# NUTRITIONAL INADEQUACIES AND DETERMINANTS AMONG ADOLESCENT SCHOOL GIRLS IN RURAL TANZANIA

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**ABSTRACT**

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Nutritional inadequacies are significant problems in developing nations such as Tanzania. Nutritionally high-risk groups are children under 5 years of age, adolescent girls, pregnant and lactating women, and the elderly. The high rates of adolescent pregnancies in Tanzania exacerbates the viscous cycle of maternal-child malnutrition and under development for the nation. This study aimed to investigate the prevalence and determinants of nutritional inadequacies such as stunting, underweight, anemia, and low iodine status (UIC <50 µg/L) among adolescent schoolgirls in rural Tanzania, Kilolo district. A cross-sectional survey was conducted in lean season between January and March of 2016 when the secondary schools were in session. This study involved 208 adolescent girls (12-19 years of age) who enrolled in the secondary day school with approval of their caregivers. Nutritional inadequacies were evaluated by anthropometrics, biochemical and dietary assessment approaches. We found high prevalence of stunting (22.8%), underweight (5.8%), anemia (22.8%), low iodine status (16.4%) and inadequate dietary intakes of energy (91.3%) and micronutrients Socio-economic status of adolescent girls' caregivers was the more important determinants of nutritional inadequacies of adolescent girls than characteristics of adolescents. The present study provides the evidences that caregivers are important predictors in determining adolescent girls' nutritional inadequacies in Kilolo district of Tanzania. This study could not discern the differences among adolescents who attend schools from those who dropped out or have never enrolled in secondary schools. In the future, the impacts of the nutritional inadequacies of adolescent girls should be investigated by a longitudinally designed study.

## TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

# KEYS TO ABBREVIATIONS

| | |
|---|---|
| AI | Adequate Intake |
| BMI | Body Mass Index |
| FAO | Food Agriculture Organization |
| IDA | Iron Deficiency Anemia |
| IDDS | Individual Dietary Diversity Score |
| IOM | Institute of Medicine |
| LBW | Low Birth Weight |
| MAR | Mean Nutrient Adequacy Ratio |
| MDG | Millennium Development Goal |
| NAR | Nutrient Adequate Ratio |
| RDI | Recommended Dietary Intake |
| RNI | Reference Nutrient Intake |
| UIC | Urinary Iodine Concentration |
| UNICEF | United Nations Children's Fund |
| WHO | World Health Organization |

# Chapter 1. Background

## 1.1 Nutritional issues in Tanzania

Tanzania, a sub-Saharan Africa country, is a young nation with the total population of 47 million people. Of the total population, 47% are women of reproductive age (15-49 years) (NBS, 2013; UNICEF, 2013). According to the 2010 Tanzanian Demographic and Health Survey (TDHS) results, 20%women of reproductive age had never attended schools, 50% had completed primary education, and only 16% attained secondary school (NBS and ICF Macro, 2011).

At the primary school level, the enrollment rate of girls is about the same as that of boys. Starting at the first year of secondary school, the gender disparities in net enrollment ratio begin to increase between the two sexes. In 2012, one girl for every three boys enrolled in the first year (Form I) of the secondary school (URT, 2014). Among the reasons for this difference was the failure to be promoted to the next level due to truancy and school dropout due to pregnancies (UNICEF, 2010; URT, 2014). Adolescent pregnancies are reported to start as early as the third year (Standard III) of primary school (URT, 2014).

Tanzania is among the nations with the highest rate of adolescent pregnancies (UNICEF, 2010). Aaccording to the 2010 national report, 52% of women participated in a national health survey reported to have given births to children by the age of 19 years (NBS and ICF Macro, 2011). In addition, 28% of women between the ages of 20-24 years have also reported to give birth before 18 years of age (UNFPA, 2013). One of the major reasons for the high prevalence of adolescent pregnancies is the minimum legal age of marriage of 15 years for girls (UNICEF, 2010).

Adolescent pregnancies contribute to poor health indicators of maternal and infant mortality (Delisle, 2005) and childbirth -related complications. In fact, Tanzania reports high rate of pregnancy and/or delivery-related complications (UNICEF, 2010) which have increased maternal mortality ratio (450/100,000 live births) and under-five mortality (68/1,000 live births) (UNICEF, 2013).

Mothers who bear children at an early age are more likely to have more children than those who delay marriage and childbearing. On average, women in Tanzania bear more than five children during their lifetime (NBS, 2011). These scenarios of childbearing at an early age contribute to high fertility rate in Tanzania, pose significant public health problems for both young mothers and their offspring, and thus perpetuate the viscous cycle of maternal and child malnutrition.

## 1.2 Adolescent girls in developing countries

Adolescence is the transitional stage of development between 10-19 years of age (Delisle, 2005). Adolescents experience intensive biological, emotional, social, and cognitive changes to reach adult maturity (Delisle, 2005). These changes increase demand for nutrients needed for growth and failure to meet the nutrient requirements leads to adverse short- and long-term nutritional and health problems (Delisle, 2005).

The consequences of nutritional problems facing adolescent girls include delayed cognitive development and function (Delisle, 2005), poor work capacity (NBS, 2011), decreased performance in school (UNICEF, 2010; Ecker et al., 2011), increase in the risk of maternal and child mortality (UNICEF, 2010; MoHSW, 2008; Delisle, 2005), and other poor birth outcomes such as low birth weight (TFNC, 2014; MoHSW, 2008). These consequences would be much more serious in adolescent girls when further compounded with pregnancies (Ecker et al., 2011).

Women of reproductive age in Tanzania are affected by some nutritional problems. About 53% of pregnant women and 40% of nonpregnant women were affected by anemia, respectively, similarly 42% of adolescent girls have iron deficiency anemia (hemoglobin (Hb)

<12 g/dl). Among reproductive aged women, 11% experience chronic energy deficiency (body mass index (BMI) <18.5 kg/$m^2$) with a higher rate in women aged 15-19 years (10.2%) than in older women aged 45-49 years (7%) (NBS and ICF Macro, 2011).

In developing countries such as Tanzania, optimal nutritional status is achieved primarily by improving individual accessibility to diversified diet at household level and adequate nutrient intake at individual level (Kalinjuma et al., 2013; Minot et al., 2006; Arimond et al., 2004). In addition, advocates for appropriate health care practice (UNICEF, 2013; Ivers et al., 2011), proper, good sanitation and healthy environment for the vulnerable groups are important (UNICEF, 2013; Ecker, 2011; Blössner et al., 2005). However, very little attention is directed towards adolescent girls given their vulnerability to nutritional health problems compared to those in other life stages and industrialized countries (Delisle, 2005).

## 1.3 Problem statement

Tanzania has high rates of adolescent pregnancies due to the cultural aspects and legal age of marriage of 15 years that allows girls to become pregnant at early age. Adolescent pregnancies carry additional stress of nutritional requirements for both growing mother and fetus. At the same time, girls are involved in agricultural activities that make them prone to consequences of nutritional inadequacy. Notably, pregnancy complications and poor birth outcomes have lasting effects on major health indicators such as maternal death, infant mortality, low birth weight and stunting which is one of the most serious public health problems. However, there is insufficient information on the extent and determinants of nutritional inadequacies among adolescent girls in rural Tanzania.

## 1.4 Objectives and specific aims

The purpose of this study was to assess nutritional inadequacies and identify their determinants among adolescent girls in rural Tanzania. Specific aims were to 1) assess nutritional inadequacies using various nutrition status assessment methods (i.e., 24-hour dietary recalls, anthropometric measurements and biochemical testing), 2) identify sociodemographic and household characteristics associated with nutritional inadequacies, and 3) explore determinants of nutritional inadequacies (underweight, stunting, anemia, and low iodine) among adolescent girls in rural Tanzania.

## 1.5 Significance of the study

Optimal nutrition among adolescent girls is very important given their role as students, mothers/caregivers, farmers, and providers. Poor maternal-child health indicators in Tanzania are complicated with high rates of adolescent pregnancies that are particularly high in rural Tanzania. Findings of the present study on determinants of nutritional inadequacies among adolescent girls in rural Tanzania would contribute to the existing scientific body of knowledge that can be the basis for health policies and program planning of appropriate interventions in rural schools of Tanzania. Giving birth to healthy newborns and rearing healthy children are expected to render prosperous national development and public health.

# Chapter 2. Literature Review

## 2.1. Introduction

Malnutrition andundernutrition (Blössner et al., 2005) imply lack of proper nutrition caused by not having enough to eat (UNICEF, 2013). Causes of undernutrition and determinants of micronutrient inadequacy among adolescent girls can be explained using the United Nations International Children's Emergency Fund (UNICEF) conceptual framework of malnutrition (Figure 1).

These causes of undernutrition are categorized into three groups; basic (e.g., household food security), underlying (e.g., inadequate access to food, in adequate care, and insufficient health services and unhealthy environment) and immediate causes (e.g., inadequate dietary intake and diseases) (UNICEF, 2013).

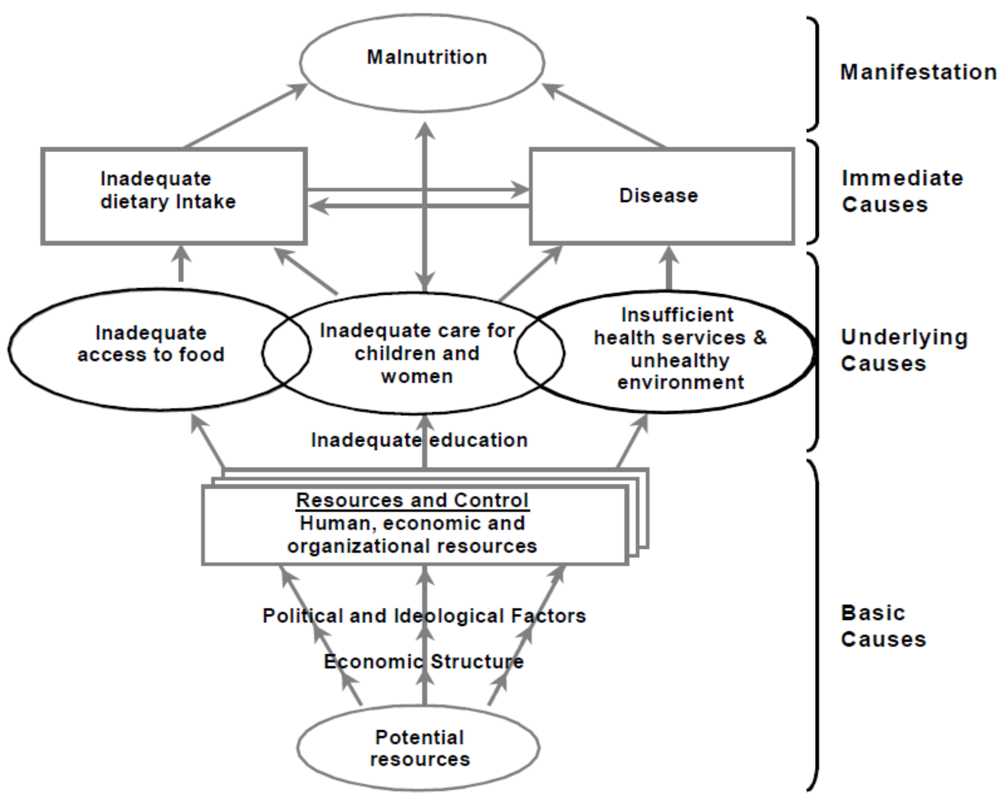


Figure 1. Modified UNICEF conceptual framework of malnutrition

## 2.2. Public health issues associated with nutritional inadequacies in adolescent girls in developing countries

Overall, the interaction between food and nutrient intake, and health status of an individual affects his/her nutritional status (UNICEF, 2013), while socioeconomic status of the household is the major hindrance to accessibility of food in most developing countries (IFPRI, 2014). Recently, studies have reported that members in food insecure families had the least resources (Kisanga et al. 2013; Ntwenya et al., 2015) and lacked access to improved health care services (Hokororo et al., 2015; IFPRI, 2014; UNICEF, 2013). Adolescent girls are one of the vulnerable members within households that can be disproportionately exposed to the effect of having low socioeconomic status of households.

A bilateral relationship exists between food insecurity and human immunodeficiency virus (HIV) (Weiser et al., 2011). Lack of food may cause those with economic dependency to find such ways to seek for foods as involvement in transactional sex, staying in high-risk or abusive sexual relationships (FAO, 2008). Women are more vulnerable because of reliance on men to provide food for themselves and their children (Miller et al., 2011). On the other hand, food availability improves nutrition and health of people living with HIV (Piwoz and Preble, 2000). Food insecurity has also made some adolescents run away from their homes with the intention to find strategy of acquiring food (Whitbeck et al, 2006); hence inadequate dietary intake increases the vulnerability of adolescent girls leading to public health issues in developing countries.

## 2.3. Nutritional inadequacies of women of reproductive age in Tanzania

### 2.3.1 Underweight

BMI is an anthropometric index of body weight and overall nutrition status. BMI is defined as the ratio of body weight in kilograms divided by height in meters squared. Having poor nutritional status is indicated by a low BMI. Pregnant women with low BMI have high risks for obstructed labor, losing life (UNICEF, 2010) and/or giving birth to a baby with low birth weight which constrains his/her later stages of life (UNICEF, 2010; NBS and ICF Macro, 2011).

In Tanzania, 11% of women of reproductive age have BMI below 18.5 kg/m$^2$, indicating underweight. The prevalence of underweight is higher among adolescent girls in the rural areas (NBS and ICF Macro, 2011) than those in urban areas and women aged between 45-49 years (TFNC, 2014).

BMI-for-age percentile is the recommended anthropometric index for assessing and monitoring nutrition status of adolescent girls (WHO and CDC, 2007; Delisle, 2005; Kuczmarski et al., 2002). The World Health Organization (WHO) growth reference charts of BMI-for-age percentiles (WHO and CDC, 2007) deduce the nutrition status of the population by six-month increment in age.

Table 1. BMI-for-age cut-off point for adolescent girls aged 2-20 years

| Percentile | Body Weight |
|---|---|
| ≥ 95$^{th}$ | Overweight |
| ≥ 85$^{th}$ to < 95$^{th}$ | Risk of overweight |
| ≥5$^{th}$ to <85$^{th}$ | Normal weight |
| < 5$^{th}$ | Underweight |

Source: WHO, 2007; Kuczmarski et al., 2002.

### 2.3.2 Stunting

Stunting indicates a long-term effect of poor socioeconomic conditions and inadequate nutrition during childhood and adolescence (Woodruff and Duffield, 2002). Fetal malnutrition, infections, and inadequate dietary intake during the preschool-age have been reported to lead to stunting in adolescence (Delisle, 2005). Women with the height below 145 cm also indicates stunting during adolescence (Bosch et al., 2008).

Stunting can be noticed by short maternal stature, and increases the risk of small-for-gestational-age and preterm births in low- and middle-income countries (Kozuki et al., 2015). Kinabo and Shirima (2005) reported short stature asthe cause of poor birth outcomes among adolescent girls in three regions in Tanzania. Additionally, pregnant women stunted are at a high risk of obstetric complications due to small pelvic size (NBS and ICF Macro, 2011; Delisle, 2005).

In Tanzania, 5.4% of adolescent women aged 15-19 years had heights below 145 cm. Iringa region is one of the five regions in Tanzania with the highest prevalence of stunting in women (6.8%) (NBS and ICF Macro, 2011). Furthermore, Iringa region has the highest prevalence (40%) of stunting in under 5-year-old children (TFNC, 2014). The prevalence of stunting is the highest in children between 25-36 months old (Kalinjuma et al., 2013), hence stunting continues to be one of the most serious nutritional problems in Tanzania.

Height-for-age percentile is the recommended anthropometric index for assessing and monitoring nutrition status (linear growth) of adolescent (WHO and CDC, 2007; Delisle, 2005; Kuczmarski et al., 2002). These WHO growth reference charts of height-for-age percentiles are age- and gender-specific and easy to use (WHO and CDC, 2007).

Table 2. Height-for-age cut-off point for adolescent girls aged 2-20 years

| Percentile | Stature |
|---|---|
| <3rd | Short |
| ≥5th to <95th | Normal |
| ≥95th | Tall |

Source: WHO, 2007; Kuczmarski et al., 2002.

### 2.3.3 Iron deficiency anemia

Iron deficiency anemia (IDA) is caused by nutrient deficiency (WHO and CDC, 2007) and indicates disease status that may be associated with hemolysis, suppressed erythropoiesis, exposure to toxins and hemoglobinopathy (Grantham-McGregor and Ani, 2001; UNICEF/UNU/WHO, 2001). Most commonly identified and studied causes of IDA in developing countries are low dietary intake of iron (NBS and ICF Macro, 2011; Eicher-Miller et al., 2009; Darnton-Hill et al., 2005; Tatala et al., 1998), infectious diseases such as malaria and parasite infestations (Steketee, 2003; NBS and ICF Macro, 2011; Shaw and Friedman, 2011).

The prevalence and consequences of IDA are more common in adolescent girls than in boys (Ivers and Kimberly, 2011; Halterman et al., 2001) because of monthly blood losses through menstruation (Delisle, 2005). Most adolescent girls suffer from deficiencies of multiple micronutrients including vitamin A deficiency (WHO and CDC 2007; Haider and Bhatia, 2006; Delisle, 2005) resulted from poor diet in quantity and quality (Delisle, 2005; UNICEF/UNU/WHO, 2001).

Most significant consequences of IDA are impairment of cognitive function (Halterman et al., 2001), leading to poor performance in school (Sungthong et al., 2002) and fatigue that prevents girls from being physically active and productive (Delisle, 2005; UNICEF/UNU/WHO, 2001). Therefore, IDA can hinder girls to attain their full potential in life (Lozoff et al., 2000) or to loss of life (WHO and CDC, 2007). IDA is still the major public health problems (NBS and ICF Macro, 2011; Zimmermann, 2008; Delisle, 2005) both in industrialized and developing countries.

In Tanzania, 40% of women of reproductive age suffered from IDA in 2010 and the incidence increases with age among adolescent girls (NBS and ICF Macro, 2011). Moreover, 42% of adolescents aged 15-19 were anemic (NBS and ICF Macro, 2011) mostly because they do not meet the increased iron requirements for rapid pubertal growth. This pubertal growth comes with a sharp increase in lean body mass, blood volume and red blood cell mass (Zimmermann, 2008; WHO, 2004; UNICEF/UNU/WHO, 2001) which in turn heightens iron needs for myoglobin in muscles and hemoglobin in blood (WHO and CDC, 2007).

Table 3. Hemoglobin levels to diagnose anemia (g/dL)

| | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Nonpregnant women (≥15 years of age) | ≥12 | 11-11.9 | 8-10.9 | <8 |
| Pregnant women | ≥11 | 10-10.9 | 7-9.9 | <7 |

Source: http://www.who.int/vmnis/indicators/haemoglobin

### 2.3.4 Iodine deficiency

Iodine is an essential component of thyroid hormones and must be obtained from the diet (Rohner et al., 2014). Iodine content varies dependent on geographical demographics (Assey et al., 2006) and across a region. This variation is due to differences in geological formation, for example, impact of glaciations, flooding, soil erosion, and human activities especially densely populated area (Zimmermann, 2008). A study conducted in Somalia confirmed that iodine intake was very high among those who used drinking water from boreholes in a particular location (Kassim et al., 2014). Iodine deficiency and its health consequences exist in many parts of the world where iodide salt is not available.

Inadequate dietary iodine intake leads to iodine deficiency which may impact on thyroid hormone production. Thyroid hormone plays very important roles in the regulation of key aspects of numerous physiological processes, including growth, neurologic development, and reproductive function (Rohner et al., 2014). Severe cases of iodine deficiencies lead to hypothyroidism, goiter and cretinism (WHO et al., 2007).

