementation on weight gain has been already reported in Zimbabwean school children (Friis *et al*., 1997) Brazilian (Lira et al., 1998), Guatemalan children (Rivera *et al.*, 1998), and in Indonesian infants (Lind et al., 2004), and was attributed to an increased synthesis of the lean body mass(Golden and Golden, 1981, Friis *et al*., 1997, Rivera *et al*., 1998). Other studies contrasted this stand and concluded that zinc has no effect on weight gain but on body composition increasing the fat status of Guatemalans children (Cavan *et al.*, 1993). However, a recent meta-analysis of 32 studies has shown that zinc supplementation results in a highly significant ($P < 0.05$) increase in weight gain on pre-pubertal children (Brown et al; 2002). This could be as a result of the role zinc plays in cellular differentiation and metabolism (Wieringa *etal*., 2007).

There was an accelerated percentage change in weight gain in children that were supplemented with zinc which is in tandem with the work of Ramakrishnan et al., (2009) with Vietnamese children but not in agreement with zinc supplementation in United States and Canada (Walravens *et al*., 1983, Vanderkooy and Gibson,1987). Result of meta-analysis techniques indicate that zinc supplementation results in positive percentagechange in weight of pre-pubertal children (Brown *et al*., 2002).

MUAC which is measured at the mid-point between the tip of the shoulder and the tip of the elbow (olecranon process and acromion) is one of the anthropometric parameters. In children, MUAC is useful for the assessment of nutritional status (WHO, 1986). It is used to measure wasting. In this study, the zinc supplemented group had 42% severe wasting at recruitment (< 11.5mm) but at the end of the 3 months supplementation, only 2.5% remained wasted. The 40% reduction in prevalence rate of wasting may be attributed to the role zinc plays on key immunity mediators such as enzymes, thymic peptides, cytokines and in the regulation of lymphoid cell activation, proliferation and apaptosis (Dardenne, 2002).

At recruitment 65% of the children were zinc deficient which compares with the work of Steve-Edemba (2014) those Nigerian children are 60% zinc deficient. The observation of an improvement in structural growth as a result of zinc supplementation at physiologic doses supports the existence of zinc deficiency in children. Several lines of evidence suggest that the SZn of such low socio-economic background was marginal: first, virtually most rural dwellers are suspected of having inadequate zinc intake (Steve-Edemba, 2014), because animal products, the main source of zinc, represent only a small percentage of the usual diet. Second, high consumption of maize, yam, cassava and vegetables may reduce adequate zinc absorption as a result of high phytate and fibre content. Third, gastrointestinal diseases (worms, diarrhoea) may increase intestinal losses of zinc (Anonymous 1990; Behrens *et al*., 1990; and Hambidge, 1992).

In this study zinc supplementation resulted in higher–end-point SZnwith medium percentage increase of 19.1% in females and 22.36% in males which is consistent with the study of Mayo-Wilson et al., (2014) that recorded the SZn of 9,810 participants and had a similar outcome. The Zn-group experienced percentage change in SZn almost twice those of other groups. This agrees with the result of study of Indonesian infants (Lind *et al.*, 2003) that zinc supplementation produces a large, highlysignificant percentage change in children's SZn concentration in prepubertal children (Brown *et al*., 2002).

In this study, daily supplementation with iron and zinc in the underfive children recorded positive percentage change in weight in the Fe-Zn group. This is consistent with Mujica-Coopman (2015). In this study combined supplementation of iron and zinc was found to be less efficient than either supplement (iron or zinc) alone but was still effective in reducing both iron deficiency, anaemia and zinc deficiency. These two elements are of great requirements at this critical period of growth so they are constantly in high demand and are efficiently utilized (Wesling – Resnick, 2014). However, the less effectiveness of the Fe-Zn group could be attributed to inhibitory effects between iron and zinc as they competed for the same oxidation sites and for divalent metal transporter-1 (DMT - 1) in the process of absorption (Pizarro *et al*., 2005).

Iron and Zinc (Fe-Zn) group experienced recovery of severely wasted children from45% to 15% using the MUAC tape. It points out that combined iron and zinc supplementation for 3 months brought a 30% reduction in prevalence rate of wasting and also improvement on iron status.. Two studies carried out in Indonesian infants with the same doses but different duration of zinc and iron supplementation as this study resulted in similar efficiency (Dijkhizen *et al*, 2001; Lind *et al*., 2003). In contrast, other studies carried out (Allen *et al* 2001; Munoz *et al*; 2000 and Berger *et al*., 2000) using different doses (20mg iron and

20mg zinc) for a 6 month duration revealed combined iron and zinc supplementation had the same effect on iron status as supplementation with iron alone. But the combined supplementation hadlower effect on the serum zinc concentration than supplementation with zinc alone. The differences in the results, especially in iron status may be as a result of difference in nutritional status of the infants.

This study used a cut-off of 9:00 µmol/L of zinc as indicative of anaemic status (SL-Assay, 2005). Iron requirements were higher in infants and thus have favoured absorption from the iron and zinc supplements. At the end of the study not all anaemic children Fe-Zn group recovered suggesting than iron deficiency probably may be the main, but not the only cause of anaemia. Other nutrient deficiencies such as folate, vitamin B12 or Vitamin A as well as gastrointestinal parasitic infections may have had contributory roles (de Silva *et al*., 2006).

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

i. Half (50%) of the household heads were in the 30-39 year age group and only 10% were above fifty years. Educational qualification of the caregivers' mothers show that nearly half (49%) of them attained secondary education and 23% had no formal education. The primary occupation of 38% of households was civil service and 32% were farmers. Annual income varied with 31% earning between N50,000.00, -N100,000.00; 24% below N50,000.00 and 29% above N200,000.00

ii. Majority of the respondents (61.25%) attributed inadequate food in their households to lack ofmoney; therefore most of them (49.38%) saved their leftover food for later consumption. Preference for staple food ranked from maize (29.38%) to rice (20.63%), and more than half (54.38%) of those that maize agreed that the grain is dehulled before in the process of producing flour just to enhance its aesthetic value. Nearly half of the caregivers (49.38%) had no knowledge of micronutrient supplements and for those that have know the importance 57% do not give their children.

iii. The supplementation with iron, zinc and combined iron and zinc produced positive percentage changes in weight and MUAC of the respondents according to age group and sex. At baseline, the respondents were at different malnutrition states; mild, moderate and severe underweight, wasting and overweight states but after 3 months of supplementation all categories of underweight were fully recovered, no case of severe wasting but there was increased percentage of overweight.

iv. Iron and Zinc deficiencies wereprevalent nutritional problems in underfive children of Lafia Local Government of Nasarawa State in this study. But iron and zinc supplementation improved the nutritional status of the respondents. The percentage change in nutritional status of iron and zinc in all the test groups were generally higher when compared with the group not supplemented.

