IRON STATUS AND DIETARY DIVERSITY OF ADOLESCENT GIRLS IN SELECTED URBAN AND RURAL COMMUNITIES OF MOSHI DISTRICT, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN HUMAN NUTRITION OF SOKOINE UNIVERSITY OF AGRICULTURE MOROGORO, TANZANIA.

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ABSTRACT

Adolescence is the transitional phase of growth and development between childhood and adulthood. It presents a window of opportunity to correct nutritional status of children. Limited data are available on iron status among adolescents in Tanzania, including in Moshi district, Kilimanjaro. The aim of this study was to assess iron status and dietary diversity of adolescent girls in selected urban and rural communities of Moshi District. A total of 311 adolescent girls were enrolled in this cross-sectional study. Height and weight were taken. Hb concentration was measured using haemo-Cue photometer and dietary data were gathered using 24hr recall. Data analysis was conducted using SPSS and WHO-anthro. Results indicated that, there was a significant difference ($P<0.05$) in the prevalence of anaemia among adolescent girls in urban (14.7%) and rural (18.5%) communities. Also there was a significant difference in dietary diversity among adolescent girls in urban and rural communities of Moshi ($P< 0.05$). Adolescent girls in rural communities had a lower dietary diversity (8.3%) compared to their peers in urban communities (4.9%). The prevalence of undernutrition among adolescent girls in rural communities (23.8%) was higher compared to their peers in urban (19.6%) and the prevalence of overweight/obese (26.6%) among adolescent girls in urban communities was higher compared to their peers in rural communities (14.3%). Generally, there was a significant difference in iron status and dietary diversity among adolescent girls living in urban and rural communities of Moshi. It was recommended based on the results of this study that adolescent girls in both communities should ensure intake of a more diversified diet rich in fruits and vegetables, meat and meat products also engage in physical activities such as games, sports and home activities.

Key words: adolescent girls, iron status, dietary diversity

DECLARATION

I, Salutari Simon Swaty, do hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my own work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

_____ _____

Salutari Simon Swaty Date

(MSc. Candidate)

The above declaration is confirmed

_____ _____

Prof. T. C. E. Mosha Date

(Supervisor)

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DEDICATION

I dedicate this valuable work to my late mother and brother, Pulcheria D. Njau and Innocent Tarimo who laid the foundation of my education.

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LIST OFABBREVIATIONS

BMI	Body Mass Index
Cm	Centimetre
Ct	Concentration
Hb	Haemoglobin
Hct	Hematocrit
IDDS	Individual Dietary Diversity Score
KCMC	Kilimanjaro Christian Medical Centre
Kg	Kilograms
NBS	National Bureau of Statistics
NGO'S	Non-Governmental Organisations
SDG	Sustainable Development Goal
SPSS	Statistical Package of Social Science
UNICEF	United Nations International Childrens Emergency Fund
URT	United Republic of Tanzania
WHO	World health organisation

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Adolescence is the transitional phase of growth and development between childhood and adulthood (Sawyer, 2018). The World Health Organization (2018) defines adolescents as individuals in the 10-19 years age group. Adolescence is a period which is characterized by big changes in the body, and in the way a young person relates to the world. There are many physical, sexual, cognitive, social, and emotional changes that happen during this period (Blakemore and Choudhury, 2006). During this crucial period, dietary patterns have vital impact on lifetime nutritional status and health (Washi and Ageib, 2010). Increased nutritional needs at this stage relate to the fact that, adolescents gain up to 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeletal mass (Akhter and Sondhya, 2013). These changes put adolescents at risk of nutritional deficiencies (*Anyika et al.,* 2009). Most commonly deficiencies among adolescents are iron, vitamins A, Vitamin (B6, E, D, C) and folic acid (WHO, 2011).