During adolescence and pregnancy, iodine requirements increase because of high growth velocity (WHO and CDC, 2007; Haider and Bhatia, 2006). Adolescent girls who get married at early age and bear children (UNFPA, 2012; UNICEF, 2011; Haider and Bhatia, 2006) have high burden of meeting increased iodine requirements to support their own growth as well as for the needs of the fetus. Iodine deficiency during pregnancy are associated with increased incidence of miscarriages, stillbirths, birth defects and mental retardation (Zimmermann 2008, Rohner et al. 2014). Mild to moderate iodine deficiency has also been related to increased risks for secondary neurologic impairments such as decreased work capacity, reduced physical endurance, and poor cognitive ability (WHO 2004, WHO and CDC, 2007). Children with moderate iodine deficiency have been reported to have 10-13 IQ points less than the well-nourished counterparts (Hynes et al., 2013; Zimmermann, 2008).

The recommended dietary intake (RDI) of iodine for nonpregnant adolescents and pregnant women is 150 µg/day and 250 µg/day, respectively (Delisle, 2005). However, in developing countries, few adolescents meet the RDI through diet due to poor eating habits and use of non-iodized salt in addition to consumption of goitrogenic compounds (Zimmermann, 2008; Mannar and Zimmermann, 2013; Rohner et al,. 2014).

Mandatory universal salt iodization (USI) is the widely implemented intervention to reduce iodine deficiency in many countries (Pearce et al., 2013; Assey, 2009). Since there is variation in iodine content in foods, the adequate amount of iodine added to salt should be above 15 ppm (15 µg/g) to provide 150 µg of recommended daily allowance of iodine (WHO and CDC, 2007). The WHO recommends that a country could be iodine adequate when 90% of the households consume adequate amount of iodized salt (WHO el al., 2007). However, in Tanzania only 59% of the households consumed iodized salt and 82% of households used iodized salt (NBS and ICF Macro, 2011). This is partially explained by the proliferation of small-scale salt producers who do not iodize their salt at the recommended levels before putting the salt on markets and poor quality at production level (Assey et al., 2009).

Median urinary iodine concentration (UIC) is the widely used biomarker to determine iodine intake at the community level. Since more than 90% of dietary iodine is excreted in urine in well-nourished individuals, adequate iodine intake leads to the high level of UIC (WHO, 2013). In Tanzania, only 22% women of reproductive age have optimal UIC (TFNC, 2014), therefore, iodine deficiency is still one of the most serious public health problems which need to be addressed especially in adolescent girls who are attending school.

Table 4. Epidemiological criteria for assessing iodine nutrition based on median UIC of school-age children (≥6 years of age, non-pregnant and non-lactating)

| **Median urinary iodine (µg/L)** | **Iodine intake** | **Iodine status** |
|---|---|---|
| **<20** | Insufficient | Severe iodine deficiency |
| **20-49** | Insufficient | Moderate iodine deficiency |
| **50-99** | Insufficient | Mild iodine deficiency |
| **100-199** | Adequate | Adequate iodine nutrition |
| **200-299** | Above | Good for pregnant/lactating mothers |
| **≥300** | Excessive | Risk of adverse health consequences |

Source: Adapted from Assessment of Iodine Deficiency Disorders and monitoring their Elimination (WHO, 2013)

## 2.4 Determinants of nutrition status among adolescent girls

### 2.4.1 Household food security

Food security is achieved when all people at all times have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for a healthy, active and productive life (FAO, 2008; Ivers and Cullen, 2011). Household food security affects adolescents' accessibility to safe, nutritious and adequate food due to supply deficit (Delisle, 2005). Most of adolescents at this age are dependent to their families, thus inadequate household food access leads to dietary inadequacy which is the underlying cause of malnutrition among adolescent girls.

Globally, more than 805 million people are chronically undernourished with the highest prevalence recorded in sub-Saharan Africa (FAO et al., 2014). Tanzania, one of the nations in this region, had 17 million people reported as undernourished in 2012-2014 with some fluctuation. This has resulted in Tanzania failing to reach both the World Food Summit target and Millennium Development Goal of halving the proportion of undernourished people by 2015 (FAO et al., 2014).

Household food insecurity status in the country differs from region to region (Kisanga et al., 2013), and one season to another (Ntwenya et al., 2015). The worst scenarios of prevalent household food insecurity are documented to be during the rainy season (Ntwenya et al., 2015). Majority Tanzanians consume three or less daily meals with little snacking, regardless of the locality (urban or rural) (Mazengo et al., 1997). However, this may be different during rainy seasons because accessibility to food before harvesting is very low and agriculturalists experience increased workload, due to various farm operations, which can affect the balance of energy intake and expenditure. The association between food intake and nutrition status at the household level has been confirmed in recent studies. Household food security was inversely associated with undernutrition in Tanzanian adolescents (Cordeiro et al., 2012), this association was also found elsewhere in infants and young children (Saha et al., 2009).

Food insecurity mostly affects households of low income status (Ntwenya et al., 2015). Those in the rural setting (Kisanga et al., 2013) of which about 73% of the Tanzanian population reside in the rural communities (NBS, 2013) and members in these communities access food from own production (MAFAP, 2013; Kisanga et al., 2013), which is mostly through cultivation. A good example is the Iringa region whose 70% of households cultivate their own food (Kalinjuma et al., 2013).

Relying on cultivation for household food affects their consumption patterns (Ntwenya et al., 2015). More than 29% of households in Tanzania are classified as highly food energy deficient (Kisanga et al., 2013) and there is high consumption of monotonousdiet as opposed to diversified diet.

#### 2.4.1.1 Individual dietary diversity

Dietary diversity is defined as any one of the following: the number of unique foods consumed over a given period of time (Hoddinott and Yohannes, 2002), a simple count of foods or the number of food groups consumed over the past 24 hours (Nguyen et al., 2013). It is one of the food security indicators that show either adequate dietary intakes or micronutrients (Mirmiran et al., 2004; Hoddinott and Yohannes, 2002). Previous studies showed the significant association between dietary diversity and dietary energy density, nutrition status, and a probability of nutritional adequacy among various populations such as university female students (Azadbakht and Esmaillzadeh, 2012), children (Arimond and Ruel, 2004; Nguyen et al., 2013), and lactating women (Henjum et al.,2015). Unfortunately, majority of households in Tanzania lack a diversified diet because of over reliance on home-cultivated foods. Most nutrients are obtained from one or two food groups, where the main source of calories is cereals and root tubers in households (Kisanga et al., 2013).

#### 2.4.1.2 Eating habits among adolescent girls

Inadequate care and inappropriate education towards eating habits provided by caregivers are one of the underlying causes of inadequate dietary intake among adolescent girls (UNICEF, 2010; Delisle, 2005). These poor eating habits make adolescent girls fail to meet nutritional requirements, which in turn affect their nutrient adequacy and their ability to be free from common nutritional problems such as underweight, IDA, iodine deficiency and their related consequences. Still and colleagues (2014) reported female students are more likely to be anemic compared to male counterparts and the reason was females consumed junk foods more than males.

In Tanzanian, 37% of adolescent women prefer to consume tea and/or coffee with meals (NBS and ICF Macro, 2011). Consuming these beverages with meals affects dietary intakes and nutrient adequacy due to compounds present in beverages such as caffeine and tannins that inhibit absorption of iron and other micronutrients in the gut and cause a poor eating habits.

The social environment such as school influences adolescents' food intake due to the relaxed atmosphere that peers create during mealtime, which affects individual preference to particular foods (Drewnowski and Hann, 1999). A study found out that adolescents prefer eating fatty and sweetened foods and drinks over fruits, vegetables, lean meat, and fish during their mealtime (Álvarez, 2015).

### 2.4.2 Poor public health and unhealthy environment

Poor public health infrastructure and an unhealthy environment are the third underlying factor of underweight. . During rainy season, the health environment alters according to rainfall, the rate of infection and infestation increases due to the ideal breeding environment for the vectors and parasites. Malaria infections increase due to exposure of the agriculturalist to these breeding sites during farm work.

#### 2.4.2.1 Malaria and malnutrition among adolescent girls

Having malaria parasites reduces red blood cell count because it involves increased removal of circulating red blood cells as well as their decrease in production at the site hence the reactions leading to anemia (MoHSW, 2008). Malaria infections cause nausea, vomiting, fever, and loss of appetite. In Tanzania, the estimated prevalence of maternal anemia due to malaria infections is about 15% (MoHSW, 2008).

The use of insecticide-treated mosquito net is the most applied intervention to prevent malaria and its related consequences of maternal and under-five mortality (UNICEF, 2010). The insecticide-treated mosquito nets are provided to pregnant mothers during antenatal visits (NBS and ICF Macro, 2011) and progressively, the practice of sleeping under insecticide-treated mosquito net has improved among majority of households. Additionally, 64% of children under 5 years slept under these insecticide-treated mosquito nets the night before the interview, although, the usage decreases with increase in age (NBS and ICF Macro, 2011) which may be possible that some non-pregnant adolescents aged 10-15 years are not captured by the interventions.

Another preventive measure for malaria is the provision of two doses of sulfadoxine-pyrimethamine for intermittent preventive treatment during routine antenatal care visits (UNICEF, 2010; MoHSW, 2008). However, some pregnant mothers visiting antenatal clinics do not receive intermittent preventive treatment due to supply deficit (Shirima and Kinabo, 2004). In addition, the strategy of providing intermittent preventive treatment during antenatal care visits maybe a barrier to the intervention of preventing malaria, especially pregnant adolescent due to barriers associated with seeking reproductive health (Hokororo, 2015). Moreover, few pregnant mothers turn up for these visits and it was ascertained in 2010 DHS that only 43% of women received the recommended 4+ antenatal care visits, and only 15% received their first antenatal care visit during the first trimester of pregnancy (NBS and ICF Macro, 2011).

#### 2.4.2.2 Parasitic infestation due to inadequate care towards adolescent girls

Poor disposal of waste creates unhealthy environment for adolescents particularly for those in early adolescence stage. This poor practice creates a conducive environment for worms and other helminthes. Intestinal worm infestation is a global health problem (Henjum et al., 2015) with soil-transmitted helminthes being the most common cause of intestinal worm infections (Kumar et al., 2014). Intestinal infestation with helminthes is among the causes of anemia in children and adolescents (Steketee, 2003; Nelima, 2015) because the presence of worm infestation in the gut decreases bioavailability of nutrients for example iron from the host tissues (Shaw and Friedman, 2011) and physically damage the gut leading to inflammation that in turn result to iron loss and anemia.

In Tanzania, worm infestations are one of the leading causes of anemia (NBS and ICF Macro, 2011). Prevention of intestinal infection is done during antenatal and post-natal clinic visits, by providing deworming drugs and nutritional advice to improve dietary intake of iron through a balanced and adequate diet (NBS and ICF Macro, 2011; MoHSW, 2008).

About 70% of children under five years of age have received deworming drugs (TFNC, 2014). However, there is still a missing piece about deworming information of adolescent girls, especially nonpregnant ones despite their risk to worm infestations (Briscoe and Aboud, 2012). Adolescent girls would remain vulnerable to severity of IDA when parents neglect the practice of deworming. This is because young women are frequently affected by one or more existing micronutrient deficiencies in developing countries (Shaw and Friedman, 2011).

## 2.5 School system in Tanzania

In Tanzania, the average age to enroll into primary education level is seven years old. Majority of adolescent girls (10-19 years of age) are enrolled in schools, and they are expected to go to secondary school at an average age of 13 years. The net enrollment ratio for primary schools has been increasing since the national universal education policy was included in Millennium Developmental Goals in 1999 (URT, 2014). About 95% of children in Tanzania attend government schools while the remaining attends non-governmental or private schools (URT, 2014).

Students are selected on merit bases in schools. They go to schools around their residence for easy accessibility of education services (Mrosso, 2016). Although not all wards have respective government schools, some wards have more than one schools while other wards have nogovernment schools. This means that some students are enrolled in schools away from their residential ward and walk long distance every day to school. The academic year starts at the beginning of the calendar year and end in December with three school breaks in each year. This indicates that adolescents would be easily accessible from schools to capture information during lean period of January through March (Mrosso, 2016).

The majority of government schools in the region are day schools, in which students attend schools between 8:00 am and 6:00 pm. Day school students obtain only snacks from school canteens and the main meals of the day are consumed from households because most day schools do not provide meals to students. Therefore, day schools are one of the most effective channels of promoting good nutrition (McNaughton, 2011).

# Chapter 3. Methods

## 3.1 Kilolo district

Kilolo district among the six district of the Iringa region is located in the northeastern direction of the region. The district has total population of 218,130 (105,856 males and 112,274 females) with an average household size of 4.3 (NBS, 2013). Administratively the district is divided into 22 wards (NBS, 2013). The main economic activity of Kilolo district is agriculture for cultivation of maize, sunflower and tomatoes. The district had the least per capita GDP in 2008 and the least service activities with poor roads, hospitals and schools (NBS, 2011). This was the reason of choosing rural schools from Kilolo district as our sample frame.

## 3.2 Pilot survey

Apilot survey was carried out before the onset of the main study in order to assess the tools and instruments for the study. This pilot survey was carried out at Mjimkuu primary school (Morogoro region) among adolescent girls, while waiting for a permission to carry out our study in Iringa region. The pilot study helped the researcher gaining confidence in collecting the data from adolescent girls. Five adolescent girls recruited for the pilot survey from Morogoro region had similar characteristics as adolescent girls in Kilolo district (day scholars and same age as those who were to be recruited from Iringa). This pilot study was necessary for the researcher to practice research instruments (Pronto Massimo-7 with Rainbow) and test the questionnaires.

## 3.3 Study design and recruitment of study subjects

This cross-sectional study was conducted between January-March, 2016 with a multistage, random sampling design that followed proportionate to sample size techniques at district, school and class levels.

Four out of 24 schools were selected because each school had a capacity of providing more than 50 adolescent girls. These four schools were selected from four clusters of eight schools categorized according to the campus direction from the Kilolo district office (i.e., East, West, North and South of Kilolo district council head office). Randomizing allowed all schools to get a chance of participating in their respective clusters, while proportionate to sample size made it easy to have a systematic approach to getthe sample size at all levels (Kothari, 2004). First step was to obtain total number of participants from a respective class in a respective school using proportionate to sample size technique. Then a briefing session was carried out to provide a description about the study to the students in the entire school, and then randomly selected participants. The selected students were asked if they were willing to participate and further checked if they met inclusion criteria to be fully recruited in the study.

## 3.4 Inclusion criteria

This study involved adolescent girls between 12-19 years of age enrolled in form I-IV of the secondary ordinary level (middle school) and only students who reported not to have felt any symptom of illness and/or not on medication, mentally well, willing to participate and had parent/guardian approval (with a signed consent form) were recruited. In addition, only day scholars and one participant per household were included in the study.

The study purposively selected government schools, which are typical school settings in a rural area such as Kilolo district and normally adolescent girls are enrolled.

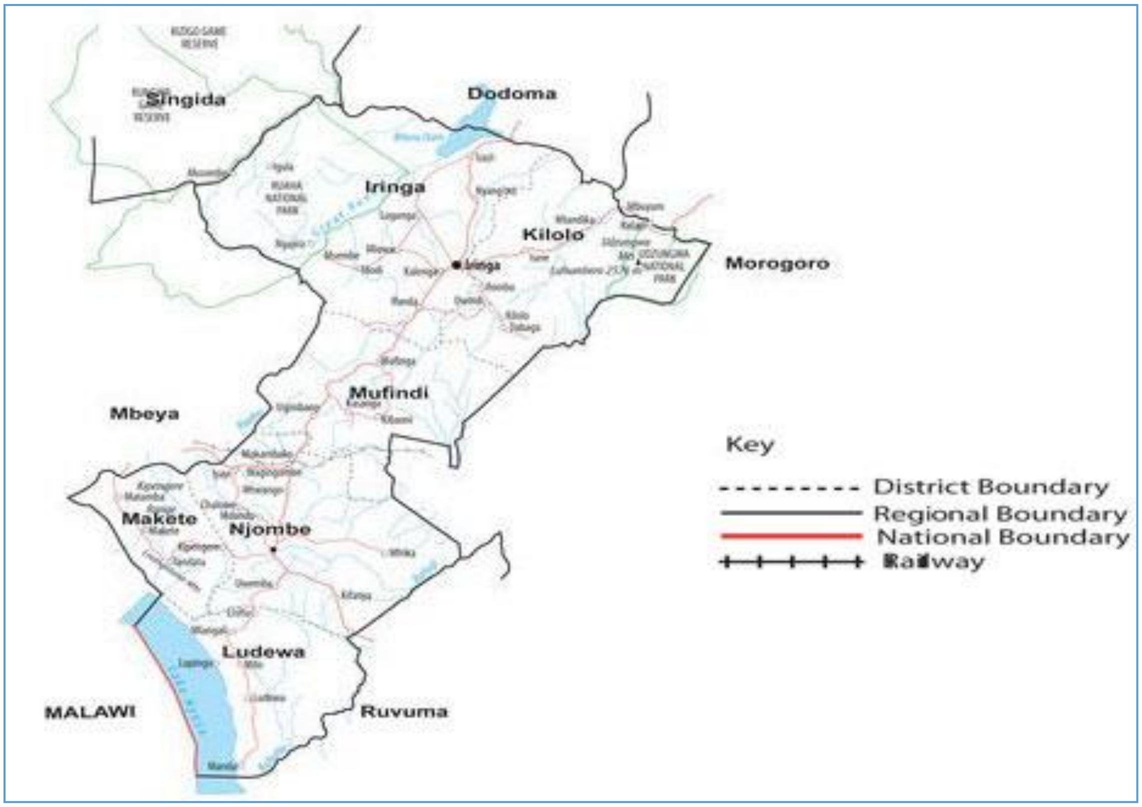


Figure 2. Map of Iringa in Kilolo district

### 3.4.1 Research team

Two female research assistants (nutritionist undergraduate students from Sokoine University of Agriculture) were recruited and a nurse from a health service of Iringa to help in data collection. The main researcher (Saidah Bakar) liaised with the team, participants, supervised all activities, and got involved in data collection. Research team members were fluent in Kiswahili and Hehe (local dialect) language so this made communication easy, made interviewees to be comfortable, and helped to get the intended responses (Kothari, 2004).

Two days training of research team was conducted before data collection. Interviewers gained knowledge and skills on a 24-hour dietary recall methods and how to probe for responses in a non-offensive manner, estimate portion size using locally available household measurements, and weigh food samples using 1kg kitchen digital scale. They also gained skills on handling biological samples such as urine and blood. Moreover, they had hands on both invasive (HemoCue and MBI Kits) and non-invasive (Massimo Pronto-7 with Rainbow) machines to test hemoglobin concentrations and the salt iodine content and accurately measured weights and heights during the practice.