6.2 Conclusion

The study revealed that socio-economic status of the respondent caregivers were weak resulting in poor access to foods rich in iron and zinc micronutrients. This is because the people depend mainly on plant based diets of maize, yam, cassava and rice.

The study has provided the evidence that combined daily iron and zinc supplementation had a positive effect on iron and zinc status and that single zinc or iron supplement increased weight gain. Iron supplement when co-administered with zinc loweredSZn similarly zinc supplement lowered SFe and may reduce the beneficial effect of iron supplements. However this negative interaction is not very pronounced as to discourage joint supplementation. Even in the presence of zinc, the benefit of iron supplementation on iron indicators was significant and important. Iron appeared to have a more negative effect on SZn.

6.3 Recommendation

From this work I recommend that iron and zinc supplementation improve Anthropometric data and nutritional status of underfive children and reduced malnutrition.

Further work should be done in monitoring the period of iron and zinc supplementation and the determination of the most beneficial combination of iron and zinc for children below 5 years to promote and ensure adequate stores.

The uderfive-based iron and zinc intervention programmes could still be carried out using other sensitive and specific biochemical indicators of iron and zinc.

Nutrition education directed at caregivers and primary health workers will go a long way to improve feeding practices and nutritional status of children and there should be increased advocacy for dietary diversification so as to increase consumption of iron and zinc rich foods by the children from early age.

REFERENCES

Adamson, J.W (2012). Iron deficiency and other hypoproliferative anaemias. In: Longon D.L., Fancy A.S., Kasper, F.D.L., Hauser, S.L., Jameson, J.L., Loscalzo, J. (eds); *Harrisons' Principles ofInternational Medicine*. 18th ed. New York: McGraw- Hill: pp. 844-851.

Agget, PJ. Iron. In: Erdman, J.W., Macdonald, I.A., Zeisel, S.H. (2012). *Present Knowledge inNutrition* 10th ed. Washington DC: Wiley-Blackwell: pp. 506-20.

Akman, M., Cebeci, D., Okur, V., Angin, H., Abali, O., Akman, A.C. (2004). Effects of iron deficiency on infants' developmental test performance, *Acta Paediatrics*.; 93:1391-1396.

Allen, L.H., Rosado, J.L., Casterline, J.E., Lopez, P., Munoz, E. and, Garcia, O.P. (2001).Lack of hemoglobin response to iron supplementation in anemic Mexican preschoolers with multiple micronutrient deficiencies.*American Journal of Clinical Nutrition*, 71: 1485-1494.

Anonymous.(1990).Zinc and copper wastage during acute diarrhoea.*Nutrition Review* 48: 19-22.

Baqui, A.H., Fischer-Walker, C.V.L., and Zaman, K.(2005). Weekly iron supplementation does not block increases in serum zinc due to weekly zinc supplementation in Bangladeshi infants. *Journal of Nutrition*, 135 (9): 2187-2191.

Barreiro, P. L. and Albandoz, J. P. (2001).Population and Sample.*Sampling Techniques*: 10 - 11

Bates, B., Lennox, D.A., Prentice, A., Bates, C., Page, P., Nicholson, S., Swan, G. (2008/2009-2011/2012). *National Diet and Nutrition Survey*: *Results from years combined of the rollingprogramme of UK* pp 17-21.

Beard, J.L. (2001) Iron biology in immune function, muscle metabolism and neuronal functioning.*The Journal of Nutrition*, 131 (25-2):5685-95.

Behrens, R.H., Tomkins, A.N., Roy, S.K. (1990). Zinc supplementation during diarrhea, a fortification against malnutrition? *Lancet*; 2: 442-3.

Berger, J., Dyck, J.L., Galan, P., Aplogan, D.A., Scneider, F.D., Traissac, P., Herdberg, S. (2000).Effect off daily iron supplementation on iron status, cell-mediated immunity, and incidence of infection in 6-36 month old Togolese children.*European Journal of Clinical Nutrition*; 54 (1): 29-35.

Berger, J., Ninh, N.X., Khan, N.C., Ngien, N.C., Lien, D.K., Irung, N.Q., Khoi, H.H. (2006) Efficacy of combined iron and zinc supplementation on micronutrient status and growth in Vietnamese infants. *European Journal Clinical Nutrition*,; 60:443-454

Berglund, S. (2012).*Effects of Iron supplementation on iron status, health and micrological development in marginally low birth weight infants. Umea, Sweden* pp. 16-24.

Berti, C., Faber, M., and Smuts, C.M. (2014) Prevention and control of micronutrient deficiencies in developing countries: current perspectives.*Nutrition and Dietary Supplements*, 6:41-57.

Bhandari, T.R., and Chihetri, M. (2013). Nutritional status of under 5year children and factors associated in Kapitrastu district Nepal. *Journal of Nutritional Health andFood Science*,; 1:6.

Bhutta, Z.A., Ahmed, T., Black, R.E., Cousens, S., Dewey K., and Giugliani, E. (2008). What works? Interventions for maternal and child undernutrition and survival.*The Lancet*, 371:417-440

Bhutta, Z.A., Black, R.E., and Brown, K.H. (1999). Prevention of diarrhoea and pneumonia by zinc supplementation in children in developing countries: pooled analysis of randomized controlled trials. Zinc Investigators' Collaborative Group.*Journal ofPediatrics*, 135: 689-97.

Black, M.M., Quigg, A.M., Hurley, K.M., Pepper, M.R. (2011). Iron deficiency and iron deficiency anemia in the first two years of life: strategies to prevent loss of developmental potential. *Nutrition Review*, 69 Suppl: S 64-7.

Black, R.E. (1998) Therapeutic and preventive effects of zinc on serious childhood infectious diseases in developing countries.*American Journal of ClinicalNutrition* ; 68: 476S- 479S

Black, R.E. (2003). Zinc deficiency, infectious disease and mortality in the developing world. *Journal of Nutrition*, 133:1485S-1489S.

Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., de Onis, M., Ezzati, M., Mathers, C., Rivera, J. (2008).Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*, 371:243- 60.