Globally anaemia is a public health problem. It affects over a quarter of the global population, impacting both developed and developing countries and has major consequences for human health as well as social and economic progress. It affects 24.8% of the world population (Peña-Rosas and WHO, 2011; Tesfaye *et al.,* 2015). The prevalence of anaemia among adolescents in developed countries is 6% and 27% in developing countries. In Tanzania, prevalence of anaemia among females aged 15–19-years was 47.3%, while in Kilimanjaro region the prevalence of anaemia was reported to be 28.2% (URT, 2016; Balci *et al.*, 2012).

Anaemia is defined as a decrease in the number of red blood cells or the amount of haemoglobin in the blood (Shaka and Wondimagegne, 2018). Iron-deficiency anaemia is a condition that occurs when the body does not have enough iron. Also, iron deficiency anaemia may be defined as a blood haemoglobin level below 12.0 g/dl in non-pregnant girls (WHO, 2018). The most common causes of iron deficiency are believed to be inadequate intake from diet and low bioavailability (Nelima, 2015). Poor dietary habits and inadequate intake of food rich in iron such as meat and meat products, fresh fruits and vegetables have been pointed out as major causes of iron deficiency (WHO, 2006).

The World Health Assembly (2012) called for a 50% reduction in anaemia among women of reproductive age (15-49 years) by 2025 (WHO, 2016). Although adolescent's specific data are lacking globally, it is estimated that, approximately 30% of adolescents are anaemic; therefore, to reach this goal, approximately 600 million adolescent girls living in developing countries must become a prime focus of anaemia reduction efforts In the pursuit of more anaemia control options that can be adopted by countries, intermittent (weekly) iron and folic acid supplementation for menstruating adolescent girls and adult women has been proposed for areas in which the burden of anaemia is between 20% and 39% (WHO, 2011). In areas where anaemia prevalence is 40% or higher, daily iron supplementation can be given to women for three months per year (WHO, 2016).

Adolescents are at high risk of iron deficiency and anaemia due to rapid pubertal growth with sharp increase in lean body mass, blood volume, and red cell mass, which increases iron requirements for myoglobin in muscles and Haemoglobin in the red blood cells. Iron requirement increases two to three folds from a pre-adolescent level of ~0.7–0.9 mg iron/ day to as much as 1.37–1.88 mg iron/day in adolescent boys and 1.40–3.27 mg iron/day

in adolescent girls (WHO, 2011). Having knowledge on the degree and causes of anaemia in adolescent girls is important, as this is a window of opportunity for interventions to improve adolescents health. Thus this study aimed at assessing iron status and dietary diversity of selected urban and rural adolescent girls in Moshi district, Kilimanjaro region.

1.2 Problem Statement and Study Justification

This study aimed at assessing iron status and dietary diversity of urban and rural adolescent girls, as this group has typically been considered less vulnerable to poor health, and has received less attention, despite the fact that, many health problems which occur later in life can be mitigated by adopting healthy lifestyle behaviors during adolescence. Also, limited data are available regarding iron status among adolescents in Tanzania, particularly in Moshi district.

Nutrition interventions to reduce consequences of iron deficiency anaemia must address the root causes. Cost-effective anaemia prevention and control strategies should be well-documented because they have power for their intended objectives in different settings (Gebreyesus *et al.,* 2019), As there is paucity of data on anaemia among adolescent girls living in developing countries in the complex ecologic context of poverty and malnutrition (Tesfaye *et al.,* 2015). At all levels, the negative effects of iron deficiency anaemia justify public health action. Unfortunately, many initiatives to prevent anaemia commonly target infants, young children, pregnant and lactating women, and rarely adolescents.

1.3 Study Objectives

1.3.1 General objective

To assess iron status and dietary diversity of selected urban and rural adolescent girls in Moshi District.