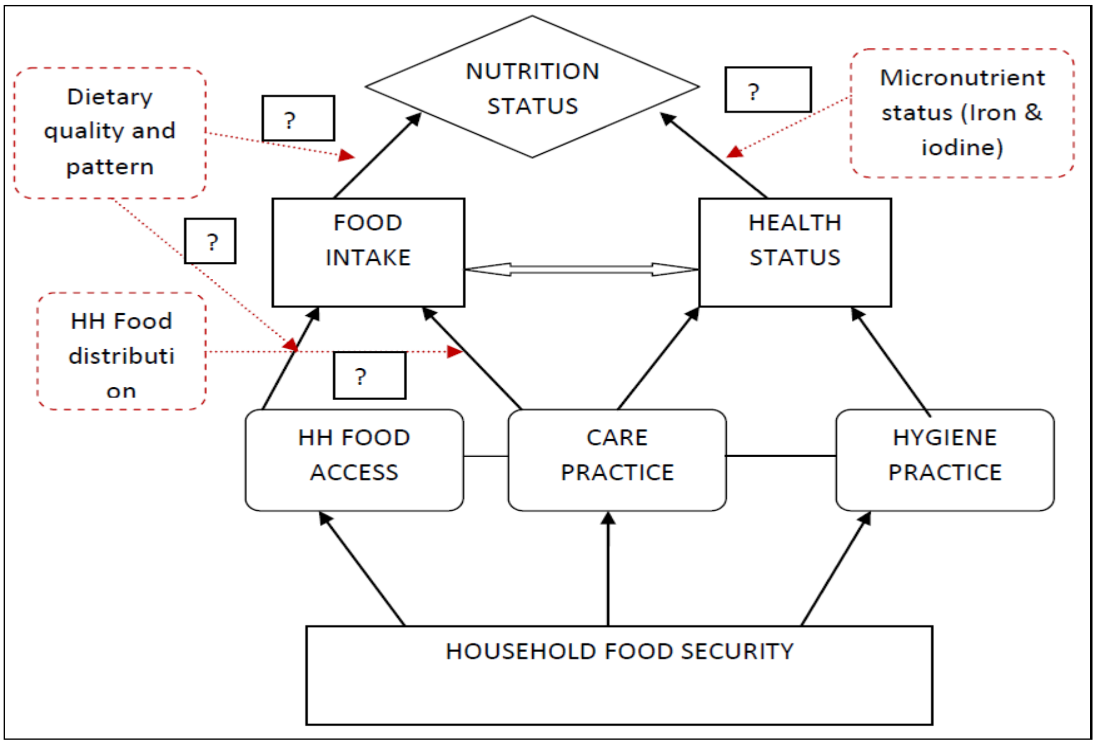


Figure 3. Modified research design on determinants of nutritional status

## 3.5. Sample size calculation and sampling procedure

### 3.5.1 Sample size calculation

Kilolo district council has 24 ward secondary day schools, a ward is the second lowest administrative level before a village level (Mrosso, 2016). These 24 day schools had 4,783 female students enrolled in first-forth year (Form I-IV) of secondary school.

Using the formula,

$$n = \frac{z^2 \times p \times q \times N}{e^2 \times (N-1) + z^2 \times p \times q} = \frac{(1.96)^2 \times 0.5 \times (1-0.5) \times 4783}{(0.05)^2 \times (4783-1) + (1.96)^2 \times 0.5 \times (1-0.5)}$$

Where, p = sample proportion, which we set at 0.5 and q = 1 - p;

z = the value of the standard variant at a given confidence level with the 95% the z value is 1.96;

n = size of sample and N is the total number of students in all schools in Kilolo district.

We desired to work with 200 students because of the time and budget constrain. In addition, collecting data from 200 subjects was enough to get a generalizable relationship (Kothari, 2004) and to infer the outcomes to the entire Kilolo adolescent girls.

From Fishers formula, required sample size is estimated to be less than 10,000,

$$nf = \frac{n}{1} + \frac{n}{N} = \frac{200}{1} + \frac{200}{4783}$$

Where, nf = obtained sample size

n = desired sample size

N = total population

Therefore, sample size was 200 was set at confidence interval of 95% and p value 0.05 (Israel, 1992).

### 3.5.2 Sampling procedure

This was multistage sampling at three stages: first sampling at district level to get four schools, second sampling at the school level to get actual number of participants per each school, and lastly at classroom level.

#### 3.5.2.1 District level

The Kilolo District Education Office provided secondary information on number of government day schools in the district, geographical location, population of female students in each of the 24 schools and contact information of heads of each school. Categorization of schools into four geographical location clusters from Kilolo district with help from an education officer. Four out of the 24 day schools were randomly selected to representthe entire Kilolo district. Overall, of the four schools surveyed, three were located in the typical rural settings and one in the semi urban geographical areas, thus 65% and 35% of subjects were found in typical rural and semi-urban residence, respectively.

#### 3.5.2.2 School level

Prior to the survey, the main researcher made a courtesy call to the office of head of school. The head of school provided personnel to work with during the visit, generally either a biology teacher or a matron. The assigned personnel acquired class registers from class teacher and these registers helped in systematically obtaining a number of adolescent girls randomly selected in each classroom. The whole study set up was discussed with the personnel who was assigned before the day of data collection.

A brief session was conducted either in the classroom or at a school assembly, usually a day before the survey. Three topics were discussed: 1) consequences of nutritional inadequacy (i.e., iodine deficiency and IDA), 2) the advantage of knowing one's nutritional status (i.e., BMI and iron and iodine status), and 3) description about the study with emphases on confidentiality and benefit of the study.

#### 3.5.2.3 Classroom level

After the briefing sessions, random selection of the student from respective classes was made. Upon accepting to participate, a respondent was given a parents/guardians consent form. The recruited students were given containers for salt sample from home and instructions on how to keep the salt sample safe. Both the signed consent form and salt samples were collected from participating subjects on the data collection day, then coded with correspondent code.

## 3.6 Ethical clearance

The study was conducted under the permission from Michigan State University Institute Review Board certificate number: 15-666 and Tanzania, the National Institute for Medical Research: NIMR/HQ/R.8a/Vol.IX/2027. Correspondingly, the postgraduate research committee (Faculty of Agriculture), at Sokoine University of Agriculture, the Iringa regional offices, Kilolo district and Kilolo district medical offices allowed the study to be carried out after reviewing the protocol. Furthermore, participating students gave verbal consent after their parents/guardians signed consent forms to allow their girls to take part in the study (certificates, letters and consent forms in the **APPENDICES**).

### 3.7 Data collection tools and measures

During data collection, a trained team of three interviewers conducted data. Adolescent girls, our primary sampling unit, provided information on their socioeconomic as well as their caregivers' characteristics, general health status, deworming practice and consumption of iodized salt.

The trained team took anthropometric and biochemical measurements and a 24-hour dietary recall. Sequential interviewing procedure following questionnaire sections by each interviewer made sure that all respondent completed the assigned section that day before the respondent headed to the next interviewer.

### 3.8 Different methods for assessing nutrition status of adolescent girls

#### 3.8.1 BMI-for-age

Underweight is defined as BMI-for-age less than 5th percentile of the WHO growth reference for the population. The condition of underweight is due to the short-term situation of inadequate nutrient intake, or malnutrition that results from condition of diseases or chronic food insecure circumstances.

BMI is a well acceptable anthropometric indicator in assessing body weight status of adults and children (Delisle, 2005; NBS and ICF Macro, 2011; NOO, 2011; Patton et al., 2013). However, due to the difficulties of using the same indices in adolescent subjects and disparities in age and geographic location (Woodruff and Duffield, 2002), the use of BMI-for-age has been recommended (NOO, 2011). Due to this recommendation, further uses of gender- and age-specific charts (BMI-for-age charts for girls aged 2 to 20 years) have made the task friendly.

### 3.8.2 Iron status assessment in the population

#### 3.8.2.1 HemoCue machine

Hemoglobin is widely used biomarker for assessing iron status due to the convenience of measuring, ease of interpreting and relatively economical procedure for clinical and field studies. Hemoglobin measurement has such drawbacks as low specificity and sensitivity (Zimmermann, 2008) as the measurement can be affected by attitude of 3000 meters above sea level (WHO, 2001). Hemoglobin is measured in g/dL using blood samples from either vein or capillary (Morris et al., 1999).

HemoCue machine is a reliable machine that uses quantitative method for screening for hemoglobin concentrations in field surveys based on the cyanmethemoglobin method. The machine is either an electric or a battery-operated HemoCue photometer (HemoCue AB, Ängelholm, Sweden). The machine uses pre-treated disposable cuvettes that collect small amount of blood samples (WHO, 2001) and quickly generates results. The HemoCue system is suitable for rapid field surveys as it gives satisfactory accuracy and precision when evaluated against standard laboratory methods (WHO, 2001).

However, HemoCue machine uses semi-invasive collection of capillary blood drawn after a small finger prick of a non-dominant hand with minor discomfort left behind. The procedure of drawing blood samples tends to stress subjects in different ways. In areas of high HIV/AIDS epidemic, the participation and compliance can be reduced.

Compliance in the field can be increased when subjects consent to the research tools used (Kothari, 2004). Using a non-invasive instrument and procedures for testing hemoglobin levels has been recommended for by reducing pain and discomfort, saving time, and increasing recruitment rate (Gayat et al., 2012; Al-Khabori et al., 2014).

#### 3.8.2.2 Massimo Pronto-7 with Rainbow

A non-invasive quick spot-checking total hemoglobin measuring instrument is battery operated and portable to be carried. This machine has been used in several studies (Gayat et al.,2012), validated (Al-Khabori et al., 2014) for use in pediatric populations, blood donors (Al-Khabori et al., 2014) and in population where compliance to invasive machines is a problem.

Massimo Pronto-7 with Rainbow measures hemoglobin by using the arterial blood with a technique of multi-wave length spectrophotometry that measures multiple components of several hemoglobin moieties. The machine has been validated and the difference of less than 2 g/dL was observed at both below normal value and above normal value of 12 g/dL observed in 99% and 94%, respectively (Masimo, 2016).

### 3.8.3 Methods of assessing iodine status in the population

#### 3.8.3.1 Salt iodine

Iodine concentrations in iodized salt at the point of production should be within the range of 20-40 mg of iodine per kg of salt (i.e., 20-40 ppm of iodine) in order to provide 150 µg of iodine per person per day (WHO and CDC, 2007). Iodine intake is assessed from diets using salt or foods prepared with iodized salt. Both quantitative and qualitative methods are used to determine iodized salt consumption.

The easiest method of qualitative assessment in field has been the use of rapid salt test kits. Of many rapid field test kits, validated MBI Kits has been commonly used in developing countries for its low cost and simplicity (MBI Kits, Madras, India) (Assey et al., 2009;

Zimmermann, 2008). The MBI Kits have a reagent, which makes iodine in the salt to go through a series of reactions and develop color. The color is compared with a color chart in the MBI Kit, showing whether or not the salt sample iodine is either below or above 15 ppm WHO and CDC, 2007; WHO, 2013). Presence of iodine is determined depending on the color of the chart present in the kit. Therefore, the populations are categorically classified based on proportion as adequate (≥ 90%), unsatisfactory (76 ≤ to <90%), poor (50 ≤ to <76%), or very poor (<50%). However, there are no gold standard analytical measure for iodine intake or iodine in foods. A proxy for iodine intake and iodine status is UIC (WHO, 2013).

### 3.8.3.2 UIC from urine sample

Urinary iodine excretion, a good marker of very recent diet, is used as an indicator to assess iodine status in the population using median UIC (WHO and CDC, 2007). The concentration in an individual's urine varies on a daily basis or even during the same day (Zimmermann, 2008; WHO and CDC, 2007). Therefore, use of median UIC for a population is recommended (Rohner et al., 2014; Zimmermann, 2008).

Research protocol was carefully observed during urine collection. Urine samples ranging from 0.5-1.0 mL were collected in small cups, transferred to tubes, tightly sealed with screw tops and then kept in cool, dry place to avoid evaporation, which would artificially increase the concentration (Zimmermann, 2008; WHO and CDC, 2007).

Iodine concentration of urine was determined by ammonium per sulfate digestion with spectrophotometry, based on the Sandell Kolthoff reaction (Pino et al., 1996; WHO and CDC, 2007). This method required a heating block, a spectrophotometer, and chemical reagents. For each urine sample, an aliquot of 0.25-0.5 mL was digested with ammonium per sulfate at 110 °C for 1 hour; arsenious acid and ceric ammonium sulphate were added to the sample and left to stand until the decrease in yellow color over a fixed time period was observed and then absorbance of the solution at 405 nm was measured spectrophotometrically. Iodine standards with known concentrations between 0 and 300 µg/L were used in this analysis. The absorbance data were then entered into the computer and a standard curve constructed by plotting the log of the absorbance at 405 nm on the X-axis versus the standard iodine concentration in µg/L on the Y-axis with a scatter plot, using Excel on a desktop computer.

The iodine concentration in microgram per liter (µg/L) of each specimen was calculated by using the equation of the linear trend line of this chart. There was an inverse endpoint color reaction, all specimen that had absorbance value lower than the acceptable standard curve (or calculated concentration >300 µg/L) were re-assayed using a dilution of 1:3 or 1:5. To ascertain the validity and reliability of the results, reference materials (urine samples) supplied by the US Center for Diseases Prevention and Control (WHO and CDC, 2007) were used concurrently during the analysis.

### 3.8.4 Dietary and nutrient intake assessment

#### 3.8.4.1 Twenty-four-hour dietary recall methods

Twenty-four-hour dietary recall method is among the most commonly used method to measure food and nutrient intake of an individual. Twenty-four-hour dietary recall method is also referred to as a retrospective diet assessment method, because an individual is asked about food and beverage they consumed during the previous day(s) before the study. This tool uses a proxy measure to assess nutrition status, and nutrient adequacy (Thompson and Subar, 2013). The 24-hour dietary recall method is inexpensive and has less recall errors. However, one of its limitation is the failure to determine habitual diet at an individual level if single 24-hour dietary recall is taken (Raina, 2013) and misreporting by the respondents especially adolescents (Kerr et al., 2015) hence more than one 24-h dietary recall data are needed to find a reliable and precise association between food intake and nutritional status of an individual (Holmes et al., 2008).

Foods intakes of an individual were computed after direct weight of estimates with food images or household utensil to obtain portion size. These foods were appropriately identified from Tanzania food composition tables (Lukmanji et al., 2008). Nutrient intake was estimated by multiplying the amount of each food item consumed by the nutrient composition and then summing the nutrient intake from all food items consumed. Only average intake was measured to compare among groups of individual. By comparing total nutrient intake to the reference nutrient intake (RNI) or using mean nutrient adequacy ratios (MARs) for nutrient, an individual nutrient intake was calculate.

Formula:

$$- Nutrient\ intake\ = Frequency\ \times Portion\ size\ (g) \times Nutrient\ content\ per\ 100\ g$$

$$- Nutrient\ adequacy\ ratio\ (NAR) = \frac{Intake\ of\ a\ particular\ nutrient}{Recommende\ dietary\ intake}$$

$$- MAR = \frac{Total\ NARs}{Total\ number\ of\ nutrients}$$

### 3.8.4.2 Individual dietary diversity score (IDDS)

IDDS is defined as the number of foods or food groups consumed by an individual in the past 24 hours. The number of food groups and the kind of food group to include in the questionnaire depends on the specific objective of the study (Webb et al., 2006). The IDDS questionnaire consists of 5-14 food groups; the tool is used as a means to calculate for micronutrient adequacy and food security. The subject is asked to recall the foods eaten in the previous day before the survey and from the list of food groups, respondent confirm the forgotten foods by saying “yes or no”.

### 3.9 Data processing and statistical analyses

Responses to the questionnaires were checked daily for completeness of responses after data collection, and there after entered in the Excel spread sheet. Data were cleaned on the criteria that respondents who were mistakenly recruited (did not meet inclusion requirement). For example, data of one student was removed when the researcher found that a respondent was from an orphanage. The information she provided would have changed the meaning of the study for instance having 100 members of the household as maximum.

Descriptive analysis was performed for socio-economic variables, anthropometric characteristics, dietary intake-related variables including nutrient intakes and IDDS, and biochemical measurement such as hemoglobin level and UIC. Categorical variables were presented as frequencies (n) and percentages (%). Continuous variables were presented as means with standard deviations (SDs). Chi-square tests were conducted to examine independent associations of nutritional inadequacy measurements such as stunting, underweight, anemia, and low iodine status with various characteristics of study subjects. Pearson's correlation tests were conducted to examine NAR of each nutrients, MAR, and IDDS. To identify socioeconomic and nutritional determinants of various nutritional inadequacies, the multivariate logistic regression analyses were conducted to estimate adjusted odds ratios (AORs) with 95% confidence intervals (95% CIs) for nutritional inadequacies (e.g., underweight, stunting, anemia, and iodine status) after adjustment for age (continuous), locality, religion, Illness within the past two weeks, experience of menarche, household size, total energy intake, and sex, marital status, education level, and occupation of caregiver, household size, and total energy intake.

All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 20 (Chicago, IL, USA), EXCEL and SAS (version 9.4, SAS Institute Inc, Cary, NC, USA). *P* values less than 0.05 were considered as statistically significant.

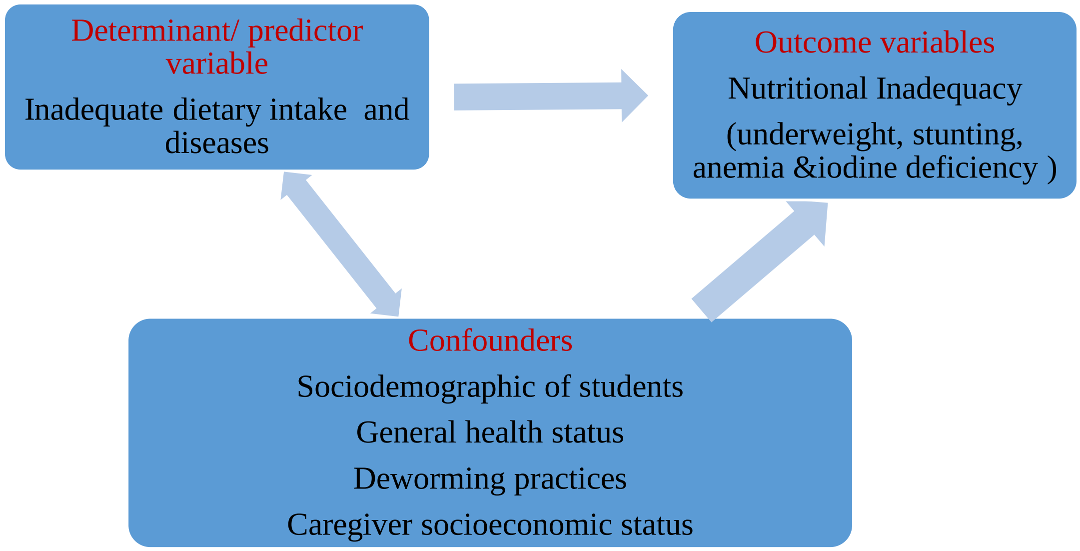


Figure 4. Summary of the logistic regression model used in the present study

# Chapter 4. Results

The findings and discussion are presented in the order of the following specific objectives: 1) assessing nutritional status of adolescent girls bydifferent nutrition status assessment methods (i.e., anthropometric, biochemical measurements, and dietary recall), 2) associations between individual characteristics and nutrition status of adolescent girls, 3) associations between household characteristics and nutrition status of adolescent girls, 4) associations between dietary intake and nutrition inadequacies of adolescent girls, and 5) determinants of nutrition inadequacies among adolescent girls.

## 4.1 General characteristics of the study subjects and their caregivers

### 4.1.1 Sociodemographic, school and home environment of study subjects

This study includes 208 subjects with 16.4% from Mtitu, 22.6% from Irole, 26.0% from Kilolo and 35.1% from Ilula secondary school. Out of the 208, Ilula secondary school had slightly higher number of subjects (n=73) while Mtitu secondary had least number of participant subjects (n=35) (Table 5). Overall, results showed that majority of the subject (66.4%) were over 15 years of age, followed by those between 12-14 years of age (33.7%). Almost all subjects belonged to Christianity (92.3%) followed by Muslims (7.7%). Most subjects reported the main caregiver to be biological father (46.2%).The proportions of those that referred biological mother and relatives as main caregivers were similar with 25.0% and 28.9%, respectively. In addition, majority of subjects reported to be staying with their immediate family (mother and father) during the school days (65.0%) while small percents reported staying independently (2.9%) or with relatives (4.8%). Almost all subjects (96.2%) reported that they walk to school and very few use public transport (4%). On average, subjects walk a distance of 3.0±1.8 Km.

### 4.1.2 General health status, menstruation experience, and deworming practice of study subjects

About 26% of subjects reported having at least one symptom of illness in the past two weeks prior to the study. Most of those who reported sick suffered from cough (77.8%), followed by malaria (18.5%) and diarrhea episodes (3.7%) (Table 6). Majority of subjects reported having had experienced menarche (66.4%) and had their menstrual period few days before the survey. More than 67% of the total population had heard about deworming practice. Of the study subjects who heard of deworming, 96% had actually ever dewormed. However, the deworming practice was irregular because majority of subject reported having last deworming more than one year before the survey (94.1%).