Brown, K.H., Peerson, J.M., Rivera, J., and Allen, L.H. (2009). Effect of supplemental zinc on growth and serum zinc concentrations of preputertal children: a meta-analysis of randomized controlled trials. *American Journal of Clinical Nutrition*, 75: 1062-1071.

Brown, K.H., Wuehler, S.E., Peerson, J.M. (2001).The importance of zinc in human nutrition and estimation of the global prevalence of zinc deficiency *Food and Nutrition Bulletin*; 22: 113-25.

Burtis, A. (1999). *Tietz Textbook of Clinical Chemistry*, 3rd ed AACC

Cavan, K.R., Gibson, R.S., Grazioso, C.F., Isalgue, A.M., Ruz, M., Solomons, N.W. (1993). Growth and body composition of periurban Guatemalan children in relation to zinc status: A cross-sectional study. *American Journal of Clinical Nutrition*, 57: 334-43.

Center for Disease Control and Prevention (2012). *National report on biochemical indicators ofdiet and nutrition in the US population (1999-2002) Atlanta: National Center for EnvironmentalHealth* pp 43-51.

Chiejina C. (2012). Malnutrition: Cognitive functions of Nigerian children under threat. *Bussiness Day*, 31 January.

Civil Society Scaling-up Nutrition in Nigeria (CS-SUNN).(2015). *Malnutrition status of womenand children in Nigeria and three focal states (Kaduna, Nasarawa and Niger) January* pp15-27.

Cogswell, M.E., Looke,r A.C., Pfeiffer, C.M., Cook, J.D., Lacher, D.A., Beard, J.L., Lunche, S.R., and Grummer-Strawn, L.M. (2009.) .Assessment of iron deficiency in U.S. preschool children and non pregnant females of childbearing age: National Health and Nutrition Survey2003-2006. *American Journal of Clinical Nutrition*, 89: 1334-1342.

Cook, J.D.(2003). Diagnosis and management of iron-deficiency anaemia.*Ballieres BestPractice and Research*. *Clinical Haematology* 18: 319-32.

Cook, J.D., Flowers C.H. and Skikne, B.S. (2003). The quantitative assessment of body iron.*Blood*, 101:3359-3364.

Cossack, Z.T.(1991). Decline in somatomedin-C (insulin-like growth factor-1) with experimentally induced zinc deficiency in human subjects. *Clinical Nutrition (Edinburgh)*; 10: 284-9.

Cousins, R.J. (2006). Zinc.In: Brownman, B.A., Russel, R.M. (eds). *Present Knowledge inNutrition*, 9th ed. Washington,DC: International Life Science Institute, pp 445-457.

Dardenne, M. *Zinc and Immune Function.*CVNRS UMR 8603, Hopital Necker, France horizon.Documentation.Irfd.fr/exl-doc/pleins…6/b…/010004592.pdf.

de Silva, A., Atukorala, S., Weerasingle, I., and Ahluwaha, N. (2003). Iron Supplementation improves iron status and reduces morbidity in children with or without upper respiratory tract infections: A randomized controlled study in Colombo, Sri Lanka. *American Journal of Clinical Nutrition*; 77: 234-41.

Dehghan, M., Danesh, N.A. and Merchant, A.T. (2005).Childhood obesity, prevalence and prevention.*Journal of Nutrition*; 4:4-24.

Diagnostic Chemicals Limited*: Serum iron – SL Assay* 2005.

Dijkhuizen, M.A., Wieringa, F.T., West, C.E., Matuti, S., (2001). Effects of iron and zinc supplementation in Indonesian infants on micronutrient status and growth.*Journal of Nutrition*; 131: 2860-65.

Domellof M., Lonnerdal B., Dewey K.G., Cohen R.J., Rivera L.L., and Hernell O.(2002). Sex differences in iron Status during infancy. *Pediatrics*; 110 (3): 545-552.

Domellof, M.(2001). Iron requirement in infancy. *Annals of Nutrition Metabolism;* 59: 59-63.

Domellof, M.(2010). Benefits and Harms of Iron Supplementation in Iron deficient and iron-sufficient children.*Nestle Nutrition workshop Pediatric Program*; 65: 153-162; Discussion 162-175.

Eastwood, M. (2003).*Principles of Human Nutrition*. 2nd ed. Oxford: Blackwell Science. pp

Ekwochi, U., Odetunde, O.I., and Obi, I.E. (2013).Iron deficiency among non-anemic underfive children in Enugu, South East Nigeria.*Annals of Medical Health Science Resources*; 3 (3):402-406.

e-LENA: (2014). Zinc supplementation in the management of diarrhea. *E-Library of Evidencefor Nutrition Actions* 9eLENA) 9 July,.

Expert Scientific Working Group (ESWG) (1983).Summary of a report on assessment of the iron nutritional status of the United States population.*American Journal of Clinical Nutr*ition; 42:1318- 1330.

Fiorentino, M., Bastard, G., Sembiene, M., Fortin, S., Traissac, P., Landaise, E., Icard-Verniere, G., Wieringa, F.T., and Berger, J. (2013). Anthropometric and micronutrient status of school children in an urban West African setting: A cross- sectional study in Dakar (Senegal). *Plos.org*

Fischer-Walker, C.L. and Black, R.E., (2007). Functional indicators for assessing zinc status. *Food and Nutrition Bulletin*; 28 (suppl):5454-79.

Frazer, D.M., Wilkins, S.G., Becker, E.M., et al., (2002) Heparin expression inversely correlates with the expression of duodenal iron transporters and iron absorption in rats. *Gastroenterology*, 123 (3): 835-844.

Friis, H., Holhlor, P., Mduluza, T., Kaondera, K., Sdandstrom, B., Michaelsen, K.D. et al., (1997). The impact of zinc supplementation on growth and body composition: a randomized controlled trial among rural Zimbabwean school children. *European Journal of Clinical Nutrition* 51: 38-45.

Fulwood, R., Johnson, C.L., and Bryner, J.D.(1982). Hematological and nutritional biochemistry reference data for persons 6 months – 74 years of age in United States. 1976-1980. National Center for Health Statistics, *Vital Health Series*, 11(232):34-45.

Genc, S., Erten, N., Karan, M.A., Besisik, S.K., Saka, B., Tascioglu, C., and Sivas, A. (2004) Soluble transferring receptor and soluble transferring receptor-ferritin index for evaluation of the iron status in elderly patients. *Tohoku Journal of Experimental Medicine*, 202 :135-142

Gibson R.S. (2005). *Nutritional Assessment*, 2nd ed. New York. Oxford University Press pp 36-9.