1.3.2 Specific objectives

i. To assess haemoglobin (Hb) and hematocrit (HCT) status of selected urban and rural adolescent girls in Moshi District.
ii. To assess dietary diversity of selected urban and rural adolescent girls in Moshi District.
iii. To determine the BMI status of selected urban and rural adolescent girls in Moshi District.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Adolescence

Adolescence is the transitional phase of growth and development between childhood and adulthood (Sawyer, 2018). The World Health Organization (2018) defines adolescents as individuals in 10-19 years age group. Adolescence is a period which is characterized by big changes in the body, and in the way a young person relates to the world. There are many physical, sexual, cognitive, social, and emotional changes that happen during this period hence increased nutritional needs (Abbaspour *et al.,* 2014). Adolescent requires proteins for bodybuilding and help in repair and maintenance of body tissues, Carbohydrates and fats for energy, Vitamins and minerals such as iron, calcium, zinc for growth, repair and regulation of vital body functions. Adolescent females require approximately 2200 calories/day, whereas male adolescents require 2500 to 3000 calories/day, most commonly deficiencies among adolescents are iron, vitamins A, Vit B6, Vit E, Vit D, Vit C, and folic acid (WHO, 2011).

2.2 Anaemia

Anaemia is defined as a haemoglobin concentration below a specified cut-off point. The world health organization (2011) defines anaemia in children aged under 5 years and pregnant women as a haemoglobin concentration <110 g/L, and anaemia in non-pregnant women as a haemoglobin concentration <120 g/L. For an anemic individual the heart must work harder to pump the amount of blood required to obtain enough oxygen around the body. During intense exercises, cells may not be able to carry enough oxygen to meet

the body's needs, thus the individual may become exhausted and weak (Johnson, 2013). The prevalence of anaemia remains high globally, particularly in low-income settings, where a significant proportion of young children and women of childbearing age resides, it is estimated that around one in five menstruating females are anaemic (WHO, 2015).

The prevalence of any anaemia among girls aged 15-19 years is highest in South Asia (54%), followed by sub-Saharan Africa (35%), Europe and Central Asia (27%), Latin America and Caribbean (20%) and Middle East and North Africa (16%) (USAID, 2018). In Tanzania, 45% of women aged 15-49 years are anaemic, 33% of women are classified as mildly anaemic, 11% are moderately anaemic, while 1% are severely anaemic (URT, 2016).

Anaemia among adolescence reduces physical and mental capacity, diminishes concentration in work and educational performance, and affects current and future reproductive health, for those who will become pregnant (Onabanjo and Balogun, 2014). Related to this, young maternal age increases the risk of maternal anaemia during pregnancy (Shaka and Wondimagegne, 2018). The prevalence of iron deficiency and subsequent anaemia increases at the start of adolescence for both males and females. In girls, this is caused by increased nutritional requirements for growth, exacerbated a few years later by the onset of menstruation (Adem *et al.,* 2015). The physical and physiological changes in adolescence stage increases the demand for iron and makes them more vulnerable to nutritional deficiencies (Abbaspour *et al.*, 2014).

2.3 Causes of Anaemia

The most common causes of anaemia include nutritional deficiencies, particularly iron deficiency, though deficiencies in folate, vitamins B12 and Vit A are also important causes. Haemoglobin opathies and infectious diseases, such as malaria, tuberculosis, HIV and parasitic infections, (Ramzi *et al.,* 2011). Anaemia can cause a range of symptoms including fatigue, weakness, dizziness and drowsiness. Adolescents girls and pregnant women are especially vulnerable, with an increased risk of maternal and child mortality could also cause anaemia (Balarajan *et al.,* 2011). Anaemia is one among the foremost important health problems throughout the globe, adolescent children are one among the main risk groups for anaemia.

2.3.1 Iron deficiency anaemia

Iron deficiency anaemia is caused by low levels of folate or vitamin B-12, and a low vitamin C intake. Most commonly identified and studied causes in developing countries are low dietary intake of iron, infectious diseases such as malaria and parasite infestations (Nelima, 2015). Prevalence and effects of iron deficiency anaemia are more common in adolescent girls than in boys because of monthly blood losses through menstruation (de Andrade *et al.,* 2014). In Tanzania, the prevalence of anaemia among females aged 15–19 years is 47.3% and in Kilimanjaro region, prevalence of anaemia is 28.2% (URT, 2016). Prevalence of anaemia as a public health problem is categorized as follows: <5% no public health problem, 5-19.9% mild public health problem, 20-39.9% moderate public health problem, ≥40% severe public health problem (De Benoist *et al.,* 2008).