### 4.1.3 Consumption of iodized salt among study subjects

Majority of the subjects (70.7%) brought salt samples from home on the day of survey. All subjects who brought salt samples reported that they used the same salt to cook household food a day prior to survey (Table 7). Almost all the salt samples (n=147) brought in had iodine (98.6%). More than 95% of salt with iodine contained more than 15 ppm of iodine.

### 4.1.4 Socioeconomic characteristics of caregivers of the study subjects

Result showed that proportion of male caregivers was slightly higher (53.9%) than female counterpart (46.2%). The proportion of those in marriage institution was also found to be three times higher (71.2%) than caregivers who were single (i.e., divorced, separated, never married, widowed or in an open relationship) (28.9%) (Table 8). Majority of caregivers had attained primary school education (62.5%) followed by secondary/tertiary (25.0%) and no schooling (12.5%). Furthermore, majority of caregivers were peasant farmers (74.5%) followed by education/health professional/businessmen (25.5%). About 55% of the households had household size ranging from 5-14 people and more than 34% of household had at least three members who were under 18 years of age.

Table 5. Sociodemographic, school and environment of the study subjects

| Variables | Frequency (n) | Percentage (%) |
|---|---|---|
| Total | 208 | 100.0 |
| School | | |
| Kilolo | 54 | 26.0 |
| Mtitu | 34 | 16.4 |
| Irole | 47 | 22.6 |
| Ilula | 73 | 35.1 |
| Locality | | |
| Rural | 135 | 64.9 |
| Semi-urban | 73 | 35.1 |
| Religion | | |
| Christian | 192 | 92.3 |
| Muslim | 16 | 7.7 |
| Age (years)[1] | | |
| 12-14 | 70 | 33.7 |
| 15-19 | 138 | 66.3 |
| Currently living with | | |
| Independent | 6 | 2.9 |
| Family | 135 | 64.9 |
| Relatives | 57 | 27.4 |
| Friends | 10 | 4.8 |
| Transportation to school | | |
| Walk | 200 | 96.1 |
| Public car | 8 | 3.9 |
| Distance to school (km)[1] | | |
| ≤1.5 | 51 | 24.5 |
| 1.5 < to ≤3 | 91 | 43.8 |
| 3 < to ≤4.5 | 36 | 17.3 |
| >4.5 | 30 | 14.4 |
| Relationship with caregiver (n=202) | | |
| Mother | 52 | 25.0 |
| Father | 96 | 46.2 |
| Relative | 60 | 28.8 |

[1]Mean age was 15.11±1.48 years and mean distance to school was 2.95±1.82 km.

Table 6. General health status, menstruation experience and deworming practice of study subjects

| Variables | Frequency (n) | Percentage (%) |
|---|---|---|
| Illness within the past two weeks | | |
| Yes | 54 | 26.0 |
| No | 154 | 74.0 |
| Type of illness | | |
| Malaria | 10 | 18.5 |
| Diarrhea | 2 | 3.7 |
| Cough | 42 | 77.8 |
| Experienced menarche | | |
| Yes | 138 | 66.4 |
| No | 70 | 33.7 |
| Last menses (n=138) | | |
| Few days | 97 | 70.3 |
| Four weeks | 35 | 25.4 |
| More than three months | 6 | 4.4 |
| Ever heard of deworming | | |
| Yes | 140 | 67.3 |
| No | 68 | 32.7 |
| Ever dewormed (n=140) | | |
| Yes | 135 | 96.4 |
| No | 5 | 3.6 |
| Timing of last deworming (n=135) | | |
| Three months | 8 | 5.9 |
| More than a year | 127 | 94.1 |

Table 7. Consumption of iodized salt among study subjects

| Variables | Frequency (n) | Percentage (%) |
|---|---|---|
| Brought salt | | |
| Yes | 147 | 70.7 |
| No | 61 | 29.3 |
| Used salt brought in cooking[1] | | |
| Yes | 147 | 100.0 |
| No | 0 | 0.0 |
| Presence of iodine in brought salt[1] | | |
| Yes | 145 | 98.6 |
| No | 2 | 1.4 |
| Amount of iodine in brought salt (ppm)[2] | | |
| <15 | 7 | 95.2 |
| ≥15 | 138 | 4.8 |

[1]The total n for those variables was 147.
[2]The total n for the variable was 145.

Table 8. Socioeconomic characteristics of caregivers[1] of the study subjects

| Variables | Frequency (n) | Percentage (%) |
|---|---|---|
| Sex | | |
| Men | 112 | 53.9 |
| Women | 96 | 46.2 |
| Marital status | | |
| Married | 148 | 71.2 |
| Single[2] | 60 | 28.9 |
| Education level | | |
| No school | 26 | 12.5 |
| Primary | 130 | 62.5 |
| Secondary | 36 | 17.3 |
| Tertiary | 16 | 7.7 |
| Education level | | |
| No school | 26 | 12.5 |
| Primary | 130 | 62.5 |
| Secondary/tertiary | 52 | 25.0 |
| Occupation | | |
| Peasant farmer | 155 | 75.0 |
| Education/health professional/business | 53 | 25.0 |
| Household size[3] | | |
| ≤5 | 94 | 74.5 |
| >5 | 114 | 25.5 |
| No. of household member under 18 years of age[4] | | |
| ≤3 | 137 | 45.2 |
| ≥4 | 71 | 54.8 |

[1]Caregiver referred to a person who provides food or money for purchasing food.
[2]Single included those who divorced, separated, never married, widowed or are in an open relationship.
[3]Mean household size was 5.74±2.01 and the largest household size was 14.
[4]Mean number of household member under 18 years of age was 3.04±1.47.

## 4.2 Diet diversity and nutrient adequacy among study subjects

### 4.2.1 Individual diet diversity of study subjects

IDDS calculated from dietary diversity questionnaires indicated that the most consumed foods are from starchy staples (group 1) including cereals and white root and tubers (100%, all subjects consumed) followed by dark green leafy vegetables (group 2) (71.6%) and legumes, nuts, and seeds (group 8) (49.0%). Organ meats (group 5) (0.48%) and milk and milk products (group 9) (3.37%) were the least consumed food groups by the subjects (Table 9). On average, study subjects consumed 3.0±1.5 food groups and all subjects consumed at least two and at most 7 food groups (Table 10). A larger percentage of adolescent girls consumed one or more food groups of meat/fish, eggs, legumes/nuts/seeds, and milk/milk products with increasing IDDS of study subjects. Only those with an IDDS of 5 or more showed more than half (>50%) of the study subjects consumed meat/fish, legumes/nuts/seeds, and other fruits and vegetables. In addition, only at an IDDS of 7 were 25% of subjects having milk and milk products.

Table 9. Frequency of each food group component of Individual Diet Diversity Score (IDDS) among study subjects

| **Food group** | **Frequency (n)** | **Percentage (%)** |
|---|---|---|
| Group 1: Starchy staples | 208 | 100.0 |
| Group 2: Dark green leafy vegetables | 149 | 71.6 |
| Group 3: Other vitamin A rich fruits and vegetables | 91 | 43.8 |
| Group 4: Other fruits and vegetables | 71 | 34.1 |
| Group 5: Organ meat | 1 | 0.5 |
| Group 6: Meat and fish | 84 | 4.5 |
| Group 7: Eggs | 12 | 5.8 |
| Group 8: Legumes, nuts and seeds | 102 | 49.0 |
| Group 9: Milk and milk products | 7 | 3.4 |

Table 10. Percent consumption of different food groups by Individual Diet Diversity Score (IDDS) and its components

| IDDS | n | % | Starchy staples | Dark green leafy vegetables | Other vitamin A rich fruits and vegetables | Other fruits and vegetables | Organ meat | Meat and fish | Eggs | Legumes, nuts and seeds | Milk and milk products |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | % | | | | | |
| **2** | 24 | 11.5 | 100.0 | 41.7 | 0.0 | 8.3 | 0.0 | 16.7 | 0.0 | 33.3 | 0.0 |
| **3** | 70 | 33.7 | 100.0 | 74.3 | 25.7 | 25.7 | 0.0 | 24.3 | 2.9 | 35.7 | 1.4 |
| **4** | 64 | 30.8 | 100.0 | 75.0 | 59.4 | 39.1 | 0.0 | 45.3 | 4.7 | 48.4 | 3.1 |
| **5** | 30 | 14.4 | 100.0 | 76.7 | 63.3 | 50.0 | 3.3 | 53.3 | 6.7 | 73.3 | 6.7 |
| **6** | 16 | 7.7 | 100.0 | 81.3 | 87.5 | 50.0 | 0.0 | 87.5 | 18.8 | 81.3 | 6.3 |
| **7** | 4 | 1.9 | 100.0 | 75.0 | 50.0 | 75.0 | 0.0 | 100.0 | 50.0 | 75.0 | 25.0 |

### 4.2.2 Macronutrient and micronutrient intakes of study subjects

Dietary intake data were collected using 24-hour dietary recall questionnaires. Twenty-four-hour dietary recalls were used to estimate total nutrient intakes from all foods and beverages consumed by study subjects and then NAR values of energy, protein and 11 micronutrients (energy, protein, vitamin A, thiamin, riboflavin, niacin, vitamin B6, vitamin B12, vitamin C, folate, calcium, iron, and zinc) and MAR were calculated. Dietary intake of majority nutrients did not meet the Institute of Medicine's Recommended Dietary Allowance (RDA) (Table 11). More than 90% of subjects did not obtain the recommended level of energy intake with mean energy intake of 1390±541 kcal/day. Likewise, only about 15% of subjects consumed more than the recommended level of iron with mean iron intake of 9.0±3.1 mg/day. Pearson's correlation analyses indicated that intake of nutrients, except vitamin A, vitamin B2, and calcium, were significantly correlated with IDDS (all, $P$ <0.05). Most of nutrients, except thiamin and vitamin B6, had an average NAR below 75%. The mean MAR was 0.6±0.2 and significantly correlated with IDDS (Pearson's correlation coefficient=0.3, $P$ <0.01) (Table 12).

Table 11. Percent of subjects whose intake meets Recommended Dietary Allowance (RDA) of nutrients

| Nutrients | RDA | | | % meeting RDA |
|---|---|---|---|---|
| | 12-13 yrs | 14-18 yrs | 19 yrs | |
| Energy (kcal) | 2071 | 2368 | 2403 | 8.7 |
| Carbohydrates (g/day) | 130 | 130 | 130 | 89.9 |
| Carbohydrates (% energy) | 45-65 | 45-65 | 45-65 | 89.9 |
| Protein (g/day) | 34 | 46 | 46 | 19.7 |
| Protein (% energy) | 10-30 | 10-30 | 10-35 | 93.3 |
| Total fat (% energy) | 25-35 | 25-35 | 20-35 | 38.9 |
| Fiber (g/day) | 26 | 26 | 25 | 16.4 |
| Vitamin A (µg/day) | 600 | 700 | 700 | 25.0 |
| Thiamin (mg/day) | 0.9 | 1 | 1.1 | 27.9 |
| Riboflavin (mg/day) | 0.9 | 1 | 1.1 | 19.2 |
| Niacin (mg/day) | 12 | 14 | 14 | 12.0 |
| Vitamin B6 (mg/day) | 1 | 1.2 | 1.3 | 28.9 |
| Vitamin B12 (µg/day) | 1.8 | 2.4 | 2.4 | 4.8 |
| Pantothenic acid (mg/day) | 4 | 5 | 5 | 10.1 |
| Vitamin C (mg/day) | 45 | 65 | 75 | 37.5 |
| Vitamin D (µg/day) | 5 | 5 | 5 | 1.0 |
| Vitamin E (mg/day) | 11 | 15 | 15 | 4.3 |
| Folic acid (µg/day) | 300 | 400 | 400 | 2.9 |
| Sodium (g/day) | 1.5 | 1.5 | 1.5 | 4.3 |
| Potassium (g/day) | 2.3 | 2.3 | 2.3 | 15.9 |
| Manganese (mg/day) | 1.6 | 1.6 | 1.8 | 87.5 |
| Magnesium (mg/day) | 240 | 360 | 310 | 27.9 |
| Copper (µg/day) | 700 | 890 | 900 | 88.9 |
| Calcium (mg/day) | 1300 | 1300 | 1000 | 0.0 |
| Iron (mg/day) | 8 | 15 | 18 | 14.9 |
| Zinc (mg/day) | 8 | 9 | 8 | 12.5 |
| Phosphorus (mg/day) | 1250 | 1250 | 700 | 2.4 |

Table 12. The nutrients adequacy ratios (NAR) and mean adequacy ratio (MAR) among study subjects and its correlation with Individual Diet Diversity Score (IDDS) among study subjects

| **Nutrients** | **NAR** | | **Correlation[1] with IDDS** |
|---|---|---|---|
| | mean | SD | |
| Energy | 0.59 | 0.21 | 0.2395** |
| Protein | 0.68 | 0.24 | 0.2479** |
| Vitamin A | 0.55 | 0.35 | 0.0047 |
| Thiamin | 0.75 | 0.23 | 0.2206** |
| Riboflavin | 0.62 | 0.27 | 0.1178 |
| Niacin | 0.66 | 0.21 | 0.2195** |
| Vitamin B6 | 0.77 | 0.21 | 0.3377** |
| Vitamin B12 | 0.21 | 0.28 | 0.2304** |
| Vitamin C | 0.71 | 0.30 | 0.3191** |
| Folic acid | 0.47 | 0.19 | 0.1531* |
| Calcium | 0.15 | 0.11 | 0.0904 |
| Iron | 0.63 | 0.22 | 0.1701* |
| Zinc | 0.67 | 0.21 | 0.2196** |
| MAR | 0.57 | 0.15 | 0.3034** |

[1]* P <0.05, ** P <0.01

### 4.3 Prevalence of nutritional inadequacies among study subjects

#### 4.3.1 Prevalence of underweight and stunting among study subjects

BMI-for-age percentiles indicated that more than 90% of the study subjects had BMI between 5th and 85th percentiles with a mean BMI of 19.81±3.55 kg/$m^2$. The prevalence of underweight (BMI-for-age <5th percentile) was significantly higher in adolescent girls who had not experienced menarche compared to those who had experienced ($P$ <0.05) (Table 9).

Height-for-age percentiles showed that more than 78% of subjects had normal stature (5th ≤ Height-for-age <85th percentile) with mean height of 152.4±5.77 cm. However, the prevalence of stunting was 21.6% as indicated by Height-for-age <5th percentile and not significantly different between experience of menarche.

#### 4.3.2. Prevalence of Iron deficiency anemia among study subjects

Iron status of the study subjects was tested using semi-invasive (HemoCue) and non-invasive (Massimo Pronto-7) machines. HemoCue machine had lower number of subjects willing to test hemoglobin levels (n=184) compared to Massimo Pronto-7 machine (n=200). However, HemoCue machine was more reliable than Massimo Pronto-7 when considering the ability to measure the level of hemoglobin. HemoCue machine managed to read hemoglobin levels of all 184 subjects who agreed to use the machine whereas Massimo Pronto-7 machine failed to read hemoglobin levels of 44% (n=88) of the study subjects who agreed to be tested (Table 9).

Results from the Massimo Pronto-7 with Rainbow showed that the prevalence of anemia was 25.9% with mean hemoglobin level of 12.7±1.2 g/dL. When using HemoCue machine, the prevalence of anemia was 22.8% with mean hemoglobin level of 12.9±1.3 g/dL. There is no association of the experience of menarche with the prevalence of IDA diagnose by HemoCue and Massimo Pronto-7 machines.

### 4.3.3 Iodine status and prevalence of UIC <50 µg/L among study subjects

Majority (n=175) of the study subjects provided urine samples while 16% refused to participate. The reasons for refusal were that providing urine sample did not feel comfortable due to menstrual status or no reason. Based on UICs from urine samples, iodine status of the study subjects was adequate since the median UIC was 227.1 µg/L. The prevalence of UIC <50 µg/L was 16.4% and there is no significant difference between those who had and had not experienced menarche (Table 9).

Table 13. Prevalence of nutritional inadequacies among study subjects

| Nutritional status | Total | | Ever experienced menarche | | | | *P* value |
|---|---|---|---|---|---|---|---|
| | | | Yes | | No | | |
| | n | % | n | % | n | % | |
| Stunting | | | | | | | |
| No | 163 | 78.4 | 50 | 24.0 | 113 | 54.3 | 0.1082 |
| Yes | 45 | 21.6 | 20 | 9.6 | 25 | 12.0 | |
| Underweight | | | | | | | |
| No | 196 | 94.2 | 62 | 29.8 | 134 | 64.4 | 0.0231*[1] |
| Yes | 12 | 5.8 | 8 | 3.9 | 4 | 1.9 | |
| Anemia diagnosed by HemoCue[2] | | | | | | | |
| No | 142 | 77.2 | 51 | 27.7 | 91 | 49.5 | 0.8549 |
| Yes | 42 | 22.8 | 14 | 7.6 | 28 | 15.2 | |
| Anemia diagnosed by Pronto[3] | | | | | | | |
| No | 83 | 74.1 | 30 | 26.8 | 53 | 47.3 | 0.8635 |
| Yes | 29 | 25.9 | 11 | 9.8 | 18 | 16.1 | |
| UIC <50 µg/L | | | | | | | |
| No | 174 | 83.7 | 54 | 26.0 | 120 | 57.7 | 0.1082 |
| Yes | 34 | 16.3 | 16 | 7.7 | 18 | 8.7 | |

[1]* $P$ <0.05

[2]The total n for the variable was 184.

[3]The total n for the variable was 112.

### 4.4 Determinants of nutritional inadequacies of study subjects

#### 4.4.1 Associations of characteristics of study subjects and their caregivers with nutritional inadequacies

The presence of stunting was significantly associated with occupation of caregivers ($P$ = 0.0325) (Table 14). Underweight was significantly associated with experience of menarche ($P$ = 0.0231). Anemia had a significant association with caregivers' sex ($P$ = 0.0341) and education level ($P$ = 0.0053) (Table 15).

Chi-square test showed that low iodine status (UIC <50 µg/L) was associated with locality (rural vs. semi-urban). No associations were found between iodine status and socioeconomic characteristics of caregivers. Characteristics of subjects and their caregivers stratified by UIC are shown in Table 16. UIC tend to be associated with socioeconomic characteristics of their caregivers than general characteristics of adolescent girls. Highest tertile of UIC groups were from household caregivers with high educated ($P$ <0.01) and from a larger household ($P$ <0.01). However, no significant associations were found between characteristics of adolescent girls and UIC.