Gibson, R.S. (1990) .*Principles of Individual Assessment*. New York. Oxford University Press.

Gibson, R.S. (2011).Strategies for preventing multi micronutrient deficiencies: A review of experiences with food-based approaches in developing countries. In: Thompson B., Amoroso L., (eds). *Combating Micronutrient Deficiences , Food- Based Approaches.* Rome,Italy, CAB International and FAO;:7-27.

Gibson, R.S., Bailey, K.B., Gibbs, M., Ferguson, E.L.(2010). A review of phytate, iron zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. *Food and Nutrition Bulletin*; 31 (2 Suppl): S134-46.

Golden, M.H.N. and Golden, B.E.(1981). Effect of Zinc supplementation on the dietary intake, rate of weight gain, and energy cost of tissue deposition in children recovering from severe malnutrition.*American Journal of Clinical Nutrition*, 34: 900-908.

Gordon, C.C., Chumlea, W.C.V., Roche, A.F. (1988). Stature, recumbent length, and weight; In: Lohman JG, Roche AF, Martorell R. (eds), *Anthropometric Standardization Manual*. Champaigne, IL Human Kinetic Books. pp 78-92

Gorstein, J. and Akre, J. (1988).The use of anthropometry to assess nutritional status.*World Health Statistics Quarterly*, 41 (2):48-58

Habicht, J.P., Meyers, L.D. and Brown, C. (1982).Indicators for identifying and counting the improperly nourished.*American Journal Clinical Nutrition*, 35: 1241-1254

Hambidge, K.M. (1992). Zinc and Diarrhoea.*Acta Paediatrics*, 381: 82-6.

Health Management Information System (HMIS (2014), State Ministry of Health, Lafia Nasarawa State.

Healthy Children Org. www.healthychildren.org/english/.../nutrition/.../childhood-nutritiondaspx. 2014.

Hess, S.Y., Pearson, J.M., and Brown, K.H. (2007)Use of serum zinc concentration as an indicator of population zinc status. *Food and Nutrition Bulletin*, 28 (suppl):403-29.

Hoddinot, J., Maluccio, J.A., Behman, J.R., Flores, R. and Martorell, R, (2008).Effect of nutrition intervention during early childhood on economic productivity in Guatemalan adults. *Lancet*, 371: 411-416

Horton, S., Alderman, H. and Rivera, J.A. (2008). Challenge Paper: Hunger and Malnutrition. *Copenhagen Consensus*, May 11.

Hurrell, R., and Egli, I. (2010). Iron bioavailability and dietary reference values. *American Journal of Clinical Nutrition*, 91: 1461S-6S

Institute of Medicine (2001). Food and Nutrition Board.(2001). *Dietary reference intakes: vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc*. Washington DC; National Academic Press, pp 24-31.

IZA International Zinc Association. (2010). Zinc saves Kids. www.zinc.org/health/

IZA International Zinc Association , (2013), In: *Teck's Zinc and Health Program in partnershipwith Zinc Alliance for Child HealthGBCHealth*, pp

King, J.C. (2011) Zinc: An essential but elusive nutrient. American Journal of Clinical *Nutrition*, 94:6793-6845.

Krebs, N.S., Himes, J.H., Jacobson, D., Nicholas, T.A., Okilday, P., (2007).Assessment of child and adolescent overweight and obesity.*Pediatrics*, 120 (4): 5193-5228.

Kumar, P. and Clark, M..L (2012).*Kumar and Clark's Clinical Medicine* (8thed) Edinburg: Elsevier/Saunders, pp 113-45.

Lafia Local Government Authority (LLGA) (2014).*Data on preschool children in Lafia LocalGovernment*, Nasarawa State.

Lander, R.L., Enkhjargal, T., Batjargal, J., Bailey, K.B., Diof, S., Green, T.J., Skeaff, C.M., and Gibson, RS. (2008). Multiple micronutrient deficiencies persist during early childhood in Mongolia. *Asia Pacific Journal of Clinical Nutrition*, 17 (3): 429-440.

Lee, R.D., and Nieman, C.D. (2013).*Nutritional Assessment* (Sixth Edition) McGraw-Hill. International Edition ; pp 166-77

Lee. R.D. and Nieman, D.C. (1996).Laboratory Tests for the Assessment of Nutrition Status.*Nutrition in Peddiatrics*, 2nd ed., B.C. Decker, Hamilton, Ontario, pp 77-89.

Life Sciences Research Office, Federation of American Societies for Experimental Biology (LSROFASEB). (1989). *Nutrition monitoring in the United States; an update reporton nutrition monitoring. Washington DC. U.S. Department of Health and Human Services, Public Health Service*.

Lind, T., Lonnerdal, B., Stenlund, H., Gamayanti, I.L., Ismail, D. and Seswandhadna, R. (2003)community-basred randomized control trial on iron and zinc supplementation in Indonesian infants: effects on growth and development. *American Journal of Clinical Nutrition*; 80:729-736.

Lira, P., Ashworth, A. and Morris, S. (1998). Effect of Zinc supplementation on the morbidity, immune functions and growth of low birth-weight, full-term infants in northeast Brazil.*American Journal of Clinical Nutrition*; 68: 4185-4245.

Lonnerdal, B., and Hernell, O. (2010).Homeostatic regulation of iron and its role in normal and abnormal iron status in Infancy and childhood.*Annales of Nestle.*; 68(3): 96-104.

Lynch, S.R. (2011). Improving assessment of iron status, *American Journal of ClinicalNutrition*, 93:1188-118

Lynch, S.R., and Stoltzfus, R.. (2003). Iron and ascorbic acid: proposed fortification levels and recommended iron compounds. *Journal of Nutrition*; 133:2978S-84S

Mascarenhas, N.R., Zemel, B. and Stallings, V.A. (1998).Nutritional Assessment in Pediatrics.*Nutrition*, 14:105-115.

Mayo-Wilson, E., Imdad, A., Junior, J., Dean, S. and Bhutta, Z.A. (2014). Preventive zinc supplementation for children, and the effect of additional iron: a systematic review and meta-analysis *British Medical Journal Open*, 4 e004647

Mei, Z., and Grummer-Strawn, L.M.(2011). Comparison of changes in growth percentiles of US children on CDC 2000 growth charts with corresponding changes on WHO 2006 growth charts. *Clinical Pediatrics*, 50:402-407.