Iron-deficiency anaemia often develops slowly, and symptoms could also be mild initially, as the condition gets a worse, symptom including fatigue, weakness, dizziness,

headaches, low body temperature, pale or yellow skin, rapid or irregular heartbeat, shortness of breath or chest pain, especially with physical activity and brittle nails may manifest (Johnson, 2013). Iron deficiency anaemia has also been shown to affect cognitive and physical development in children and reduce productivity in adults (Balarajan *et al.,* 2011).

WHO oversees several programmes across all WHO Regions to assist in reducing the prevalence of anaemia through treatment and prevention. These guidelines, policies and interventions aim to extend dietary diversity, improve feeding practices and improve the bioavailability and intake of micronutrients through fortification or supplementation with iron, folic acid and other vitamins and mineral. Intervention that deals with the underlying and basic causes of anaemia look at issues like disease control, water, sanitation and hygiene, reproductive health and root causes like poverty, lack of education and gender norms (WHO, 2017)**.**

2.3.2 Malaria and parasitic infestation

Malaria parasites inside the body reduce red blood cell count because it involves increased removal of circulating red blood cells and decrease in production resulting to anaemia (Douglas *et al.,* 2012). Malaria infections also cause nausea, vomiting, fever, loss of appetite and reduce food intake. The anaemia associated with malaria is multifactorial and is usually associated with *P falciparum* infection. In patients with low immunity, anaemia may be secondary to erythrocyte infection and a loss of infected red blood Cells (Nelima, 2015).

Poor sanitation and hygiene creates unhealthy environment for adolescents. This poor practice creates a favourable environment for worms infestation. Intestinal worm

infestation is a global health problem (Henjum *et al.,* 2015). Intestinal worm infestation with- helminthic is among the causes of anaemia in children and adolescents because the presence of worm infestation in the gastrointestinal track decreases bioavailability of nutrients and physically damages the intestines leading to inflammation that result into iron loss hence anaemia (Nelima, 2015; Shaw and Friedman, 2011).

Poor nutritional status during adolescence is a crucial determinant of health outcomes at a later stage of life. According to Amare *et al.* (2012) the common causes of malnutrition among adolescents within the poor community are poor access to food and inadequate knowledge about healthy foods and dietary requirements. Additionally, the subsequent factors like food security, gender inequality, social and economic status, availability of water, women's educational status, healthcare facilities, housing, and proper sanitation all contribute to the nutritional status of any community (Teji *et al.*, 2016).

2.3.3 Undernutrition

Undernutrition has become endemic in both develop and developing countries, the economically disadvantaged in these countries are the victims of the circumstances. Consistent with Silangwe (2013) the two main causes of undernutrition are Protein Energy Malnutrition and micronutrient deficiencies. Undernutrition is a matter which requires immediate action because it hinders economic progress and productivity (Ojo *et al.,* 2011). Undernutrition is not necessarily a shortage of food, but could be due to micronutrient deficiency, infectious diseases, poor sanitation and poor health services. It is also described as the disorder due to inadequate intake of nutrients necessary for the body functions (Hadley *et al.,* 2011). Undernutrition can also cause anaemia, Iron-deficiency anaemia occurs when the body does not have enough iron

caused by poor dietary habits and inadequate intake of food rich in iron such as meat and meat products, fresh fruits and vegetables (WHO, 2006).

2.4 Measures of Anaemia

2.4.1 Haemoglobin Concentrations

Haemoglobin concentration is a measure of anaemia (body iron status). Almost two thirds of the iron in the body approximately 2.5 grams of iron is found in haemoglobin, the protein in red blood cells that carries oxygen to tissues (Percy *et al.,* 2017). The HemoCue photometer is widely used to measure haemoglobin in anaemia surveys. Although the instrument is excellent on its own, data quality is dependent on good blood sample collection (capillary blood sample) (Karakochuk, 2017).