Table 14. Independent association of sociodemographic characteristics of the study subjects and their caregivers with the presence of stunting and underweight among study subjects

| Variables | Total | | Stunting | | | | | Underweight | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yes | | No | | *P* value | Yes | | No | | *P* value |
| | n | % | n | % | n | % | | n | % | n | % | |
| Total | 208 | 100.0 | 45 | 21.6 | 163 | 78.4 | | 12 | 5.8 | 196 | 94.2 | |
| ***General characteristics of subjects*** | | | | | | | | | | | | |
| Age (years) | | | | | | | | | | | | |
| 12-14 | 70 | 33.7 | 13 | 6.3 | 57 | 27.4 | 0.4814 | 4 | 1.9 | 66 | 31.7 | 0.9807 |
| 15-19 | 138 | 66.4 | 32 | 15.4 | 106 | 51.0 | | 8 | 3.9 | 130 | 62.5 | |
| Locality | | | | | | | | | | | | |
| Rural | 135 | 64.9 | 33 | 15.9 | 102 | 49.0 | 0.2182 | 7 | 3.4 | 128 | 61.5 | 0.7567 |
| Semi-urban | 73 | 35.1 | 12 | 5.8 | 61 | 29.3 | | 5 | 2.4 | 68 | 32.7 | |
| Religion | | | | | | | | | | | | |
| Christian | 192 | 92.3 | 42 | 20.2 | 150 | 72.1 | 0.7705 | 10 | 4.8 | 182 | 87.5 | 0.2327 |
| Muslim | 16 | 7.7 | 3 | 1.4 | 13 | 6.3 | | 2 | 1.0 | 14 | 6.7 | |
| Illness within the past two weeks | | | | | | | | | | | | |
| Yes | 54 | 26.0 | 13 | 6.3 | 41 | 19.7 | 0.7011 | 2 | 1.0 | 52 | 25.0 | 0.7352 |
| No | 154 | 74.0 | 32 | 15.4 | 122 | 58.7 | | 10 | 4.8 | 144 | 69.2 | |
| Experienced menarche | | | | | | | | | | | | |
| Yes | 138 | 66.4 | 25 | 12.0 | 113 | 54.3 | 0.1082 | 4 | 1.9 | 134 | 64.4 | 0.0231[*1] |
| No | 70 | 33.7 | 20 | 9.6 | 50 | 24.0 | | 8 | 3.9 | 62 | 29.8 | |
| ***Socioeconomic characteristics of caregivers*** | | | | | | | | | | | | |
| Sex | | | | | | | | | | | | |
| Men | 112 | 53.9 | 25 | 12.0 | 87 | 41.8 | 0.8665 | 4 | 1.9 | 108 | 51.9 | 0.2319 |
| Women | 96 | 46.2 | 20 | 9.6 | 76 | 36.5 | | 8 | 3.9 | 88 | 42.3 | |

Table 14. (cont'd)

| Variables | Total | | Stunting | | | | P value | Underweight | | | | P value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yes | | No | | | Yes | | No | | |
| | n | % | n | % | n | % | | n | % | n | % | |
| Marital status | | | | | | | | | | | | |
| Married | 148 | 71.2 | 30 | 14.4 | 118 | 56.7 | 0.4617 | 7 | 3.4 | 141 | 67.8 | 0.3333 |
| Single | 60 | 28.9 | 15 | 7.2 | 45 | 21.6 | | 5 | 2.4 | 55 | 26.4 | |
| Education level | | | | | | | | | | | | |
| No school | 26 | 12.5 | 6 | 2.9 | 20 | 9.6 | 0.5136 | 2 | 1.0 | 24 | 11.5 | 0.3848 |
| Primary | 130 | 62.5 | 25 | 12.0 | 105 | 50.5 | | 9 | 4.3 | 121 | 58.2 | |
| Secondary/tertiary | 52 | 25.0 | 14 | 6.7 | 38 | 18.3 | | 1 | 0.5 | 51 | 24.5 | |
| Occupation | | | | | | | | | | | | |
| Peasant farmer | 155 | 74.5 | 28 | 13.5 | 127 | 61.1 | 0.0325* | 11 | 5.3 | 144 | 69.2 | 0.3032 |
| Education, health professional, And business | 53 | 25.5 | 17 | 8.2 | 36 | 17.3 | | 1 | 0.5 | 52 | 25.0 | |
| Household size | | | | | | | | | | | | |
| ≤5 | 94 | 45.2 | 19 | 9.1 | 75 | 36.1 | 0.7359 | 8 | 3.9 | 86 | 41.4 | 0.1442 |
| >5 | 114 | 54.8 | 26 | 12.5 | 88 | 42.3 | | 4 | 1.9 | 110 | 52.9 | |
| ***Consumption of iodized salt*** | | | | | | | | | | | | |
| Amount of iodine in brought salt (ppm)[2] | | | | | | | | | | | | |
| ≥15 | 138 | 95.2 | 30 | 20.7 | 108 | 74.5 | 0.6389 | 9 | 6.2 | 129 | 89.0 | 0.4003 |
| <15 | 7 | 4.8 | 1 | 0.7 | 6 | 4.1 | | 1 | 0.7 | 6 | 4.1 | |

[1]* $P < 0.05$

[2]The total n for the variable was 145.

Table 15. Independent association of sociodemographic characteristics of the study subjects and their caregivers with the presence of anemia and UIC <50 µg/L among study subjects

| Variables | Total | | Anemia[1] | | | | *P* value | UIC <50 µg/L | | | | *P* value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yes | | No | | | Yes | | No | | |
| | n | % | n | % | n | % | | n | % | n | % | |
| Total | 208 | 100.0 | 42 | 22.8 | 142 | 77.2 | | 34 | 16.4 | 174 | 83.7 | |
| ***General characteristics of subjects*** | | | | | | | | | | | | |
| Age | | | | | | | | | | | | |
| 12-14 | 70 | 33.7 | 12 | 6.5 | 51 | 27.7 | 0.4604 | 13 | 6.3 | 57 | 27.4 | 0.5556 |
| 15-20 | 138 | 66.4 | 30 | 16.3 | 91 | 49.5 | | 21 | 10.1 | 117 | 56.3 | |
| Locality | | | | | | | | | | | | |
| Rural | 135 | 64.9 | 33 | 17.9 | 96 | 52.2 | 0.1862 | 9 | 4.3 | 126 | 60.6 | <0.0001** |
| Semi-urban | 73 | 35.1 | 9 | 4.9 | 46 | 25.0 | | 25 | 12.0 | 48 | 23.1 | |
| Religion | | | | | | | | | | | | |
| Christian | 192 | 92.3 | 37 | 20.1 | 133 | 72.3 | 0.3164 | 31 | 14.9 | 161 | 77.4 | 0.7298 |
| Muslim | 16 | 7.7 | 5 | 2.7 | 9 | 4.9 | | 3 | 1.4 | 13 | 6.3 | |
| Illness within the past two weeks | | | | | | | | | | | | |
| Yes | 54 | 26.0 | 11 | 6.0 | 39 | 21.2 | 0.8705 | 5 | 2.4 | 49 | 23.6 | 0.1342 |
| No | 154 | 74.0 | 31 | 16.9 | 103 | 56.0 | | 29 | 13.9 | 125 | 60.1 | |
| Experienced menarche | | | | | | | | | | | | |
| Yes | 138 | 66.4 | 28 | 15.2 | 91 | 49.5 | 0.8549 | 18 | 8.7 | 120 | 57.7 | 0.0773 |
| No | 70 | 33.7 | 14 | 7.6 | 51 | 27.7 | | 16 | 7.7 | 54 | 26.0 | |
| ***Socioeconomic characteristics of caregivers*** | | | | | | | | | | | | |
| Sex | | | | | | | | | | | | |
| Men | 112 | 53.9 | 16 | 8.7 | 82 | 44.6 | 0.0341* | 18 | 8.7 | 94 | 45.2 | 0.9079 |
| Women | 96 | 46.2 | 26 | 14.1 | 60 | 32.6 | | 16 | 7.7 | 80 | 38.5 | |

Table 15. (cont'd)

| Variables | Total | | Anemia[1] | | | | P value | UIC <50 µg/L | | | | P value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yes | | No | | | Yes | | No | | |
| | n | % | n | % | n | % | | n | % | n | % | |
| Marital status | | | | | | | | | | | | |
| Married | 148 | 71.2 | 27 | 14.7 | 105 | 57.1 | 0.2445 | 26 | 12.5 | 122 | 58.7 | 0.5383 |
| Single | 60 | 28.9 | 15 | 8.2 | 37 | 20.1 | | 8 | 3.9 | 52 | 25.0 | |
| Education level | | | | | | | | | | | | |
| No school | 26 | 12.5 | 11 | 6.0 | 11 | 6.0 | 0.0053** | 2 | 1.0 | 24 | 11.5 | 0.4123 |
| Primary | 130 | 62.5 | 22 | 12.0 | 93 | 50.5 | | 22 | 10.6 | 108 | 51.9 | |
| Secondary/tertiary | 52 | 25.0 | 9 | 4.9 | 38 | 20.7 | | 10 | 4.8 | 42 | 20.2 | |
| Occupation | | | | | | | | | | | | |
| Peasant farmer | 155 | 74.5 | 33 | 17.9 | 105 | 57.1 | 0.6856 | 28 | 13.5 | 127 | 61.1 | 0.2896 |
| Education, health professional, and business | 53 | 25.5 | 9 | 4.9 | 37 | 20.1 | | 6 | 2.9 | 47 | 22.6 | |
| Household size | | | | | | | | | | | | |
| ≤5 | 94 | 45.2 | 18 | 9.8 | 63 | 34.2 | 0.8626 | 17 | 8.2 | 77 | 37.0 | 0.5755 |
| >5 | 114 | 54.8 | 24 | 13.0 | 79 | 42.9 | | 17 | 8.2 | 97 | 46.6 | |
| ***Consumption of iodized salt*** | | | | | | | | | | | | |
| Amount of iodine in brought salt (ppm)[3] | | | | | | | | | | | | |
| ≥15 | 138 | 95.2 | 30 | 22.6 | 98 | 73.7 | 0.5873 | 26 | 17.9 | 112 | 77.2 | 0.5246 |
| <15 | 7 | 4.8 | 0 | 0.0 | 5 | 3.8 | | 2 | 1.4 | 5 | 3.5 | |

[1]The total n for anemia was 184.
[2]*P* <0.05, ** *P* <0.01
[3]The total n for the variable was 145.

Table 16. Independent association of sociodemographic characteristics of the study subjects and their caregivers across the tertile categories of urinary iodine concentration (UIC)

| Variables | Total | | UIC | | | | | | Chi-square |
|---|---|---|---|---|---|---|---|---|---|
| | | | Tertile 1 | | Tertile 2 | | Tertile 3 | | |
| | n | % | n | % | n | % | n | % | |
| Total | 175 | 100.00 | 58 | 33.1 | 58 | 33.1 | 59 | 33.7 | |
| ***General characteristics of subjects*** | | | | | | | | | |
| Age (years) | | | | | | | | | 2.29 |
| 12-14 | 57 | 32.6 | 15 | 26.3 | 19 | 33.3 | 23 | 40.4 | |
| 15-19 | 118 | 67.4 | 43 | 36.4 | 39 | 33.1 | 36 | 30.5 | |
| Locality | | | | | | | | | 3.02 |
| Rural | 127 | 72.6 | 45 | 35.4 | 44 | 34.7 | 38 | 29.9 | |
| Semi-urban | 48 | 27.4 | 13 | 27.1 | 14 | 29.2 | 21 | 43.8 | |
| Religion | | | | | | | | | 4.99 |
| Christian | 162 | 92.6 | 56 | 34.6 | 55 | 34.0 | 51 | 31.5 | |
| Muslim | 13 | 7.4 | 2 | 15.4 | 3 | 23.1 | 8 | 61.5 | |
| Illness within the past two weeks | | | | | | | | | 5.00 |
| Yes | 49 | 28.0 | 10 | 20.4 | 19 | 38.8 | 20 | 40.8 | |
| No | 126 | 72.0 | 48 | 38.1 | 39 | 31.0 | 39 | 31.0 | |
| Experienced menarche | | | | | | | | | 0.65 |
| Yes | 121 | 69.1 | 42 | 34.7 | 38 | 31.4 | 41 | 33.9 | |
| No | 54 | 30.9 | 16 | 29.6 | 20 | 37.0 | 18 | 33.3 | |
| ***Socioeconomic characteristics of caregivers*** | | | | | | | | | |
| Sex | | | | | | | | | 1.16 |
| Men | 94 | 53.7 | 30 | 31.9 | 29 | 30.9 | 35 | 37.2 | |
| Women | 81 | 46.3 | 28 | 34.6 | 29 | 35.8 | 24 | 29.6 | |

Table 16. (cont'd)

| Variables | Total | | UIC | | | | | | Chi-square |
|---|---|---|---|---|---|---|---|---|---|
| | | | Tertile 1 | | Tertile 2 | | Tertile 3 | | |
| | n | % | n | % | n | % | n | % | |
| Marital status | | | | | | | | | 0.91 |
| Married | 123 | 70.3 | 43 | 35.0 | 41 | 33.3 | 39 | 31.7 | |
| Single | 52 | 29.7 | 15 | 28.9 | 17 | 32.7 | 20 | 38.5 | |
| Education level | | | | | | | | | 13.32** |
| No school | 25 | 14.3 | 10 | 40.0 | 8 | 32.0 | 7 | 28.0 | |
| Primary | 108 | 61.7 | 42 | 38.9 | 37 | 34.3 | 29 | 26.9 | |
| Secondary/tertiary | 42 | 24.0 | 6 | 14.3 | 13 | 31.0 | 23 | 54.8 | |
| Occupation | | | | | | | | | 9.05* |
| Peasant farmer | 128 | 73.1 | 48 | 37.5 | 45 | 35.2 | 35 | 27.3 | |
| Education/health professional/business | 47 | 26.9 | 10 | 21.3 | 13 | 27.7 | 24 | 51.1 | |
| Household size | | | | | | | | | 10.72** |
| ≤5 | 77 | 44.0 | 25 | 32.5 | 17 | 22.1 | 35 | 45.5 | |
| >5 | 98 | 56.0 | 33 | 33.7 | 41 | 41.8 | 24 | 24.5 | |
| ***Consumption of iodized salt*** | | | | | | | | | |
| Amount of iodine in brought salt (ppm)[2] | | | | | | | | | 0.26 |
| <15 | 113 | 95.8 | 31 | 27.4 | 42 | 37.2 | 40 | 35.4 | |
| ≥15 | 5 | 4.2 | 2 | 40.0 | 3 | 60.0 | 0 | 0.0 | |

[1]$P$ <0.05, ** $P$ <0.01

[2]The total n for the variable was 145.

### 4.4.2 Odds ratios for nutritional inadequacies according to characteristics of study subjects and their caregivers

The multiple logistic regressions were conducted to identify determinants for various nutritional inadequacies including stunting, underweight, anemia, and low iodine status. The AORs of stunting (AOR=1.61; 95% CI=1.18-2.19; *P* for trend = 0.0025) and underweight (AOR=1.78; 95% CI=1.06-2.99; *P* for trend = 0.0299) increased with age (Table 17). Adolescent girls who had not experienced menarche were more likely to be at risks of stunting (AOR=3.93; 95% CI=1.62-9.50; *P* = 0.0024) and underweight (AOR=13.54; 95% CI=2.58-71.15; *P* = 0.0021) compared to those who had experienced menarche. In addition, compared to non-stunted counterparts, stunted adolescent girls were 2.96 times more likely to have caregivers who are working as peasant farmers (AOR=2.96; 95% CI=1.24-7.03; *P* = 0.0142).

Anemic adolescent girls were 3.77 time more likely to have caregivers with no education (AOR=3.77; 95% CI=1.32-10.82; *P* = 0.0407) than their non-anemic counterparts (Table 18). Adolescent girls living in semi-urban had a higher AOR of UIC <50 µg/L (AOR=16.32; 95% CI=4.92-54.11; *P* <0.001) than those living in rural area. Additionally, compared to those with adequate iodine status, adolescent girls with low iodine status (UIC <50 µg/L) were less likely to have caregivers working as blue-collar employees (AOR=0.17; 95% CI=0.03-0.97; *P* = 0.0460).

Table 17. Adjusted odds ratios for stunting and underweight by characteristics of study subjects and their caregivers[1]

| Variables | Stunting | | | *P* value | Underweight | | | *P* value |
|---|---|---|---|---|---|---|---|---|
| | AOR | 95% CI | | | AOR | 95% CI | | |
| ***General characteristics of subjects*** | | | | | | | | |
| Age | 1.61 | 1.18 | 2.19 | 0.0025**[2] | 1.78 | 1.06 | 2.99 | 0.0299* |
| Locality | | | | | | | | |
| Rural (ref) | 1.00 | | | | 1.00 | | | |
| Semi-urban | 0.52 | 0.23 | 1.19 | 0.1186 | 1.60 | 0.36 | 7.19 | 0.5394 |
| Religion | | | | | | | | |
| Christian (ref) | 1.00 | | | | 1.00 | | | |
| Muslim | 0.92 | 0.23 | 3.68 | 0.9094 | 4.61 | 0.62 | 34.32 | 0.1359 |
| Illness within the past two weeks | | | | | | | | |
| Yes (ref) | 1.00 | | | | 1.00 | | | |
| No | 0.89 | 0.40 | 2.00 | 0.7804 | 3.18 | 0.49 | 20.50 | 0.2242 |
| Experienced menarche | | | | | | | | |
| Yes (ref) | 1.00 | | | | 1.00 | | | |
| No | 3.93 | 1.62 | 9.50 | 0.0024** | 13.54 | 2.58 | 71.15 | 0.0021** |
| ***Socioeconomic characteristics of caregivers*** | | | | | | | | |
| Sex | | | | | | | | |
| Men (ref) | 1.00 | | | | 1.00 | | | |
| Women | 0.67 | 0.29 | 1.58 | 0.3603 | 3.65 | 0.75 | 17.85 | 0.1102 |
| Marital status | | | | | | | | |
| Married (ref) | 1.00 | | | | 1.00 | | | |
| Single | 1.37 | 0.55 | 3.40 | 0.5003 | 0.74 | 0.15 | 3.63 | 0.7100 |
| Education level | | | | | | | | |
| No school | 1.38 | 0.45 | 4.21 | 0.8000 | 0.76 | 0.11 | 5.21 | 0.5736 |
| Primary (ref) | 1.00 | | | | 1.00 | | | |
| Secondary/tertiary | 1.25 | 0.50 | 3.10 | | 0.28 | 0.03 | 3.03 | |

Table 17. (cont'd)

| Variables | Stunting | | | P value | Underweight | | | P value |
|---|---|---|---|---|---|---|---|---|
| | AOR | 95% CI | | | AOR | 95% CI | | |
| Occupation | | | | | | | | |
| Peasant farmer (ref) | 2.96 | 1.24 | 7.03 | 0.0142* | 0.27 | 0.02 | 3.03 | 0.2888 |
| Education, health Professional, and business | 1.00 | | | | 1.00 | | | |
| Household size | | | | | | | | |
| ≤5 | 1.49 | 0.67 | 3.32 | 0.3303 | 1.74 | 0.39 | 7.80 | 0.4688 |
| >5 (ref) | 1.00 | | | | 1.00 | | | |
| ***Dietary intake of Study subjects*** | | | | | | | | |
| Total energy intake | 1.00 | 1.00 | 1.00 | 0.3594 | 1.00 | 1.00 | 1.00 | 0.7377 |

[1]The multiple logistic regression models included covariates including age (continuous), locality, religion, Illness within the past two weeks, experience of menarche, sex, marital status, education level, and occupation of caregiver, household size, and total energy intake.
[2]*P* value obtained from multiple logistic regression model with diagnosis of anemia and UIC <50 µg/L as the outcome variables (* *P* <0.05, ** *P* <0.01).