Miret, S., Simpson, R.J., McKie A.T. (2003). Dietary factors that influence iron bioavailability. *American Journal of Clinical Nutrition*, 77: 1213-9

Moeser, A.J., Kim, I.B., Van Heughten, E., and Kenapen, T.A.T.F. (2001).The nutritional value of degermed, dehulled corn for pigs and its impact on the gastrointestinal tract and nutrient excretion. *Alliance of Crop, Soil, and Environmental societies*, 80 (10): 2629-2638.

Moore, M.W., and Roche, A.F. (1983).Pediatric Anthropometry, 2nd ed. Columbus, OH: Ross Laboratories, pp 54-62.

Mueller, C., Compher, C. and Druyan, M.E., (2011). ASPEN clinical guidelines: nutrition screening, assessment, and intervention in adults. *Journal of Parenteral andEnteral Nutrition*, 35: 16-24.

Mujica – Coopman, M.F., Borja, A., Pizarro, F. and Oliverares, M. (2015).Effect of daily supplementation with iron and zinc on iron status.*BiologicalTrace ElementResearch.* 165 (1): 10-17.

Muller, O., Garenne, M., Reitmaier, P., Baltussen van- Zweeden, A., Kouyate, B. and Becher, H. (2003). Effect of zinc supplementation on growth in West African Children: a randomized double blind placebo-controlled trial in rural Burkina Faso. *International Journal of Epidemiology*. 32: 1098-1102.

Munoz, E.C., Rosado, J.L., Lopez, P., Furr, H.C., Allen, L.H. (2000). Iron and zinc supplementation improves indicaotors of Vitamin A status of Mexican preschoolers. *American Journal of Clinical Nutrition*, 71: 789-94.

Murray-Kolbe, L.E., Beard, J., Iron. In. Coates, P.M., Betz, T.M., Blackman, M.R. (eds). (2010). *Encyclopedia of Dietary Supplements*. 2nd ed. London and New York: Information Health Care; 432-8.

National Health and Nutrition Examination Survey (NHANES II) 2010.

NFNP (2005).National Nutrition Policy, Strategy or Action Plan adopted by National Food and Nutrition Policy

Nguyen, P., Grajeda, R., Melgar, P., Marcin-Kevage, J., Flores, R., Ramakrishnan, U. and Martorell, R. (2012).Effect of zinc on efficacy of iron supplementation in improving iron and zinc status in women, *Journal of Nutrition and Metabolism*; 1-8.http://dx.doi.org/10.1155/2012/216179

Nigeria and Longitued Map, www.mapsofworld.com/lat_long/nigeria-lat-long.html

Nigeria Demographic and Health Survey (NDHS)(2013). Calverton, Maryland: National Population Commission, Abuja- Nigeria and ORC/Macro. Pp269-7

Ogbebo, W. (2014) Nigeria leads 20 countries with malnutrition burden. *Leadership*. 13 April, .pp13

Omotola, B.D. (2012) Level of malnutrition in sahel region of Nigeria.. UNICEF: Nigeria at a Glance.

Onyango, A.W., de Onis, M. and Caroli, M. (2007).Field-testing the WHO child growth standards in four countries. *Journal of Nutrition* 127:149-152.

Onyebuchi, C. (2013). Micronutrient deficiencies: a public health issue. In: *National guidelineson micronutrient deficiencies control in Nigeria*. Pp x

Ozier, A.D., and Henry, B.W.. (2011).Position of the American Dietetic Association: National intervention in the treatment of eating disorders. *Journal of American Dietetics Association*; 8:1236-41.

Pagana, K.D., and Pagana, T.J., (2010). *Mosby's Manual of Diagnostic and Laboratory* Test. 4th ed. St Louis: Mosby Elsevier. Pp78

Panel on micronutrients, subcommittee on upper reference levels of nutrients and of interpretation and uses of dietary reference intakes, standing committee on scientific evaluation of dietary reference intakes.(2001). *Dietary Reference Intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron manganese, molybdenum, nickel,silicon, vanadium, and zinc*. Washington DC: National Academy Press..

Pasricha, S., Hayes, E., Kalumba, K. and Biggs, B. (2013). Effect of daily iron supplementation on health in children aged 4-23 months: a systematic review and meta-analysis of randomized controlled trials. *Lancet*, 1(2) e77-e86.

Pellertier, I.D., Frongillo, A.E. Jr, Shroeder, G.D. and Habicht, P.J. (1995).The effect of malnutrition on child mortality in developing countries.*Bulletin of World Health Organization*, X; 73 (4) 443-8.

Pizarro, F., Oliverares, M., Kani, J. and Hierro, Y., (2005).Inhibitory effects between iron and zinc in combined iron and zinc supplementation. *Review of Chilean Nutrition*, 32:19-27.

Powell, L.W. (2012) Hemochromatosis. In: Lomo, F.D.L., Lauci, A.S., Kasper, D.L., Hauser, S.L., Jaweson, J.L., Loscalzo, J. (eds).(2012). *Hannisons Principles of Internal Medicine*, 18thed. New York. McGraw-Hill: 3162.

Prasad, A.S. (2012). Discovery of human zinc deficiency: 50 years later. *Journal of Trace Element in MedicalBiology,* 26:66-69.

Ramakrishnan, U., Nguyen, P. and Martorell, R. (2009). Effects of micronutrients on growth of children under 5 years of age: meta-analyses of single and multiple nutrient interventions. *American Journal of Clinical Nutrition,* 89:191-203.

Rivera, J.A., Hotz, C., Gonzalez-Cassio, T., Neufeld, L. and Garcia-Guerra, A. (2003). The effect of micronutrient deficiencies on child growth: a review of results from community-based supplementation trials. *Journal of Nutrition*, 133(11 Suppl 2):4010S-4020S.

Rivera, J.A., Ruel, M.T., Santizo, M.C., Lonnerdal, B. and Brown, K.H. (1998). Zinc supplementation improves the growth of stunted rural Guatemalan infants. *Journal of Nutrition*, 128: 556-56.

Rosado, J.L., Lopez, P., Munoz, E., Martinez, H., Allen, L.H. (1997). Zinc supplementation reduced morbidity, but neither zinc nor iron supplementation affected growth or body composition of Mexican preschoolers. *American Journal of Clinical Nutrition*, 65: 13-19.

Roy, C.V.N., and Ennis, C.A.(2000). Iron homeostasis: new tales from the crypt. *Blood*, 96: 4020-7.

Sandstrom, B. (1997). Bioavailability of zinc. European Journal of Clinical Nutrition, 51 (1): S17-19.