Adolescent girls with Hb values below 12 g/dL are considered as anemic. Haemoglobin values of 11–11.9 g/dL, 8–10.9 g/dL, and < 8 g/dL are categorized as having mild, moderate, and severe anaemia, respectively (URT, 2016). Haemoglobin concentration provides information about the severity of iron deficiency.

Table 1: Hemoglobin cut off values for females

Hb (g/dl)	Status
≥ 12	Normal
11 – 11.9	Mild anaemia
8 – 10.9	Moderate anaemia
< 8	Severe anaemia

Source: WHO (2018)

2.4.2 Hematocrit Levels

Haematocrit is a measurement of the proportion of blood that is made up of cells; the value is expressed as a fraction of cells in blood. The value can fall to less than normal,

indicating anaemia, haematocrit measures the amount of iron in liver storage. The normal hematocrit level for men is 40 to 54%; for women it is 38 to 46% (Fowler *et al.*, 2015). Hematocrit is calculated by an automated analyser and is not directly measured. It is determined by multiplying the red cell count by the mean cell volume (Acker *et al.,* 2012). An estimated hematocrit as a percentage may be derived by tripling the haemoglobin concentration in g/dL (Ibrahim *et al.*, 2014).

2.4.3 Individual Dietary Diversity

Dietary diversity is a simple count of the number of food groups consumed over the past 24 hours (Nguyen *et al.,* 2013). It is one of food security indicators which show either adequate dietary intake or micronutrients intake. Previous studies showed significant association between dietary diversity and nutritional status among various population and social groups such as adolescents (Darapheak *et al.,* 2013; Ochieng *et al.,* 2017).

Dietary diversity is taken to be a key indicator in assessing food access, utilization, and quality of diet of individuals. Individual dietary diversity scores are shown to indicate whether the diet has adequate nutrient or not (Gebremariam *et al.,* 2015). Dietary diversity is often used as a proxy indicator for measuring nutrient adequacy. Multiple cross country studies in 2011 have proven that dietary diversity scores are reliable measures for micro and macro nutrient adequacy for females of reproductive ages (Ali *et al.,* 2014).

2.4.3.1 Twenty four hours dietary recall

A 24-hour dietary recall (24HR) is a structured interview intended to capture detailed information about all foods and beverages consumed by the respondent in the past 24 hours. A key feature of the 24HR is that, when appropriate, the respondent is asked for

more detailed information than first reported. For example, a respondent reporting fish for dinner or rice for lunch would be asked about the preparation method. This open-ended response structure is designed to prompt respondents to provide a comprehensive and detailed report of all foods and beverages consumed (Baranowski *et al*., 2012).

24HRs are typically administered by a trained interviewer, but automated self-administered tools also are available. Using 24 hours dietary recall method does provide an assessment of the diet at the population level and may be used to monitor progress or track interventions (Darapheak *et al.*, 2013). 24HRs data can be used to assess total dietary intake or particular aspects of the diet and can be used to examine relationships between diet and health or other variables, in which diet is the independent variable (Freedman *et al*., 2014).

The recall period of 24-hour which was chosen by Food and Agriculture Organization of the United Nations is a smaller amount subjected to recall error, less cumbersome for the respondent and also conforms to the recall period of time employed in many dietary diversity studies (Kennedy *et al.,* 2010). 24HR may limit participation in some groups, leading to potential selection bias, also 24HR is unable to account for day to day variation, two or more non-consecutive recalls are required to estimate usual dietary intake distributions (Kirkpatrick *et al*., 2014).

Table 2: Nutritional status categories and the corresponding z-scores

Nutritional indicator	Nutritional status	z-score range (SD)
BMI-for-age	Obese	>+2
	Overweight	>+1 to ≤+2
	Normal	≥ -2 to ≤+1
	Moderately wasted	≥ -3 to < -2

Source: WHO (2018)

CHAPTER THREE

3.0 METHODOLOGY

3.1 Overview

This chapter presents the description of the study area, study population, study design, sampling techniques, sample size, data collection, methods and analysis.