Table 18. Adjusted odds ratios for anemia and UIC <50 μg/L by characteristics of study subjects and their caregivers[1]

| Variables | Anemia | | | *P* value | UIC <50 μg/L | | | *P* value |
|---|---|---|---|---|---|---|---|---|
| | AOR | 95% CI | | | AOR | 95% CI | | |
| ***General characteristics of subjects*** | | | | | | | | |
| Age | 0.84 | 0.61 | 1.17 | 0.3053 | 1.01 | 0.67 | 1.52 | 0.9772 |
| Locality | | | | | | | | |
| Rural (ref) | 1.00 | | | | 1.00 | | | |
| Semi-urban | 0.64 | 0.25 | 1.61 | 0.3394 | 16.32 | 4.92 | 54.11 | <0.0001**[3] |
| Religion | | | | | | | | |
| Christian (ref) | 1.00 | | | | 1.00 | | | |
| Muslim | 3.08 | 0.89 | 10.69 | 0.0762 | 0.24 | 0.04 | 1.66 | 0.1485 |
| Illness within the past two weeks | | | | | | | | |
| Yes (ref) | 1.00 | | | | 1.00 | | | |
| No | 1.48 | 0.63 | 3.46 | 0.3714 | 2.99 | 0.69 | 12.97 | 0.1431 |
| Experienced menarche | | | | | | | | |
| Yes (ref) | 1.00 | | | | 1.00 | | | |
| No | 0.84 | 0.33 | 2.16 | 0.7148 | 1.35 | 0.36 | 5.11 | 0.6559 |
| ***Socioeconomic characteristics of caregivers*** | | | | | | | | |
| Sex | | | | | | | | |
| Men (ref) | 1.00 | | | | 1.00 | | | |
| Women | 2.24 | 0.93 | 5.39 | 0.0728 | 2.43 | 0.71 | 8.37 | 0.1587 |
| Marital status | | | | | | | | |
| Married (ref) | 1.00 | | | | 1.00 | | | |
| Single | 1.07 | 0.43 | 2.67 | 0.8895 | 0.64 | 0.16 | 2.52 | 0.5233 |
| Education level | | | | | | | | |
| No school | 3.77 | 1.32 | 10.82 | 0.0407* | 0.15 | 0.01 | 1.75 | 0.1449 |
| Primary (ref) | 1.00 | | | | 1.00 | | | |
| Secondary/tertiary | 1.01 | 0.38 | 2.73 | | 2.32 | 0.59 | 9.16 | |

Table 18. (cont'd)

| Variables | Anemia | | | P value | UIC <50 µg/L | | | P value |
|---|---|---|---|---|---|---|---|---|
| | AOR | 95% CI | | | AOR | 95% CI | | |
| Occupation | | | | | | | | |
| Peasant farmer (ref) | 0.77 | 0.29 | 2.05 | 0.5962 | 0.17 | 0.03 | 0.97 | 0.0460* |
| Education, health professional, and business | 1.00 | | | | 1.00 | | | |
| Household size | | | | | | | | |
| ≤5 | 0.65 | 0.29 | 1.49 | 0.3107 | 0.60 | 0.18 | 2.03 | 0.4095 |
| >5 (ref) | | | | | | | | |
| ***Dietary intake of Study subjects*** | | | | | | | | |
| Total energy intake | 1.00 | 1.00 | 1.00 | 0.1847 | 1.00 | 1.00 | 1.00 | 0.3963 |
| ***Consumption of iodized salt*** | | | | | | | | |
| Presence of iodine in salt[2] | | | | | | | | |
| Yes (ref) | - | - | | - | 1.00 | | | |
| No | - | - | | | 0.38 | 0.04 | 3.66 | 0.4017 |

[1]The multiple logistic regression models included covariates including age (continuous), locality, religion, Illness within the past two weeks, experience of menarche, sex, marital status, education level, and occupation of caregiver, household size, and total energy intake.
[2]The models also included presence of iodine in salt as an independent variable.
[3]*P* value obtained from multiple logistic regression model with diagnosis of anemia and UIC <50 µg/L as the outcome variables (* *P* <0.05, ** *P* <0.01).

### 4.4.3 Odds ratios for nutritional inadequacies according to dietary intakes of study subjects

AORs of stunting, underweight, anemia, and low iodine status according to dietary intakes are presented in Table 19 and Table 20. Only two micronutrients (iron and zinc) showed significance in AOR of stunting. Adolescent girls consuming less than recommendations for iron and zinc had lower odds for stunting (AOR: 0.21; 95% CI: 0.06-0.72; *P* = 0.0125 for iron, AOR: 0.28; 95% CI: 0.09-0.85; *P* = 0.0249 for zinc) than did those consuming more than recommendation levels after controlling for age, locality, religion, illness within the past two weeks, experience of menarche, total energy intake, household size and sex, marital status, education level, and occupation of caregiver. However, there was no significant association among dietary intakes, underweight, anemia, and low iodine status.

Table 19. Adjusted odds ratios (AORs) for stunting and underweight according to dietary intakes of study subjects[1]

| Variables | Stunting | | | *P* value | Underweight | | | *P* value |
|---|---|---|---|---|---|---|---|---|
| | AOR | 95% CI | 95% CI | | AOR | 95% CI | 95% CI | |
| Protein | | | | | | | | |
| <RDA | 0.45 | 0.18 | 1.14 | 0.0914 | 0.94 | 0.17 | 5.11 | 0.9441 |
| ≥RDA (ref) | | | | | | | | |
| Fiber | | | | | | | | |
| <RDA | 0.21 | 0.06 | 0.72 | 0.0125*[2] | 0.35 | 0.07 | 1.89 | 0.2233 |
| ≥RDA (ref) | | | | | | | | |
| Iron | | | | | | | | |
| <RDA | 0.70 | 0.27 | 1.82 | 0.4635 | 0.75 | 0.08 | 7.25 | 0.8032 |
| ≥RDA (ref) | | | | | | | | |
| Zinc | | | | | | | | |
| <RDA | 0.28 | 0.09 | 0.85 | 0.0249* | 1.19 | 0.19 | 7.55 | 0.8512 |
| ≥RDA (ref) | | | | | | | | |
| Vitamin A | | | | | | | | |
| <RDA | 1.08 | 0.46 | 2.53 | 0.8588 | 0.56 | 0.12 | 2.58 | 0.4592 |
| ≥RDA (ref) | | | | | | | | |
| Folate | | | | | | | | |
| <RDA | 0.67 | 0.07 | 6.70 | 0.7318 | - | | | - |
| ≥RDA (ref) | | | | | | | | |

[1]The multiple logistic regression models included covariates including age (continuous), locality, religion, Illness within the past two weeks, experience of menarche, sex, marital status, education level, and occupation of caregiver, household size, and total energy intake.
[2]*P* value obtained from multiple logistic regression model with diagnosis of anemia and UIC <50 µg/L as the outcome variables (* $P < 0.05$).

Table 20. Adjusted odds ratios (AORs) for anemia and UIC <50 μg/L according to dietary intakes of study subjects[1]

| Variables | Anemia | | | *P* value | UIC <50 μg/L[2] | | | *P* value |
|---|---|---|---|---|---|---|---|---|
| | AOR | 95% CI | 95% CI | | AOR | 95% CI | 95% CI | |
| Protein | | | | | | | | |
| <RDA | 1.05 | 0.38 | 2.94 | 0.9206 | 0.55 | 0.20 | 1.48 | 0.2370 |
| ≥RDA (ref) | | | | | | | | |
| Fiber | | | | | | | | |
| <RDA | 0.87 | 0.32 | 2.39 | 0.7873 | 0.92 | 0.32 | 2.69 | 0.8803 |
| ≥RDA (ref) | | | | | | | | |
| Iron | | | | | | | | |
| <RDA | 1.03 | 0.29 | 3.60 | 0.9675 | 0.82 | 0.20 | 3.31 | 0.7806 |
| ≥RDA (ref) | | | | | | | | |
| Zinc | | | | | | | | |
| <RDA | 3.11 | 0.60 | 16.05 | 0.1753 | 0.40 | 0.14 | 1.16 | 0.0901 |
| ≥RDA (ref) | | | | | | | | |
| Vitamin A | | | | | | | | |
| <RDA | 0.73 | 0.31 | 1.71 | 0.4621 | 1.46 | 0.50 | 4.26 | 0.4883 |
| ≥RDA (ref) | | | | | | | | |
| Folate | | | | | | | | |
| <RDA | 0.44 | 0.07 | 2.81 | 0.3823 | 0.56 | 0.07 | 4.66 | 0.5913 |
| ≥RDA (ref) | | | | | | | | |

[1]The multiple logistic regression models included covariates including age (continuous), locality, religion, Illness within the past two weeks, experience of menarche, sex, marital status, education level, and occupation of caregiver, household size, and total energy intake.
[2]The models also included presence of iodine in salt as an independent variable.

# Chapter 5. Discussion and Conclusion

## 5.1 Nutrition inadequacies among adolescent girls in Kilolo district

### 5.1.1 Stunting among study subjects

Height is one of the anthropometric indexes that help to determine the linear growth of adolescents and children. However, we cannot rely on height alone in assessing normal growth of adolescents since adolescents experience a sharp growth spurt and the onset of puberty (Delisle, 2005). The timing of puberty among adolescents varies depending on geographical location and race that affect physiological differences to attain normal growth (Rogol et al., 2000) so height-for-age percentiles are generally used as a screening tool of growth (WHO and CDC, 2007). Height-for-age percentiles have been used to identify stunting or chronic malnutrition among children and adolescents aged 2-20 years (MoHSW, 2008; Rogol et al., 2000). Prevalence of stunting in Tanzania has been reported to be 34% and in Iringa region was 28% (TFNC, 2014). Iringa region was also one of the top three regions with highest prevalence of stunting in under-five year children (50.1%) (TFNC, 2014).

We found that the odds of stunting among adolescent girls were higher in those who had not experienced menarche than their counterpart. One of possible explanations is that mostly the greatest gain in height takes place the year after menarche but majority of study subjects were between 12-14 years of age that they have not yet experienced menarche (United Nations System SCN, 2006). Another possible explanation is that there can be a delay of menarche in stunted adolescents (Bosch et al., 2008) as the findings from this study showed that the odds of stunting increased with age. Nutrient intakes also affect linear growth as defined from stature. Those who consumed fiber at or above RDA by WHO/FAO were more likely to be stunted compared to those who consumed fiber less than RDA. Fiber plays an important role to enhance digestion and increase bowl movement (Chan et al., 2007) and bioavailability of trace minerals.Fiber has some effects on food intakes especially overnight bloating.Thus adolescents taking high fiber in their normal diet might have poor food intakes for long time resulting in chronic nutrient inadequacies and be at a risk of stunting. Zinc is a crucial nutrient, which is recommended for linear growth and increases the immunity of children and adolescents (Delisle, 2005). We found the significant association between zinc intake and the odds of stunting. However, subjects consuming zinc more than recommended level had higher odds of stunting than those consuming zinc less than recommendation. This could be caused by the big difference in the cell sample size between zinc intake levels (at or above RDA vs. below RDA, 12.5% and 87.5%, respectively).

### 5.1.2 Underweight among study subjects

Majority of the subjects had BMI in the normal range of 19.81±3.55 kg/$m^2$ and the prevalence of underweight was only about 6% among study subjects. Many studies have investigated factors affecting weight status of adolescent. A study by Hill and colleagues (2014) stated there were the disparities in weight status between people in rural area and those in urban setting due to the difference in the level of physical activity. Considering the amount of hours spent on farms, people in the rural areas expend more energy in activities than urban people. Weight status of adolescents is also associated with people who are living with them. This is because adolescent girl living independent or with friends experienced lack time for meal preparation. Students spend most of their time in school between 7:00 am through 4:00 pm plus walking more two hours each day (URT, 2014). Lack of time for meal preparation affects food intake and induces other negative eating habits. Kumar and colleagues found that adolescents not staying with parents had an increasing chance of eating fast foods (Kumar et al., 2013). However, by contrast to previous studies, no associations between the presence of underweight and general characteristics of study subjects were found in this study.

Underweight was associated with experience of menarche in this study (*P* = 0.0231). The average age at menarche is 13 years of age in developing countries (Oh et al., 2012) and 12 years of age in industrialized countries such as US (Chumlea et al., 2003). Menarche is an important indicator of reproductive health of a woman and the age at menarche is affected by nutritional status (Bosch et al., 2008). Additionally, age at menarche is significantly associated with nutritional status (Dars et al., 2014) and weight status (Karapanou and Papadimitriou, 2010). In our study, majority of study subjects were in normal range of body weight based on the "the status quo" method which was used to know the age at menarche. We found that majority were between 15-17 years of age rather than 12-14 years of age.

Caregivers' occupation is one of the important determinants for adequate food and nutrient intakes through the consumption of a diversified diet. The association between adolescent girls' underweight and caregivers' occupation (*P* = 0.0326) was found. A study by Kisanga and colleagues (2013) explained that most of food insecurity challenges affect households who earn income from crop production and a combination of agriculture (peasant). The adolescent girls in peasant farm households tend to continue to have normally monotonous diet because members of this type of household consume food from their own production (Kisanga et al., 2013).

Underweight (BMI-for-age <5th percentile) is still among the public health problems in Tanzania (TFNC, 2014). The prevalence of underweight among adolescent girls (aged 15-19 years) is 17.9% at the national level and 5.0% among women of reproductive age of Iringa region (NBS, 2011). About 6% of study subjects were underweight in this study and the prevalence was three times higher than that of overweight (BMI-for-age ≥85th percentiles). The prevalence was higher than the regional prevalence among women of reproductive age (NBS, 2011). The impact of underweight is passed on from one generation to the next especially when adolescent girls bear children. To make matters worse, they are at a risk of getting children with low birth weight and small-for-gestational-age babies (TFNC, 2014; UNFPA, 2013; Miller, 2000).

Furthermore, in this study, the prevalence of underweight was high in the age group between 15-17 years; this makes the prevalence not to be ignored since 20,000 adolescents below 18 years of age in developing countries give birth every day (UNFPA, 2013). In Tanzania, marriage is legalized at age of 15 years for girls (UNICEF, 2010), thus, majority of women are either mothers or are pregnant with their first child at 19 years of age (NBS, 2011).

Determinants of underweight from contextual point of view are illnesses like diarrhea, which makes a person to lose some nutrients, and inadequate dietary intakes where a person's body demands are not met (UNICEF, 2013; Delisle, 2005). Additionally, underweight was prevalent in subjects who had not experienced menarche than those who had. This is because subjects who had not experienced menarche were at a young age (12-14 years of age). They probably still had some forms of childhood malnutrition carried on and not yet corrected at adolescence (Woodruff and Duffield, 2002). At the same time, these subjects are at a stage where they experience a spike in growth and so the nutrient requirement is much higher than in any other life stage (Haider et al., 2006).

### 5.1.3 Iron deficiency anemia (IDA) among study subjects

Anemia is still a global nutritional problem as it affects all age groups (IFPRI, 2014). About 40% of Tanzanian women of reproductive age have anemia and the prevalence among adolescent girls between 15-19 years of age in Tanzania is higher than the average global prevalence (42%) (NBS, 2011). In the current study, the prevalence of IDA (hemoglobin <12 g/dL) was 22.8% among adolescent girls attending schools with a mean hemoglobin level of 12.7 ±1.2 g/dL. The findings of this study coincide with the result from previous study conducted in Kenya which indicated that the prevalence of IDA was 26%. This was due to the high prevalence of malaria and worm infestations among the subjects (Nelima, 2015). However, compared to adolescents in Kenya, the self-reported information on the symptom of illness from malaria was relatively low (18%) and majority had practiced deworming in this study. Moreover, we found that these two factors were not significantly associated with IDA.

Even though no association was observed between iron intake and the odds of IDA in this study, majority of subjects consumed iron less than recommended level. In addition, most of the foods consumed by study subjects were plant-based which contain non-heme iron. Non-heme iron has low bioavailability due to compounds such as phytic acid and oxalate in plant-based diets (Hess et al., 2002). These compounds are high in cereals of which all study subjects consumed. Furthermore, the odds of becoming anemic were higher in subjects whose caregiver had no education compared to those whose caregiver attained primary education. This may suggest that education level is a socioeconomic indicator and households with high socioeconomic status tend to consume high nutrient rich foods. A study by Kim and colleagues (2014) reported that adolescent girls in household of high socioeconomic status had lower prevalence of anemia compared to their counterparts.

### 5.1.4 Iodine status among study subjects

Low dietary iodine intake is still a public health problem in both industrialized and developing countries (Pearce et al., 2013). Globally, more than 35% of people have been reported to have inadequate iodine intake (WHO, 2013). Fortunately, the prevalence of iodine deficiency has been gradually decreasing due to the success of universal salt iodization practiced in many African countries (Pearce et al., 2013). Tanzania is one of the seven countries in Africa that have been reported to have a coverage of more than 90 % of households consuming iodized salt. However, only 59% of households were reported to have consumed adequately iodized salt (NBS, 2011). Findings of the current study in which 69.7% of household consumed iodized salt are consistent with those in the previous report (NBS, 2011).

Since 90% of iodine is excreted in the urine (Rohner et al., 2014), UIC has been used as a marker for assessing iodine nutrition of a population and then interpreted based on the WHO cut-off references for iodine status classification (WHO, 2004). Universal salt iodization has been positively associated to UIC (WHO, 2013). The median UIC of the subjects who provided urine sample (n=177, 84%) was 227.1 µg/L, which indicated that the study population was consuming adequate amounts of iodine (more than 150 µg/day). The prevalence of UIC <50 µg/L was 16.4%. This is below the WHO goal of fewer than 20% of the population having <50 µg/L UIC. Our findings show a remarkable improvement of iodine nutrition as compared to the median UIC that was reported among women of reproductive age at the national level (NBS, 2011).

There is an established relationship between iron deficiency and iodine deficiency because the thyroid peroxidase requires iron molecule for the initiation of thyroid hormone formation. Particularly, low levels of ferritin, an indication of iron deficiency, decreases the activity of thyroid peroxidase, which is the initiator of the first stage of thyroid hormone synthesis (Hess et al., 2002). We found that the prevalence of IDA was higher compared to that of low iodine status.. The levels of UIC were statistically associated with education level and occupation of caregivers and household size of the adolescent girls in this study. Low socioeconomic status is positively associated with food insecurity (NBS, 2011; IFPRI, 2014; Kisanga et al, 2013). Miller (2009) also confirmed that adolescent between 12-14 years of age were the most affected by household food insecurity. Children in food insecure household were three times more likely to be at risks of nutritional inadequacies such as iodine deficiency than children in food secure household (Eicher-Miller et al., 2009).

## 5.2 Nutrition status and diet diversity among adolescent girls in Kilolo district

Household food insecurity status in the country differs from region to region (Kisanga et al., 2013) and season to season (Ntwenya et al., 2015). Worst scenarios of the prevalent household food insecurity have been documented to be during rainy season (Ntwenya et al., 2015). During rainy season, accessibility to food before harvesting is low and agriculturalist experience increased workload, which affects the balance of energy intake and expenditure, due to various farm operations.

A study by Mazengo and colleagues (1997) found that most of energy intake was from carbohydrate due to high consumption of cereal staples with little intake of animal sources. In the present study, 99.5% of the study subjects consumed cereal and cereal made products (this was either as a staple consumed at home or a snack sold at school canteen). Cereals provide energy because their biggest part is carbohydrate, but the amount of energy provided by one gram of fat (9 kcal/gram) is higher than that from carbohydrates (4 kcal/gram). In addition, majority of the subjects consumed three meals a day. This is still very common meal patterns in Tanzanian since three-meal a day pattern was reported almost 20 years ago (Mazengo et al., 1997; Kalinjuma et al., 2013). Tthe reasons for 98% of the subjects not meeting the WHO/FAO recommendations can be explained in many different ways.

Majority of adolescent girls in rural Tanzania had limited diversity in their diets because of reliance on their own cultivated foods (Kisanga et al., 2013). This is true with Kilolo district in Iringa region because about 75% of the caregivers were peasant farmers as reported by the subjects. Most of the nutrients are obtained from one or two food groups. For example, the main source of calories is starchy staples such as cereals and root tubers in such households. As mentioned earlier, majority of the study subjects consumed cereals (100%) and dark green leafy vegetables (71.6%) over eggs (5.8%), meat/fish (4.4%), and milk and milk products (3.4%).The frequency and the amount of consuming foods that could provide high amounts of energy were very low.

## 5.3 Conclusion

In the present study we found the prevalence of stunting (21.6%), underweight (5.8%), anemia (22.8%) and UIC <50 µg/L (16.4%) among adolescent girls who attend schools in rural Tanzania. They consumed iodized salt and had adequate iodine status at population level (median UIC = 227.1 µg/L). Socio-economic status of adolescent girls' caregivers was more important determinants of nutritional inadequacies than characteristics of adolescents and their nutrient intakes among Tanzanian adolescent girls in Kilolo district. Therefore, we find importance of emphasizing adolescents' caregiver education for combating nutritional inadequacies in this district of Tanzania. Findings from our cross-sectional study design provided a snap shot with high variabilities of subjects' characteristicas and health and dietary indicators. Furthermore, school-attending adolescent girls are likely different from those who dropped out or never attended schools. In the future, a longitudinal study regarding the impacts of the nutritional inadequacies in childbearing age girls needs to be conducted.