Sazawal, S., Black, R.E., Ramson, M., Chwaya, H.M., Stoltzfus, R.T., Bhutta, A. (2006). Effects of Routine prophylactic supplementation with iron and folic acid on admission to hospital and mortality in preschool children in a high malaria transmission setting community based randomized, placebo-controlled trial. *Lancet*, 367 (9505): 133-143.

Scholl, T.O., Hediger, M.L., Fischer, R.L. and Shearer, J.W. (1992). Anaemia vs Iron. *American Journal of Clinical Nutrition*, 55 (5): 985-8.rit

Shah, F.D. and Sachdev, H.P. (2006). Zinc deficiency in pregnancy and foetal outcome. *Nutrition Review,* 64 (1): 15-3

Skikne B.S. (2008). Serum transferring receptor.*American Journal of Hematology,* 83:872-875.

Solomons, N.W., and Ruz, M.(1997). Zinc and iron interaction: concepts and perspectives in the developing world. *Nutrition Resources*, 17: 177-185.

Steve-Edemba, C.L.(2014). Biochemical assessment of Zinc status of under-five children in Orphanages of Federal Capital Territory, Abuja, Nigeria.*Journal of Dental and Medical Sciences*, 7 (4): 60-70.

Stewart-Knox, B.J., Simpson, E.E. and Parr, H. (2005). Zinc status and taste acuity in older Europeans: the ZENETH study. *European Journal of Clinical Nutrition*, 59 Suppl 2: S31-6.

Stewart-Knox, B.J., Simpson, E.E. and Parr, H. (2008). Taste acuity in response tozinc supplementation in older Europeans. British Journal of Nutrition, 99 (1): 129-36

Stoltzfus R.J. and Dreyfuss, M.L, (2011) *Guidelines for the use of iron supplements to preventand treat iron deficiency anemia*. Washington D.C. ILSI Press, pp 11-15.

Stoltzfus, R.J. (2001). Iron deficiency anaemia: reexamining the nature and magnitude of the public health problem. Summary: implication for research and programs. *Journal of Nutrition*, 131: 2S-2, 679S-700S.

Stoltzfus, R.J., Chway, H.M., Montresor, A., Tielsch, J.M., Jape, J.K., Albonico, M. and Savioli, L. (2004). Low dose daily iron supplementation improves iron status and appetite but not anaremia, whereas quarterly anthelmintic treatment improves growth, appetite and anaemia in Zanzibari preschool children. *Journal of Nutrition*, 134: 348-356.

Suzuki, H., Asakawa, A., Li, J.B., Tsai, M., Amitani, H., Ohinata, K.,Komai, M., Inui A. (2011). Zinc as an appetite stimulator - the possible role of zinc in the progression of diseases such as cachexia and sarcopenia. *Recent Patents on Food, Nutrition and Agriculture*, 3 (3):226-231.

Thibault, H., Galan, P. and Selz, F. (2000). The immune response in iron-deficient young children: Effect of iron supplementation on cell-mediated immunity and incidence of infections in 6-36 month old Togolese children. *European Journal of Clinical Nutrition*, 54; 1:29-35.

Thomas, S., (2014).The role of nutrition in health promotion and chronic disease prevention.*Journal of the Academy of Nutrition and Dietetics*, 89: 278-83.

Tulchinsky, T.H. (2010).Micronutrient deficiency conditions: global health issues. *Public HealthReviews,* 32: 243-255

Tulsi, R.B., and Muniraj, C.(2013). Nutritional status of children is a proxy for assessing the entire population health status and one of the indicator major predictors of child survival. *Journal of Nutritional Health andFood Science*, 1 (1): 6-21

Uchendu, F.(2011). Micronutrient malnutrition, a tragedy to childhood growth and education.*Global Journal of Medical Research*, 11(1) 3-15.

Ulajaszek, S. J.(1994*). Anthropometry: The individual and the population*..Cambridge University Press. Pp 167-183

Umunna, O. (2014). Micronutrient deficiency, a huge challenge for Nigerian government on the nation's food security level and the ongoing national fortification programme.*Punch*.Online.

UNDP (2011).*Human Development Report*. New York: UNDP.

UNICEF (2009) *Causes of Malnutrition*. UNICEF Concptual Framework.

UNICEF (United Nation) (2013*).UNICEF Nigeria Situation Reprot*. February 2013.

Untoro, J., Karyodi, E., Wibowo, L., Erhardt, M.W. and Gross, R.(2005). Multiple Micronutrient Supplements improve micronutrient status and anaemia but not growth and morbidity of Indonesian Infants: a randomized, double-blind, placebo-controlled trial. *Journal of Nutrition*, 135: 6395-455.

USAID: (1998). *Fortification Basics: maize flour/meal*. USAID.

Vanderkooy, P.D.S., and Gibson, R.S. (1987). Food composition patterns of Canadian preschool children in relation to zinc and growth status. *American Journal of Clinical Nutrition*, 45: 609-16.

Veena, A., Yadavannavar, M.C., and Shailaja, S.P. (2012) Assessment of Nutritional Status of Under Five Children in Urban Field Practice Area. *International Journal of Current Research and Review,* 4:122-126.

Walker, B.R., Colledge, N.R., Ralston, S.H. and Penman, I. (2013). *Davidson's Principles andPractice of Medicine* 22nded.Elsevier. Health Services..

Walravens, P.A., Krebs, N.F. and Hambidge, K.M. (1983). Linear Growth of Low income preschool children receiving a zinc supplement. *American Journal of Clinical Nutrition,* 195-198.

Wessling – Rosnick, M. (2014).Iron. In. Ross, A.C.V., Caballero, B., Cousins, R.J., Tucker, K.L. and Zugler, R.C., eds. (2014). *Modern Nutrition in Health and Disease*. 11th ed. Baltimure, MD: Lippincott Williams & Wilkins; pp 176-88.

Whitney, E.and Rolfes, SR. (2008*). Understanding Nutrition*, Eleventh Edition. Thompson and Wadsworth.pp 452-453.

WHO (1995). Physical Status: the use and interpretation of anthropometry. Geneva: WHO; (*Technical Report Series* No. 854)

WHO (2008).Worldwide prevalence of anaemia 1993-2005.*WHO Global Data Base on Anaemia*..

WHO (2011).*Intermittent iron supplementation in preschool and school-age children*. World Health Organization, Geneva.

WHO (World Health Organization) (1976).*Methodology of Nutrition Surveillance*. WHO Technical Report Series No. 593. World Health Organization, Geneva.