3.2 Description of Study Area

Moshi urban is the capital of Kilimanjaro region. In the 2012 population census, Moshi urban had a population of 184 292 (URT, 2012), out of whom 89,174 were males and 95,118 were females. Administratively, the district is divided into 21 wards. Moshi Rural District is one of the seven administrative districts of Kilimanjaro Region. The district is bordered to the North by Rombo District, to the West by Hai District, to the East by Mwanga District and Kenya, and to the South by Arusha district. According to the national population census of 2012, the population of Moshi Rural District was 466 737 (URT, 2012), out of whom 225,767 were males and 240 970 were females. The council is administratively divided into 31 wards.

Moshi has a tropical wet and dry climate. Its economy is mainly based on agricultural sector whereby land under cultivation is 108 389 hectares which is 87.3%, of the total arable land. More than 80% of the District population depends mainly on agricultural activities for their livelihood. The main crops grown include coffee and bananas. The surrounding areas in Moshi district are known for extensive farms of maize and

beans, grown once per year during the long rain season. In addition, the Tanganyika Planting Company operates a very large sugar cane plantation.

Regarding health services, Moshi has one referral hospital, Kilimanjaro Christian Medical Centre (KCMC). The primary public hospital in Moshi is Mawenzi Regional Hospital. In Moshi there are more than 10 private hospitals and clinics. In both urban and rural communities of Moshi, each ward has at least one dispensary and one health center. The study area was selected due to its limited availability of data on iron status among adolescents girls. In this study 11 wards were involved, 5 wards (Kiboriloni, Miembeni, Soweto, Kilimanjaro and Pasua) from urban communities and 6 wards (Kibosho, Old Moshi, Uru, Kirima, Mabogini and Marangu) from rural communities. These wards were randomly sampled in the study to represent the entire population in the communities.

3.3 Study Design

A cross-sectional study design was conducted to assess iron status and dietary diversity of adolescent girls in selected communities. The study involved collection of data at one point in time and establishing relationship between variables.

3.4 Study Population/Sampling Frame

The study population involved all adolescent girls aged 10 – 19 years living in the selected urban and rural communities of Moshi district. The study population included only adolescent girls because of their increased vulnerability to nutritional disorders.

3.4.1 Inclusion criteria

Adolescent girls aged 10 – 19 years living in urban and rural communities of Moshi district.

3.4.2 Exclusion criteria

All adolescent girls who had received blood transfusion at least 4 months prior to the data collection were excluded. Girls who were receiving treatments for anaemia, and who were pregnant or lactating were also excluded from the study.

3.5 Sampling Technique and Sample Size

3.5.1 Sampling technique

A multistage random sampling procedure was used in this study. Using the proportion formula to determine the number of wards, a sample of 11 wards was randomly selected, 5 wards (Kiboriloni, Miembeni, Soweto, Kilimanjaro and Pasua) from urban communities and 6 wards (Kibosho, Old Moshi, Uru, Kirima, Mabogini and Marangu) were selected from rural communities. In each ward, villages were randomly selected. With help from village government, the households with adolescent girls aged 10 to 19 years were identified and enrolled into the study. For households with more than one adolescent girl, one was randomly selected. A total of 311 adolescent girls were included in the study, 143 were from urban (Kiboriloni 29, Miembeni 28, Soweto 29, Kilimanjaro 29 and Pasua 28) and 168 girls were from rural (Kibosho 28, Old Moshi 28, Uru 28, Kirima 28, Mabogini 28 and Marangu 28).

3.5.2 Sample size

Sample size was determined by using a formula by Fisher *et al*. (1991).

$N = Z^2 * P (1-P) / d^2$

Sample size = (standard deviation)2 * prevalence (1-Prevalemce) / (precision level)2

Where:

N = the desired sample size

d = Degree of accuracy desired (precision level) (acceptable error 0.05 or 5%)

P = Prevalence of anaemia in females aged 15-49 years in Kilimanjaro 28.2% (NBS, 2015)

Z = the standard normal deviate (which is 1.96 corresponding to 95%Cl)

N = 1.962 x 0.282 (1-0.0.282)／0.052 =311

A sample size of 311 adolescent girls was used.