## 5.4 Strengths

The strength of this study is the research subjects being adolescent girls, a group that attention has not been paid to in Tanzania yet but is very important in the development of the nation. The random sampling of day schools to get adolescent girls in the study allows for generalizability of the results to rural households in Kilolo district. We captured meaningful information on current prevalence of nutritional inadequacies and nutrient intakes and diet diversity in rural Tanzania. Weidentified predictors of nutritional inadequacies such as stunting, underweight, anemia, and low iodine status at the population level. Furthermore, the findings can help in designing school-based programs that can improve nutrition status of adolescent girls in Tanzania.

## 5.5 Limitations

The limitation of the study is its study design being crosssection in which the outcomes are measured at the same time as the predictors. Therefore, causal-effect relationships cannot be deduces. There is a high probability of having recall errors which can affect results based on self-reported data except anthropometric and biochemical assessments. We attribute several weak statistical associations and limited numbers of determinants identified were due to relatively small sample size and possibly recall errors.

# APPENDICES

# APPENDICES

## APPENDIX A: Briefing script (English version)

### DETERMINANTS OF NUTRITIONAL INADEQUACIES AMONG ADOLESCENT GIRLS IN RURAL TANZANIA, IRINGA REGION, CASE OF KILOLO DISTRICT

Hello. My name is Saidah M Bakar, I am working with Dr. Song at **Michigan State University** who collaborates with Dr. Nyaruhucha from **Sokoine University of Agriculture**. We are here to study maternal nutrition and child health, focusing on determinants of nutritional inadequacies among adolescent girls in the rural Tanzania. This school has been selected to participate, participant's views and feelings towards this topic will be put together in assessing the outcomes (Food security, adequate nutrient intake, and BMI, iron and iodine status) from this study participants will immediately know their nutrition status like BMI and iron status.

All information participants will provide in the interview will be kept confidential and used for the purposes of this study only and will in no way affect the participants' relationship with their parents and school administrator. The interview will take between 20 to 25 minutes of one's time.

The objective is to obtain information that will assist in designing an intervention program to help adolescent girls in rural Tanzania.

Participation will be voluntary and one can decline to participate without any consequences of any kind, participant will be asked to kindly indicate if they are willing to proceed with the interview and at the same time, a participant will be free not to answer the question she is not willing to respond to and the interviewer will go on to the next question.

As a participant, we are going to provide a consent forms that you will provide to parents and / guardians, explaining to them that this study is to know the nutrition status of adolescent girls in the district and your school by chance happened to be among the participating school. After the consent is signed by you / your parent /guardian please return this form to your class teacher because on the day we will be conducting the study, these forms will be needed. Also please remember that we will provide small container which you will provide us with 2 table spoonful of the kitchen salt, this salt will also be presented on the data collection day, furthermore, we will give you small container which will need 20mL of urine early in the morning during the survey day.

Do you have any question? (Session for question and answers)

We are going to have a small exercise in class. We will randomly select our participants and these will consent with us so as we give them the consent forms for parents/ guardians.

**Thank you very much**

**APPENDIX B*: Parent/guardian informed consent form for subjects 13-17 years old (English version)***

**Title: Determinants of Nutritional Inadequacies among Adolescent Girls in Rural Tanzania**

**Purpose:** Your daughter (1) invited to participate in this research project as per her and willingness of the school to allow their student to participate. (2) This study will identify the determinants of food insecurity and nutritional inadequacies among adolescent girls in this district. Nutritional inadequacies are common in adolescent girls because of their development peak if not corrected, nutritional deficiencies hinder their potential to study, performance in class, production in and outside schools and her reproduction later in life.

The information obtained from this study would help increasing knowledge on nutritional inadequacies and further be used in designing an intervention for adolescent girls in rural Tanzania. This study is being conducted by Michigan State University, USA in collaboration with Sokoine University of Agriculture, Morogoro Tanzania. The study is sponsored by USAID/ Innovative Agricultural Research Initiative (iAGRI)

**Procedure:** Your daughter has been selected by chance from the rest of her classmate, from your daughter's willingness to participate, you will be asked to consent to her participation. In the study, your daughter will be asked about (1) socio demographics, reproductive health, measured weight and height (2) she will have a non-invasive machine clipped on her ring finger of a non-dominant hand to assess iron status basing on hemoglobin levels (this machine does not draw blood from a subject only the sensor senses the levels of Hemoglobin, it is battery operated and has no harm). (3) Will also be asked to provide a 10mL urine sample to measure her iodine status. This urine sample will be coded and tested at the Tanzanian Food and Nutrition Laboratory. Finally will request you to recall the foods you ate in the previous 24 hours prior to study date.

**Risks/Discomforts** There is absolutely no pain using the designed tools, no health complications and providing the requested biological sample is not associated with any kind of risk.

**Benefits:** Your daughter will benefit by getting to know her nutrition status such as BMI and iron status. The researchers hope that adolescents will benefit in the future through public health interventions. Your child will also be given a pen, diary and breakfast in the morning after collecting samples and this will be TZSH 3000 ($1.88)

**Confidentiality:** No names will be attached thus no results will be released to you or anyone; the result will be kept strictly confidential and will not be shared with anyone except members of our survey team. Information about you/your child will be kept confidential to the maximum extent allowable by law. Data will be coded to increase privacy. Records will be kept at Sokoine

University of Agriculture, Michigan State University and Urine samples analyzed for research and kept for at least three years at Tanzanian Food and Nutrition Laboratory. Records will be accessible to the study team, the sponsor, and/or the MSU HRPP.

**Your Rights to not participate in the study:** Participation of your child will be completely voluntary. Refusal to participate or discontinued participation at any time will result no penalty. If you have concerns or questions about this study, such as scientific issues, or to report an injury, please contact the researchers named below:

**Won O Song, PhD, MPH, RD**
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**Contact information for Institutional Review Boards**
If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish.

**National Health Research Ethics Review Committee**
National Institute for Medical Research
2448 Ocean Road, P.O. Box 9653

**Sokoine University of Agriculture,**
P.O.Box 3000, Chuo Kikuu Morogoro, Tanzania.
E-mail: sua@suanet.ac.tz

By signing this sheet, you certify that you\your daughter have read explanation of this consent form and have received answers to all your questions/concerns. Both of your signatures below indicate voluntarily participation in this study.

Parent name: ………………………… Signature and/or thumb print………………… Date ………………

Student name: ……………………….. Signature and/or thumb print………………… Date ………………

**APPENDIX C: Introduction to students before interviewing (English version)**

Hello. My name is ………………….. .I am working with Dr. Song at **Michigan State University** who collaborates with Dr. Nyaruhucha from **Sokoine University of Agriculture**. We are here to study maternal nutrition and child health, focusing on determinants of nutritional inadequate among adolescent girls in the rural Tanzania. This school has been selected to participate, all your views and feelings towards this topic will be put together in assessing the outcomes (food security and adequate nutrient intake) from this study you will immediately know your nutrition status like BMI and iron status.

All information you give in this interview will be kept confidential and used for the purposes of this study only and will in no way affect your relationship with your parents and school administrator. This interview will take between 20 to 25 minutes of your time.

Please note that you are not taking a test. We are trying to obtain information that will assist in designing an intervention program to help adolescent girls in rural Tanzania.

This is a voluntary participation and you can decline to participate without any consequences of any kind. Kindly indicate if we can proceed with the interview.

You don't have to be in the survey but we hope that you will agree to answer the questions since your views are important. If I ask you any question you don't want to answer, just let me know and I will go on to the next question or you can stop the interview at any time.

Do you have any questions?

May I begin the interview now...............................

Signature of interviewer: …………………Date……. /……. /…….

**APPENDIX D: Survey questionnaire (English version)**

**Determinants of Nutritional Inadequacy among Adolescent Girls in Rural Tanzania Questionnaire: Iringa Region, Case of Kilolo District Council (January – March 2016)**

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**IDENTIFICATION: Code………Ward………Enumeration area.................School name …...........**

**The following questions will be asked so that we get a snap shoot about you and your household**

**Section I: Respondent's Background**

1. During school days who day you stay with?
   1 Independent 2 Family 3 Relatives 4 Others (specify)………..
2. What is the sex of the head of the household?
   1 Male 2 Female
3. What is the occupation of the head of your household?
   1 Peasant 2 Education profession 3 Health profession 4 Business man 5 Others (specify)
4. Currently what is her/his marital status?
   1 Married 2 Single 3 separated 4 Divorced 5 Widowed
5. What is the highest level of education that s/he has completed?
   1 No school 2 Primary 3 Secondary O-level 4 Secondary A-level 5 Others (specify)
6. What is your relationship with the head of the household?
   1 Mother 2 Father 3 Grandmother 4 Uncle 5 Aunt 6 Others (specify)
7. How many people are currently living in your household, including yourself? ……...
8. How many people including you are under 18yr? …………………..
9. What mode / transportation vessel do you use to come to school?
   1 Walk 2 Ride bicycle 3 Board Motorcycle 4 Use public car 5 Others (specify)
10. What is the name of your residence/ village ………………
11. By estimates how many kilometers is your residence to school?
   1 0-1 2 1-2 3 2-3 4 3-4 5 More than 4 ………..

12. May I please have the salt you brought with you to be tested for iodine content and labeled?

[1] Had salt   [2] No salt   [3] ***If no salt, skip 12 and 13***

13. Did you use this same salt to cook the main meal eaten by members in household last night?

[1] Yes   [2] No

14. Test for the presence and amount of iodine in the salt sample presented

[1] Present above 15.ppm   [2] Present below 15.ppm   [3] Not present

**Section II: Nutrition and Reproductive Health**

Now I would like to ask you questions about your reproductive health

15. In what month and year were you born? ……../………..so you are …………years old

16. What is your religion?

[1] Christian   [2] Muslim   [3] Christian - SDA   [4] Pentecostal   [5] Others

16. Have you been sick recently within the past 2 weeks?

[1] Yes   [2] No   [3] ***if no skip 17***

17. Within the past 2 week, state what you were suffering from?

[1] Malaria   [2] Diarrhea   [3] Typhoid   [4] Others (specify)…………….

18. Have you ever heard about deworming?

[1] Yes   [2] No   [3] ***if no skip 19-20***

19. Have you ever dewormed?

[1] Yes   [2] No   [3] ***if no skip 20***

20. When was the last time you dewormed?

[1] Few days ago   [2] 4 Weeks ago   [3] 3 Months ago   [4] Others (specify)………

21. Have you experienced menarche?

[1] Yes   [2] No   [3] ***if no skip 21***

22. When did you have your last menstrual period?

[1] Few days ago   [2] 4 Weeks ago   [3] 3 Months ago   [4] 1 Year ago

23. These are measurements that I will need you and me to perform

| 1 | Weight ……..kg | 2 | Height … …..cm | 3 | ***Hb (pronto)…………...g/L*** | ***4*** | ***Hb (Hemocue) ………g/dL*** |
|---|---|---|---|---|---|---|---|

24. As part of this survey we also are asking adolescents in other schools to take a test for iodine. For the iodine test, we need a small amount of your urine. Urine sample received and coded?

| 1 | Yes | 2 | No | 3 | CODE… |
|---|---|---|---|---|---|

**Section III: 24hour Dietary Recall Form**

**Now I would like us to go in details of the foods you ate from yesterday morning until now. And here will be estimating the amount you had. Feel free to mention both foods and beverages made from even local/ wild sources. Describe in detail. List one food per line**

| **Quick list of foods and drink items** | **Time Am/pm** | **Method of cooking & individual ingredients** | **Amount eaten (utensil used)** | **Activity while Eating Ex: watching TV** | **Eaten at home (Y/N)** |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

24. is the food intake described above a typical one or atypical?

| 1 | A typical | 2 | Typical |
|---|---|---|---|

***Thank you for your cooperation!!!***

**Section IV: Food Intake and Dietary Diversity**

**Now I am going to ask you what you ate and drank yesterday**

Please describe the foods (meals and snacks) that you ate or drank yesterday during the day and night, whether at home or outside the home. Start with the First food or drink of the morning. *Write down all foods and drinks mentioned. When composite dishes are mentioned, Ask for the list of ingredients when the respondent has finished, probe for meals and snacks not mentioned.*

| **List of foods the respondent ate yesterday** |
|---|
| |

| QN | Food group | Example | Yes | No |
|---|---|---|---|---|
| **01** | CEREALS | corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these(e.g. bread, noodles, porridge or other grain products) + e*.g. ugali, porridge or paste* | …… | ...... |
| **02** | WHITE ROOTS AND TUBERS | white potatoes, white yam, white cassava, or other foods made from roots e.g. *chips* | …… | …. |
| **03** | VITAMIN A RICH VEGETABLES AND TUBERS | Pumpkin, carrot, squash, or sweet potato that are orange inside + *other locally available vitamin A rich vegetables (e.g. red sweet pepper )* | …… | …. |
| **04** | DARK GREEN LEAFY VEGETABLES | dark green leafy vegetables, including wild forms + *locally available vitamin A rich leaves such as amaranth, cassava leaves, bean leaves, pumpkin leaves, okra, kale spinach* | …… | ..... |
| **05** | OTHER VEGETABLES | other vegetables (e.g. tomato, onion, eggplant) + *other locally available vegetables* | | …. |

| | | | | |
|---|---|---|---|---|
| | | | …<br>… | |
| **06** | VITAMIN A RICH FRUITS | ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + watermelon , pineapple *other locally available vitamin A rich fruit Azam juice* | …<br>… | …. |
| **07** | OTHER FRUITS | Other fruits, including wild fruits and 100% fruit juice made from these. *Mitooo,* | …<br>… | … |
| **08** | ORGAN MEAT | liver, kidney, heart or other organ meats or blood-based foods | …<br>… | ….<br>. |
| **09** | FLESH MEATS | beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects | …. | … |
| **10** | EGGS | eggs from chicken, duck, guinea fowl or any other egg, milk and milk products like yoghurt, cheese | …<br>… | … |
| **11** | FISH & SEAFOOD | fresh or dried fish or shellfish | …<br>… | … |
| **12** | DAIRY | Milk and milk products example , milk, cheese, yoghurt | | |
| **13** | Legumes , nuts and pulses | Beans, peanut, sunflower seeds, pigeon peas and the local dishes from this. | ….. | … |
| **14** | Fungi | Chanterelle , mushroom and local dishes from this and related edible species | …<br>… | …. |

**APPENDIX E: Maelezo kwa Ufupi (Briefing script) (Kiswahili version)**

Jina langu ni Saidah M Bakar, ninafanya kazi na Dr. Song katika Chuo kikuu cha Jimbo la Michigan (**Michigan State University)** ambaye anashirikiana na Dr. Nyaruhucha kutoka Chuo kikuu cha Kilimo Sokoine( **Sokoine University of Agriculture)**. Tunatafiti lishe ya uzazi na afya ya mototo kwa kuzingatia sababu za upungufu wa lishe kwa baadhi ya wasichana waliovunja ungo Tanzania vijijini. Shule hii imechaguliwa kushiriki kutoa washiriki amabapo mawazo na hisia zao kuhusiana na mada hii vitawekwa pamoja na kujua matokea(usalama wa chakula,lishe ya kutosha ya kula na BMI,madini ya chuma na kiwango cha madini ya joto).

Maelezo yote watakayotoa washiriki yatakuwa ni siri na kutumiwa kwaajili ya utafiti huu tu, na hayataathiri uhusiano uliopo kati yao na wazazi au utawala wa shule. Mahojiano yatachukua kati ya dakika 20 mpaka 25 kwa mtu mmoja.

Lengo la utafiti huu ni kupata taarifa zitakazo saidia kupanga mkakati maalum wa kusaidia wasichana waliovunja ungo Tanzania vijijini.

Ushiriki utakuwa ni wa hiyari na yeyote anaweza kukataa kushiriki bila shinikizo lolote. Washiriki pia wataulizwa kama wako tayari kuendelea na mahojiano, na pia watakuwa huru kuacha kujibu swali lolote ambalo hawako tayari kujibu na mahojiano yataendelea kwa kuulizwa maswali mengine.

Kama mshiriki,tutakupatia fomu ambazo utawapatia wazazi na/walezi, kuwaelezea kuwa utafiti huu ni kujua hali ya lishe ya wasichana waliovunja ungo wilayani na shuleni kwako, na kuwa shule yako imebahatika kuchaguliwa katika kusaidia utafiti huu.

Baada ya kusaini mkataba huu wa ridhaa yako/wazazi wako/walezi, tafadhali rudisha fomu hii kwa mwalimu wako wa darasa. Kwasababu siku tutakayokuwa tunaendesha mahojiano fomu hizi zitahitajika. Pia tutawapatia vifuko vidogo ili utuwekee vijiko vidogo viwili vya chumvi ya kupikia, na chumvi hii itachukuliwa siku ya kukusanya taarifa za mahojiano. Pia tutawapatia vichupa vidogo ambavyo tutahitaji mkojo 20mL asubuhi ya siku ya utafiti.

Una swali lolote? (kipindi cha maswali na majibu)

Tutakuwa na zoezi dogo darasani. Tutachagua washiriki wetu na tutaridhiana nao,na kuwapa fomu za ridhaa kwaajili ya wazazi/walezi.

**Ahsante Sana!**

**APPENDIX F: Fomu ya ridhaa ya Mzazi/Mlezi wa Msichana wa miaka chini ya 13-17 (Kiswahili version)**

Anwani: Sababu za upungufu wa lishe kwa baadhi ya wasichana walio balehe Tanzania vijijini.

**Lengo:** Mtoto wako (1) anaalikwa kushiriki katika utafiti huu kwa ridhaa yake na ridhaa ya shule kumruhusu kushiriki. (2) Utafiti huu utaonyesha sababu za ukosefu wa chakula katika kaya na upungufu wa lishe kamilifu katika miliwi ya wasichana katika wilaya hii. Upungufu wa virutubisho na lishe duuni ni jambo la kawaida hasa kwa wasichana walio balehe. Upungufu huu wa virutubisho na lishe duuni unaathiri uwezo wasichana hawa kujisomea, kufanya vizuri darasani, afya na uzazi na maisha bora kuanzia shule ya msingi na sendary mpaka hapo baadaye katika maisha.

Taarifa zitakazopatikana katika utafiti huu zitasaidia kuongeza maarifa kuhusu upungufu wa lishe na kuweza kutumika katika kuandaa mkakati kwa wasichana walio balehe Tanzania vijijini. Utafiti huu unaendeshwa na Chuo kikuu cha Jimbo la Michigan, Marekani kwa kushrikiana na Chuo kikuu cha kilimo Sokoine, Morogoro. Utafiti huu unadhaminiwa na USAID/ Innovative Agricultural Research Initiative (iAGRI)

**Taratibu:** Mtoto wako amechaguliwa kwa bahati kati ya darasa zima na baada ya ridhaa yake, kushiriki. Pia anahitajika kupata ridhaa yako. Yeye ataulizwa kuhusu (1) idadi ya watu na kipato katika kaya, afya ya uzazi na ataroodhesha aina mbali mbali ya chakula uliokula siku ya jana kwanzia ulivo amka hadi kuingia kitanadan (2) atawekewa mashine isio sababisha maumivu (non-invasive) kidoleni ili kupima hali ya madini ya chuma kulingana na wingi wa damu (mashine hii haitoi damu ila kihisi ndicho kitahisi wingi wa damu. Inatumia betri na haina madhara yoyote) kama atatokea kuombwa damu, atachomwa kidole chakati ili kupima hali ya madini ya chuma kulingana na wingi wa damu kwa kutumia hemocue (mashine hii inatoa damu kidogo sana kuwezesha upimaji wa wingi wa damu. Inatumia betri na haina madhara yoyote) (3) Pia ataombwa kuleta mkojo 10mL ili kupima kiwango cha madini joto mwilini. Mkojo huu utapimwa katika maabara ya tasisi ya Chakula na lishe Tanzania.