WHO. (2007) WHO Anthro for personal computers, version 2: Software for accessing growth and development of the world children. Geneva: WHO. http://www.who.int/childgrowth/software/en/

WHO.(1986). Use of interpretation of anthropometric indicators of nutritional status.*Bulletin of the World Health Organization*, 64 (6):929-941.

WHO.(2003). *The treatment of diarrhea: manual for physicians and other senior health workers*. Geneva. Switzerland

WHO/UNICEF (1998).*Guiding principles for complementary feeding of breastfed child*.Pan American Health Organization.

WHO/UNICEF.(2010.). Child growth standards and the identification of severe acute malnutrition in infants and children.*A joint statement by World Health Organization and the United Nations Children Fund.*

WHO/UNICEF/IAEA/IZiNCG.(2007). Conclusions of the joint WHO/UNICEF/IAEA/IZiNCG interagency meeting on zinc status indicators.*Food and Nutrition Bulletin*; 28 (3): S480-S484

Wieringa, F.T., Berger, J., Dikhuizen, M.A., Hidayat, A., Niunh, N.X., Utomo, B., Wasantwisut, E., Winichagon, P. (2007) *Combined iron and zinc supplementation in infants improved iron and zinc status, but interactions reduced efficiency in a multicountry trial in southeast Asia 1-3 for the SEAMTIZI (South-East Asia Multicountry Trial on iron and Zinc Supplementation in infants) study Group.*

Win, A.Z. (2015). Micronutrient deficiencies in early childhood can lower a country’s GDP: The Myanmar example. *Journal of Nutrition*, 6-11. Doi:10. 1016

Wis,e A. (1995). Phytate and zinc bioavailability.*International Journal of Food ScienceandNutrition*, 46:53-63.

Wood R.J., Ronnenberg A.G., Iron, In: Shils M.R., Shike M., Ross A.C., Cobellero B., Cousins R.J..(eds), (2006*). Modern Nutrition in Health and Disease*, 10th ed. Philadelphia: Lippincott. Williams & Wilkins, pp 248-270.

World Health Organization and United Nations Children Fund. (2014). Clinical management of acute diarrhoea. WHO/UNICEF joint statement August. (http://www.unicef.org/nutrition/files/ENAcuteFDiarrhoedareprint.pdf).

Young DS.(2001). *Effects of disease on clinical laboratory tests*. 4th ed. AACC..

Zhou S.J., Gibson R.,S. and Makrides M. (2012). Nutrient intakes and status of preschool children in Adelaide, South Australia.*Medical Journal of Australia*, 196:696-700.

APPENDICES

Appendix 1: Ethical Approval Issued by Nasarawa State Ministry of Health

SECRET

NASARAWA STATE OF NIGERIA
MINISTRY OF HEALTH

In replying, please quote reference and date
All correspondence should be directed to
the commissioner

Ministry of Health Headquarters
Private Mail Bag 032
Lafia, Nasarawa State
E-mail: nsmolafia@yahoo.com

*Telephon:*________________

MOH/OFF/237/T./I
4th November, 2014

MR. ECHODA AMEDU ANFOFUM
Department of Biochemistry,
Ahmadu Bello University,
Zaria.

RE: APPLICATION FOR ETHICAL APROVAL TO CONDUCT STUDY ON "EFFECTS OF IRON AND ZINC SUPPLEMENTATION IN THE NUTRITIONAL STATUS OF CHILDREN UNDER FIVE YEARS IN LAFIA LOCAL GOVERNMENT OF NASARAWA STATE, NIGERIA"

Reference to your letter on the above subject matter, I am directed to convey the Ministry's approval to conduct the study.

2. You must therefore, adhere strictly to the methods in your proposal and to as well request for the permissions from the Head of Schools and Parents of children you will carry the study.

3. At the end of the research, you must submit two copies to the Ministry for use and record purpose, please.

DR. EKOM G. HARUNA
Ag. Director Clinical Services
for: Honourable Commissioner

Appendix II: Questionnaires

Social Data

1. Clinic/Hospital ___________________________
2. I.D. Number _____________________________
3. Malnourished __________Normal ___________
4. Age of child (Months/years) ________________
5. Physical measurement of child:-

	Weight(cm)	Height(cm)	MUAC (cm)
Baseline			
Post-supplementation			

6. Sex of child: Male ☐ Female: ☐
7. How are you related to the child?

Father ☐

Mother ☐

Foster parent ☐

Relative (specify)___________________

8. Ethnic group _____________________________
9. Religion of

		Father	Mother
i.	Christianity		
ii.	Islam		
iii.	Traditional		
iv.	Other(specify)		

10. Level of education

Father Mother

Primary

Secondary

Post secondary

No formal education

11. Residence: Urban [ ] Rural [ ]
12. Occupation of Father
    - Civil servant
    - Farmer
    - Private business
    - Carpenter
    - Blacksmith
    - Others ______________________
    - None

HOUSEHOLD COMPOSITION

13. Your family is: Monogamous [ ] Polygamous [ ]
14. How many people are there in your family including all dependents______
15. How many children are there in the household [ ] and what are their ages

<1 year	[ ]
1 year	[ ]
1 – 2 years	[ ]
3 – 4 years	[ ]
4 – 5 years	[ ]

16. The principal Bread winner of the household is
    Father
    Mother
    Older son
    Older daughter
    Others (specify) __________________

17. If you are a mother, what is your occupation/job

____

18. Name of foods which should not be eaten by:

i. Male children _________________

ii. Female children _______________

iii. Pregnant ladies ________________

Reasons ____

____

____

19. What are the least foods for children ________________________

20. What foods are not good for your children ___________________

21. Are there any foods that make one:

i.	Ill	YES	☐	NO	☐
ii.	Have stunted growth	YES	☐	NO	☐

If yes, name foods that cause

i. Illness _______________________________

ii. Stunted growth ________________________

22. What is the best method of feeding a baby?

i. Breast feeding ☐

ii. Bottle feeding ☐

iii. Combining both ☐

23. Would you prefer to bottle-feed your child with commercially prepared baby foods (eg Cerelac, Nan)?

YES ☐ NO ☐

24. a. what are the advantages of bottle-feeding?

i. ____

ii. ____

iii. ____

iv. ____

b. what are the disadvantages of bottle feeding?

i. ____
ii. ____
iii. ____
iv. ____

25. a. what are the advantages of breast feeding?

i. ____
ii. ____
iii. ____
iv. ____

b. what are the disadvantages of breast-feeding?