3.6 Data Collection

3.6.1 Construction of a questionnaire

The questionnaire consisted of four parts, part one consisted of interview for checking if the subject can be included in the study, part two was for collecting information on the anthropometrics, part three and four were for collecting information on 24 hours dietary recall and dietary diversity scores (Appendix-1). The structured questionnaire was administered to the participants to obtain information.

3.6.2 Pre-testing the questionnaire

The questionnaire was pre-tested prior to data collection. Pre-testing involved a sample of 20 adolescent girls from Mafiga ward in Morogoro district. Mafiga ward had similar characteristics to Moshi district.

3.6.3 Training of enumerators

Three enumerators were given one day training on data collection and how to record the responses and conduct the various measurements. They were also educated on ethical issues in research, appropriate use of HemoCue photometer for anaemia testing and use of the anthropometric tools for taking weight and height measurements.

3.6.4 Administration of the questionnaire

The questionnaire was administered face to face to the respondents.

3.6.5 Measurements taken

3.6.5.1 Haemoglobin concentrations

Hemoglobin concentration was determined by capillary blood sample from a finger prick. The middle finger of the non-dominant hand was cleaned with methylated spirit and pricked with a sterile disposable safety lancet. A drop of blood was collected by a micro-cuvette. Immediately the full cuvette was cleaned and inserted into the Hemo-Cue photometer and the reading was recorded. Hemoglobin values were recorded to the nearest 0.1g/dl. Hb levels of 12g/dl were classified as normal, 11 to 11.9g/dl were classified as mild anemia, 8 to 10.9g/dl were classified as moderate while Hb < 8g/dl were classified as severe anemia (Table 1).

3.6.5.2 Hematocrit

Hematocrit is calculated based on the amount of haemoglobin and the average volume of red blood cells (Wennecke, 2004). Hematocrit levels were calculated using hemoglobin concentration. In normal conditions, there is a linear relationship between hematocrit and

the concentration of haemoglobin (ctHb). An empirical study by Kokholm (1991) has shown that, the relationship can be expressed as follows:

Hct (%) = (0.0485 × ctHb (mmol/L) + 0.0083) × 100 where by

Hct: = Hematocrit (% or volume fraction)

ctHb: = Concentration of total hemoglobin (g/dL)

Classification of Hct levels in adolescent girls; where Hct levels of 38-46% was classified as normal, less 38% was classified as below normal (anaemic) and above 46% was classified as above normal**.**

3.6.5.3 Anthropometric measurements

Weight and height were measured for each study participant.

(a) Height measurements

Height was taken when the participant was standing up without shoes on, on a horizontal flat floor with feet together, back straight and eyes looking straight ahead, and the back was pressed firmly horizontally against the height board and a head piece was used. Measurements was then taken and recorded to the nearest 0.1cm. Information on date and year of birth was also recorded.

(b) Weight measurements

A battery-powered digital SECA scale was used for measuring weight. The scale was adjusted to zero before taking the measurements. The scale was placed on a flat surface and participants were weighed without shoes and with light clothes on. Readings were carefully taken and recorded to the nearest 0.1kg. Measurements were taken twice and any discrepancy was resolved by a third measurement.

3.6.5.4 Individual dietary diversity scores (IDDS)

IDDS is the number of foods or food groups consumed by an individual in the past 24 hours. In assessing dietary diversity of women, a 9 food group questionnaire was used (Kennedy *et al.,* 2010). The IDDS questionnaire consisted of 9 food groups (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). The respondent was asked to mention all the foods (meals and snacks) eaten in the past 24 hours, starting with the first food/drink consumed in the previous morning. Categorization used were; ≤ 3 food groups-low dietary diversity, 4 and 5 food groups-medium dietary diversity and ≥ 6 food groups-high dietary diversity (Kennedy *et al.,* 2010).

3.7 Data Analysis

Responses to the questionnaire were checked for completeness after data collection, and there-after entered into the Excel spread sheet. Data were cleaned and statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 20. WHO-Anthro Plus software was used to compute z-scores for BMI for age. The BMI for age scores were calculated using the WHO (2007) reference values for children aged 5 to 19 years.