Tatizo/Usumbufu Hakuna kabisa maumivu katika matumizi ya vifaa vitakavyotumika, wala matatizo yoyote ya kiafya na vipimo vilivyotakiwa havihusiani na kuwa na tatizo lolote. Ila kwa baadhi ya watakaombwa damu maumivu kwa mbali kwenye mchubuko ambae yanaisha baada ya seconde kadha yata sikika.

**Faida:** Mtoto wako atanufaika kwa kujua hali ya lishe kama vile BMI na hali ya madini ya chuma. Watafiti wanategemea wasichana walio balehe watapata faida kupitia mkakati wa afya ya uma hapo baadaye.Mtoto wako atapatiwa peni, shajara (diary) na chai ya asubuhi baada ya kuchukua vipimo na hii itagharimu TZSH 3000 ($1.62)

**Usiri:** Hakuna majina yatakayobandikwa ndiyo maana hakuna majibu yatakayotolewa kwako au kwa yeyote. Majibu yatahifadhiwa kwa usiri wa hali ya juu, na hayataonyeshwa kwa mtu yoyote ispokuwa wajumbe katika jopo la watafiti. Taarifa zako zitahifadhiwa kwa usiri wa hali ya juu kama inavyotakiwa na sharia. Takwimu zitawekewa namba za siri ili kuongeza usiri. Kumbukumbu zitawekwa katika Chuo kikuu cha kilimo Sokoine, Chuo kikuu cha Jimbo la Michigan na vipimo vya mkojo vitakavyotumika kwaajili ya utafiti, vitawekwa kwa miaka mitatu katika maabara ya taasisi ya chakula na lishe Tanzania. Uwezo wa kupata taarifa za utafiti utakuwa ni wa wajumbe wa timu ya utafiti,wadhamini,na/au wawakilishi walioidhinishwa na taasisi.

**Haki za kutoshiriki katika utafiti huu:** Ushiriki wa Mtoto wako utakuwa ni wa hiyari. Kukataa kushiriki au kukatisha ushiriki mda wowote hautakuwa na adhabu yoyote. Kama una tatizo lolote au swali kuhusu utafiti huu, kama vile maswala ya kisayansi au kutoa taarifa ya hatari. Tafadhali wasiliana na watafiti wafuatao:


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**Mawasiliano kwa Bodi ya Mapitio ya Kitaasisi**

Kama una swali lolote kuhusiana na jukumu au haki zako kama mshiriki wa utafiti, kupata taarifa au kutoa taarifa au kutoa malalamiko kuhusiana na utafiti huu. Unaweza kuwasiliana na umtakaye.

**Michigan State University's Human Research Protection Program**
Telephone: +1 517 355 2180, E-mail: irb@msu.edu or Regular mail: 408 West Circle Drive, Olds Hall Room 207, MSU, East

**National Health Research Ethics Review Committee**
**National Institute for Medical Research**

Kwa kusaini karatasi hii, umekubali kuwa umesoma/kuelewa maelezo ya mkataba huu wa kuridhia na kupata majibu ya maswali yote. Saini yangu hapo chini inaashiria, nimekubali kwa hiyari yangu ushiriki wangu/wa Mtoto wangu katika utafiti huu.

Jina la mzazi/mlezi …………… Saini na /au dole gumba……………… Tarehe …………

Namba ya utambulisho/ mtoto …………Saini na /dole gumba……………Tarehe………

**APPENDIX G: Fomu ya ridhaa ya Mzazi/Mlezi/Msichana wa miaka 18-19 (Kiswahili version)**

**Anwani: Sababu za upungufu wa lishe kwa baadhi ya wasichana waliobalehe Tanzania vijijini.**

**Lengo:** wewe (1) Unaalikwa kushiriki katika utafiti huu kwa ridhaa yako na ridhaa ya shule kuruhusu kushiriki. (2) Utafiti huu utaonyesha sababu za ukosefu wa chakula katika kaaya na upungufu wa virutubisho katika chakula kwa wasichana katika wilaya hii. Upungufu wa virutubisho katika lishe ni jambo la kawaida hasa kwa wasichana waliobalehe. Upungufu huu wa virutubisho katika lishe unaathiri uwezo wa kujisomea, kufanya vizuri darasani, kusoma, uzazi na maisha bora kuanzia shule ya msingi na sendari mpaka hapo baadaye katika maisha.

Taarifa zitakazopatikana katika utafiti huu zitasaidia kuongeza maarifa kuhusu upungufu wa virutubisho na kuweza kutumika katika kuandaa mkakati kwa wasichana waliobalehe Tanzania vijijini. Utafiti huu unaendeshwa na Chuo kikuu cha Jimbo la Michigan, Marekani kwa kushrikiana na Chuo kikuu cha kilimo Sokoine, Morogoro. Utafiti huu unadhaminiwa na USAID/ Innovative Agricultural Research Initiative (iAGRI)

**Taratibu:** Wewe umechaguliwa kwa bahati kati ya darasa zima na baada ya ridhaa yako, kushiriki. utaulizwa taarifa kuhusu (1) idadi ya watu na kipato katika kaya, afya ya uzazi na utaroodhesha aina mbali mbali ya chakula uliokula siku ya jana kwanzia ulivo amka hadi kuingia kitanadan (2) utawekewa mashine isio sababisha maumivu (**non-invasive)** kidoleni ili kupima hali ya madini ya chuma kulingana na wingi wa damu (mashine hii haitoi damu ila kihisi ndicho kitahisi wingi wa damu. Inatumia betri na haina madhara yoyote) kama itatokea kuombwa damu, utachomwa kidole chakati ili kupima hali ya madini ya chuma kulingana na wingi wa damu na hemocue (mashine hii inatoa damu kidogo sana kuwezsha upimaji wa wingi wa damu. Inatumia betri na haina madhara yoyote) (3) Pia utaombwa kuleta mkojo 10mL ili kupima kiwango cha madini joto mwilini. Mokojo huu utapimwa katika maabara ya tasisi ya Chakula na lishe Tanzania.

**Tatizo/Usumbufu** Hakuna kabisa maumivu katika matumizi ya vifaa vitakavyotumika, wala matatizo yoyote ya kiafya na vpimo vilivyotakiwa havihusiani na kuwa na tatioz lolote. Ila kwa baadhi ya watakaombwa damu maumivi kidogo kwenye mchubuko ambae yanaisha baada ya seconde kadha.

**Faida:** utanufaika kwa kujua hali ya lishe kama vile BMI na hali ya madini ya chuma. Watafiti wanategemea wasichana waliobalehe watapata faida kupitia mkakati wa afya ya uma hapo baadaye.utapatiwa peni, shajara (diary)na chai ya asubuhi baada ya kuchukua vipimo na hii itagharimu TZSH 3000 ($1.62)

**Usiri:** hakuna majina yatakayobandikwa ndiyo maana hakuna majibu yatakayotolewa kwako au kwa yeyote. Majibu yatahifadhiwa kwa usiri wa hali ya juu, na hayataonyeshwa kwa mtu yoyote ispokuwa wajumbe katika jopo la watafiti. Taarifa zako zitahifadhiwa kwa usiri wa hali ya juu kama inavyotakiwa na sharia. Takwimu zitawekewa namba za siri ili kuongeza usiri. Kumbukumbu zitawekwa katika Chuo kikuu cha kilimo Sokoine, Chuo kikuu cha Jimbo la Michigan na vipimo vya mkojo vitakavyotumika kwaajili ya utafiti, vitawekwa kwa miaka mitatu katika maabara ya taasisi ya chakula na lishe Tanzania. Uwezo wa kupata taarifa za utafiti utakuwa ni wa wajumbe wa timu ya utafiti, wadhamini, na/au wawakilishi walioidhinishwa na taasisi.

**Haki za kutoshiriki katika utafiti huu:** Ushiriki wako utakuwa ni wa hiyari. Kukataa kushiriki au kukatisha ushiriki mda wowote hautakuwa na adhabu yoyote. Kama una tatizo lolote au swali kuhusu utafiti huu, kama vile maswala ya kisayansi au kutoa taarifa ya hatari. Tafadhali wasiliana na watafiti wafuatao:

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Kama una swali lolote kuhusiana na jukumu au haki zako kama mshiriki wa utafiti, kupata taarifa au kutoa taarifa au kutoa malalamiko kuhusiana na utafiti huu. Unaweza kuwasiliana na umtakaye.

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Kwa kusaini karatasi hii, umekubali kuwa umesoma/kuelewa maelezo ya mkataba huu wa kuridhia na kupata majibu ya maswali yote. Saini yangu hapo chini inaashiria, nimekubali kwa hiyari yangu ushiriki wangu/ katika utafiti huu.

Namba ya utamblisho ………………………… Saini na /dole gumba…………………….

Tarehe…………………………

**SABABU ZA UPUNGUFU WA LISHE KWA BAADHI YA WASICHANA WALIO BALEHE TANZANIA VIJIJINI, MKOA WA IRINGA, UTAFITI WA HALMASHAURI YA WILAYA YA KILOLO.**

**APPENDIX H*:* Utambulisho Introduction to students before interviewing (Kiswahili version)**

Jina langu ni ….  …...  ninafanya kazi na Dr. Song katika Chuo kikuu cha Jimbo la Michigan (**Michigan State University)** ambaye anashirikiana na Dr. Nyaruhucha kutoka Chuo kikuu cha Kilimo Sokoine ( **Sokoine University of Agriculture)**. Tunatafiti lishe ya uzazi na afya ya mtoto kwa kuzingatia sababu za upungufu wa lishe kwa baadhi ya wasichana walio balehe Tanzania vijijini. Shule hii imechaguliwa kushiriki kutoa washiriki amabapo mawazo na hisia zao kuhusiana na mada hii vitawekwa pamoja na kujua matokeo (ukosfu wa chakula,lishe inaotosheleza, BMI,madini ya chuma na kiwango cha madini joto).

Maelezo yote utakayotoa kama mshiriki yatakuwa ni siri na kutumiwa kwaajili ya utafiti huu tu, na hayataathiri uhusiano uliopo kati yako na wazazi au utawala wa shule. Mahojiano yetu yatachukua kati ya dakika 20 mpaka 25.

Lengo la utafiti huu ni kupata taarifa zitakazo saidia kupanga mkakati maalum wa kusaidia wasichana walio balehe Tanzania vijijini.

Kumbuka kushiriki kwako ni kwa hiyari na unaweza kukataa kushiriki bila shinikizo lolote. Uko tayari tayari kuendelea na mahojiano, naomba uwe huru kuacha kujibu swali lolote ambalo utakuwa hawuko tayari kujibu na naomba unioneshe ishara ya kuendelea na mahojiano kwa kuuliza maswali mengine.

Una swali lolote?

Naweza kuanza mahojiano sasa.............

Saini ya msaili: …………………Tarehe ……. /……. /…….

Ahsante Sana!

**APPENDIX I: Survey questionnaire (Kiswahili version)**

**DODOSO LA SABABU ZA UPUNGUFU WA LISHE KWA BAADHI YA WASICHANA WALIO BALEHE: TANZANIA VIJIJINI, MKOA WA IRINGA, UTAFITI WA HALMASHAURI YA WILAYA YA KILOLO. (January –March, 2016)**

**UTAMBULISHO: Kata …………………Numeration Area.......................mkuu wa shule…………………….... Maswali yafuatayo yataulizwa ilipupate ufahamu wa kuhusu wewe na kaya yako**

**Sehemu I: Taarifa za mhojiwa**

1. Unakaa peke yako au na familia?

   1 Peke yangu  2 Familia  3 Ndugu  4 Wengine

2. Ni ipi jinsia ya kiongozi wa kaya?

   1 Mme  2 Mke

3. Ni ipi kazi ya kiongozi wa familia?

   1 Peasant  2 Fani katika Elimu  3 Afya  4 Biashara  5 Nyengine

4. Kwasasa,ni ipi hali yake ya ndoa?

   1 Ameoa/kuolewa  2 Pekee  3 Wametengana  4 Ameachwa  5 Mjane

5. Kiwango chake cha elimu alichohitimu?

   1 Hakusoma  2 Msingi  3 Sekondari O-level  4 Sekondari A-level  5 Nyengine (taja)

6. Ni upi uhusiano wako na kiongozi wa kaya?

   1 Mama  2 Baba  3 Bibi  4 Mjomba  5 Shangazi  6 Nyengine (taja)

7. Watu wangapi wanaishi katika kaya yako kwasasa, ukijiju, uishana wewe? ……...
8. Watu wangapi ukijijumuisha na wewe wako chini ya umri wa miaka 18? …………………..

9. Unaweza kunipatia chumvi uliyoleta ili iwekewe alama?

1 Ana chumvi    2 Hakuna chumvi    3 ***Kama hakuna chumvi,ruka 9 na 10***

10. Je, ulitumia chumvi hii kupikia chakula kilicholiwa na wana kaya jana usiku?

1 Ndiyo    2 Hapana

11. Jaribu uwepo na kiwango cha madini ya joto katika chumvi

1 Present ……………...ppm    2 Not present

**Sehemu II: Afya ya uzazi**

Sasa ninapenda kukuuliza maswali kuhusu afya yako ya uzazi

12. Ulizaliwa mwezi na mwaka gani? ……../………..hivyo,una miaka …………

13. Ipi dini yako?

1 Christian    2 Muislamu    3 msabato    4 Pendekoste    5 Nyengine

13. Umeshawahi kuugua hizi wiki mbili zilizopita?

1 Ndiyo    2 Hapana    3 ***Kama hapana,ruka 14***

14. Ndani ya wiki mbili zilizopita,elezea ulikua unaumwa nini?

1 Maleria    2 Kuhara    3 Taifodi    4 Nyengine (elezea)…………….

15 Umesha vunja ungo?

1 Ndiyo    2 Hapana    3 ***hapana ruka 16***

16 .lini ulivunja ungo kwa mara ya kwanza

17 Lini mwisho ulipata siku zako?

1 Siku chache    2 Wiki 4    3 Miezi 3    4 Mwaka 1

18. hivi ni vipimo ambavyo nitahitaji mimi na wewe tuvifanye

| 1 | Uzito ……….kg | 2 | Urefu ………....cm | 3 | ***Hb level …………...g/L*** |
|---|---|---|---|---|---|

19. Kama sehemu ya utafiti huu.tumewataka pia wasichana walio balehe kufanya kipimo cha madini joto. Kwa kipimo cha madini joto,tunahitaji kiasi kidogo cha mkojo. Mkojo umepokelewa na kuwekewa namba?

| 1 | Ndiyo | 2 | Hapana |
|---|---|---|---|

**Sehemu IV: Fomu ya kujua mlo kwa masaa 24**

**Sasa tungependelea kujua kwa undani aina ya vyakula ulivyokula kuanzia jana asubuhi mpaka hivi sasa. Na hapa tutakadiria kiwango ulichokula. Jisikie huru kutaja vyakula pamoja vinywaji hata kama ni vya kiasilia. Elezea kwa undani na taja chakula kimoja kwa kila mstari.**

| Orordha ya vyakula na vinywaji | Muda Am/pm | Njia ya upikaji & aina ya vyakula ulivyopika | Kiwango ulichokula (utensil used) | Ulifanya nini ukiwa unakula Mf : kutazama TV | Ulikula nyumbani (N/H) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

***Asante kwa ushirikiano wako!!!***

**Chakula kilicholiwa na utofauti wa lishe**

**Sehemu IV: Ssasa ntakuuliza nini ulichokula na kunywa jana**

Tafadhali elezea vyakula (milo and vitafunio) ambavyo umekula au kunywa jana asubuhi na usiku, ikiwa ni nje au nyumbani. Anza na chakula cha kwanza au kinywaji cha asubuhi. Andika vyakula na vinywaji ulivyotajwa. *Mkama ametaja milo iloandaliwa ataje vitu jumuishi katika mlo huo pale mhojiwa takapomaliza kutaja milo na vitafunio.*

| **Orodha ya vyakula alivyokula mhojiwa jana** |
|---|
| |

| **Swali** | **Kundi la chakula** | **Mfano** | **ndiyo** | **Hapana** |
|---|---|---|---|---|
| | | | | |
| **01** | CEREALS | Mahindi,wali,ngano,mtama,ulezi au aina yoyote ya nafaka au chakula kilichotengenezwa na aina hii ya nafaka (mf:mkate,tambi,uji au chakula cha nafaka) + mf: *ugali,uji au tambi* | …… | ...... |
| **02** | MIZIZI MYEUPE NA MIZIZI | Viazi mviringo,viazi vikuu,mihogo au aina ya chakula chengine kitokacho na miziz mf:Chipsi | …… | …. |
| **03** | MBOGA ZA MAJANI ZENYE VITAMINI NA MIZIZI | Boga,karoti,viazi vitamu ambavyo ndani vina rangi ya chungwa +mboga zenye vitamin A *(mf pilipili hoho nyekundu )* | …… | …. |

| | | | | |
|---|---|---|---|---|
| **04** | MBOGA ZA MAJANI ZENYE KIJANI ILIYOKOZA. | Mboga za majani zenyre kijani iliyokoza,pamoja zile pori + majani yenye vitamin A kama mchicha,majani ya muhogo,majani ya maharage,majani ya boga,bamia,sukuma wiki. | …… | ..... |
| **05** | MBOGA NYENGINEZO | Mboga nyenginezo(mf. Nyanya,vitunguu,biringanya) + mboga pori nyenginezo | …… | …. |
| **06** | MATUNDA YENYE VITAMINI A | Embe bivu,tikiti maji,papai, na juisi iliyotengenezwa na matunda haya + nanasi na matunda pori mengine yenye vitamin A | …… | …. |
| **07** | MATUNDA MENGINE | Matunda mengine,pamoja na matunda na juisi iliyotengenezwa na matunda haya kwa 100%. *Mitooo,* | …… | … |
| **08** | NYAMA YA MIFUGO YA KIENYEJI | Ini,figo,moyo au nyama nyengineyo ya mfugo wa kienyeji au vyakula vyenye asili ya damu. | …… | ….. |
| **09** | NYAMA ZA MINOFU | Nyama ya ng'ombe,nguruwe,kondoo,mbuzi,sungura,kuku,bata, aina nyenyineyo ya ndege,wadudu | …. | … |
| **10** | MAYAI | Mayai ya kuku,bata,kanga au mayai mengineyo. | …… | … |
| **11** | SAMAKI NA VYAKULA VYA BAHARINI | Samaki wabichi au kukausha au wa kwnyw maganda | …… | … |
| **12** | MAZIWA NA VYENYE ASILI YA MAZIWA | Maziwa, mtindi,jibini,maziwa ya unga,vyakula vyenye maziwa ndani kama samli. | | |

**MICHIGAN STATE UNIVERSITY**

# Initial IRB Application Approval

August 10, 2015

To: Won Song
139 GM Trout Building

Re: **IRB#** 15-666 Category: EXPEDITED 2, 3
**Approval Date:** August 7, 2015
**Expiration Date:** August 6, 2016

Title: Determinants of Nutritional Inadequacies among Adolescent Girls in Rural Tanzania

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved**.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

**Renewals**: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an ***Application for Renewal*** application at least one month before expiration. If the project is completed, please submit an ***Application for Permanent Closure***.

**Revisions**: The IRB must review any changes in the project, prior to initiation of the change. Please submit an ***Application for Revision*** to have your changes reviewed. If changes are made at the time of renewal, please include an ***Application for Revision*** with the renewal application.

**Problems**: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,

Ashir Kumar, M.D.
BIRB Chair

c: SAIDAH BAKAR


Office of Regulatory Affairs
**Human Research Protection Programs**

**Biomedical & Health Institutional Review Board (BIRB)**

**Community Research Institutional Review Board (CRIRB)**

**Social Science Behavioral/Education Institutional Review Board (SIRB)**

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