i. ____
ii. ____
iii. ____
iv. ____

26. Why would you breast/bottle feed your baby?

____

27. Who advised you to breast or bottle-feed your baby?

The doctor ☐ My mother-in-law ☐ Not applicable ☐

The nurse ☐ A friend ☐ Mother ☐

I saw other women doing so ☐

28. At what age (months) do you start to wean your baby______

29. How do you wean your baby? ______________________________

30. Do you use the same food as adults eat in the household for weaning?

YES ☐ ☐

31. Explain how food is made soft enough for your baby during weaning

____

DIETARY ATTITUDE

32. State some foods which you are forbidden to eat by your

Religion ________________________________

Ethnic group_____________________________

Area___________________________________

33. How often do you give your child (please tick which is applicable)

	Everyday	Once a week	Occasionally	Never
Meat				
Fish				
Egg				
Milk				

34. How much money do you spend on food for the household every month? N____________

35. Who buys the food?(please tick whichever is applicable)

Father ☐

Mother ☐

Servant ☐

Children ☐

Other relatives ☐

36. Do you always have adequate food for your child?

YES ☐ ☐

37. If not why? (please tick the reasons which are applicable)

i. There is not enough money to buy food.
ii. There are too many children in the household to feed.
iii. There is no one around to cook till at night.
iv. Not applicable.

COOKING AND EATING HABIT

How many meals are cooked for the household to eat daily? __________

38. Who decides how much food is to be cooked? ____________________

39. This daily amount of food for the household is

    i. Sufficient ☐
    ii. Manageable ☐
    iii. Insufficient ☐

40. Yesterday, what did you have for the

    i. First meal ___________________________
    ii. Second meal _________________________
    iii. Third meal __________________________
    iv. Fourth meal _________________________

41. What is done with the left over (if any)?

    i. Given to relatives. ☐
    ii. Given to neighbors. ☐
    iii. Given to beggars. ☐
    iv. Saved for eating later. ☐
    v. Given to domestic animals. ☐
    vi. Thrown away as rubbish. ☐
    vii. Others (specify) __________________

42. Do you think that cooking food for a long time makes it more palatable?

    YES ☐ NO ☐

43. When was the last baby born in your household?

    ____

ATTITUDE AND PRACTICES OF INTAKE OF MULTVITAMIN SUPPLEMENTS

44. What time do you start to give multivitamins/supplements to your children?

    i. <12 months ☐
    ii. Last 12 months ☐
    iii. 13 – 36 months ☐
    iv. >36 months ☐

45. What time do you give the multivitamin/supplement?

    i. Breakfast ☐
    ii. Lunch ☐
    iii. Supper ☐

iv. Anytime

46. The multivitamin is usually given

i. With meal
ii. Without meal
iii. With drugs
iv. Anyhow

47. The multivitamins are given to the young children as

i. Capsule
ii. Tablets
iii. Syrup
iv. Others

REASONS FOR THE INTAKE OF MICRONUTRIENT SUPPLEMENTS BY CHILDREN UNDER FIVE YEARS.

48. Why do you give micronutrient supplements to your child?

i. Prevention of diseases
ii. Enhance digestion or absorption of food
iii. Enhance fitness and intelligence
iv. No reason

49. How do you get to know about micronutrient supplements?

i. The doctor
ii. A nurse
iii. My parent
iv. A friend
v. Newspaper/Magazines/Posters/Handbills
vi. Others________________________________

50. What do you know of micronutrient supplements and how they work?

i. Supplement nutrient are contents of food.
ii. Boost blood levels of minerals and vitamins.
iii. Prevent and cure diseases and illnesses.
iv. None of the above.

Appendix III: Consent Form

EFFECTS OF IRON AND ZINC SUPPLEMENTATIONS ON THE NUTRITIONAL STATUS OF CHILDREN UNDER FIVE YEARS IN LAFIA LOCAL GOVERNMENT OF NASARAWA STATE.

Dear Sir/Madam,

I am Mr. Echoda Amedu Anfofum, a student of Biochemistry Department, Ahmadu Bello University, Zaria. I wish to undertake a research on the effects of iron and zinc supplementation on the nutritional status of children under five years in Lafia Local Government of Nasarawa State using the Primary Health Centers and some selected nursery schools.

Negative effects of iron deficiency on cognitive and affective functions in infancy persist even after iron deficiency and anaemia have been corrected. Growth retardation, hypogonadism, mental lethargy, genetic disorders and sickle cell disease are associated with suboptimal zinc status. Zinc interacts with important hormones like osteocalcin, somatomedin-c, testosterone, synthesis and activation of thyroid hormone, insulin, activation of vitamin A etc. Timely intervention with these micronutrients will improve the infant's haematological status, growth and prevent developmental deficits.

Initials of participant …………………………… Serial Number ………….

I have explained the nature and purpose of research to the participant above.

Signature of Researcher ………………….. Date ………………………

Printed name of Researcher ……………………………………………..

Appendix IV: Malnutrition Status of Underfive Children in Lafia Local Government Nasarawa State at the Beginning and End of Supplementation.

	Baseline				Endline			
	Fe	Zn	Fe-Zn	C	Fe	Zn	Fe-Zn	C
Weight- For- Age (Underweight%)								
Z-score < -1SD	30	14.5	24	15	-	-	-	12.5
Z-score < -2SD	10.5	7.5	15	14	-	-	-	13
Z-score < -3SD	5	10	12.5	7.5	-	-	-	2.5
N	28	38	42	53	25	18	50	58
Weight- For- Height (Wasting) (%)								
Z-score < -1SD	12.5	10	15	15	5	2.5	5	20
Z-score < -2SD	20	-	2.5	2.5	5	-	2.5	5
Z-score < -3SD	5	-	-	2.5	-	-	-	-
N	72	88	68	72	82	92.5	85	75
Overweight (%)								
Z-score < -1SD	5	5	10	7.5	5	5	7.5	10
Z-score < -2SD	2.5	-	5	2.5	-	2.5	2.5	5
Z-score < -3SD	-	-	2.5	-	-	-	-	-
N	70	88	68	70	80	90	82	71
MUAC-for-Age	Fe	Zn	Fe-Zn	C	Fe	Zn	Fe-Zn	C
Wasting (%)								
Z-score < -1	17.5	22.5	23	38	-	2.5	2	20
Z-score < -2	47.5	30	25	30	7.5	10	2.5	7.5
Z-score < -3	23	23	47.5%	25	-	-	-	-

Fe ….. Iron Group; Zn ….. Zinc Group; Fe-Zn ……Iron-Zinc Group; C …. Control Group.