Descriptive analysis was performed; categorical variables such as age were presented as frequencies (n) and percentages (%). Continuous variables such as height, weight were presented as means with standard deviations (SDs). Independent samples-t-tests were used to compare the means of the two groups at 95% confidence intervals.

3.8 Ethical Clearance

Ethical approval was obtained from Sokoine University of Agriculture and permission letters from Regional Administrative Secretary from Kilimanjaro Region and District Administrative Secretary in Moshi. Written informed consent was also obtained from mothers/caregivers of the adolescent girls at the time of enrolment into the study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Age, Height, Weight and BMI for age of the surveyed Adolescent Girls

A total of 311 girls were included in the study. Of these, (46%) and (64%) were from the urban and rural communities, respectively. Table 3 shows the age, height, weight, and BMI for age of the rural and urban adolescent girls. The overall mean age was 14.62 and a standard deviation of 0.50, with the average height being 153cm, in comparison mean height was higher among adolescent girls in rural communities 154. Overall mean BMI for age was 21.53 with a standard deviation of 4.33 and was higher among urban adolescent girls 22.15 compared to their counterparts in rural which was 21.

Table 3: Age, height, weight and BMI of the surveyed adolescent girls

Parameters	Overall	Urban	Rural

	(mean ± SD)	(mean ± SD)	(mean ± SD)
Age(years)	14.62 ± 0.50	14.07 ± 2.70	15.09 ± 2.20
Height(cm)	153.33 ± 9.05	151.63 ± 9.29	154.79 ± 8.60
Weight(kg)	50.60 ± 11.05	50.80 ± 12.25	50.42 ± 9.95
BMI for age	21.53 ± 4.33	22.15 ± 5.03	21.00 ± 3.56

4.2 Iron Status of the Adolescent Girls in Urban and Rural Communities

4.2.1 Haemoglobin (Hb) status of the adolescent girls in urban and rural communities

Table 4 shows a total of 311 adolescent girls from urban and rural communities of Moshi district who were assessed for iron status using Hb concentration levels. Out of 311 adolescent girls examined, 259 (83.3%) had normal haemoglobin levels (≥ 12 g/dl), 38 (12.2%) showed mild degree of anaemia (11 – 11.9 g/dl) while 14 (4.5%) had moderate anaemia (8 – 10.9 g/dl). More than 80% of the adolescent girls from both urban and rural communities had normal Hb levels (≥ 12 g/dl). Moderate degree of anaemia (8 – 10.9 g/dl) was more among the rural adolescent girls 10 (6%) compared to the urban adolescent girls 4 (2.8%). There was a significant difference ($P< 0.05$) in Hb status between the two groups of adolescent girls from urban and rural communities.

The overall prevalence of anaemia in adolescent girls was found to be 16.7%, out of this 12.2% had mild anaemia and 4.5% had moderate anaemia. In a study conducted by Teji *et al.* (2016), among Ethiopian adolescent girls aged 10- 19 years, prevalence of anaemia was 32% out of which 1.8% had severe anaemia, although they used a larger sample size compared to the present study. Another study by Kulkarni *et al.*, (2012) among adolescent girls in Nagpur, India the prevalence of anaemia was found to be very high (90.1%), the majority of the adolescent girls had mild or moderate anaemia (88.6%) and only1. 5% had severe anaemia.

The current study indicates that there was a significant difference (P<0.05) in the prevalence of anaemia among adolescent girls in urban communities relative to their counterparts in rural communities. Adolescent girls in rural communities had higher prevalence of anaemia (18.5%) compared to their peers in urban communities (14.7%). These results were similar to a study done by Shedole *et al.* (2017) in Davangere, India the prevalence of anaemia was higher among adolescent girls in rural communities (96.88%) than their peers in urban (72.42%) communitie.

Anaemia is significantly associated with a low BMI for age, adolescent girls with low BMI for age are 3.2 times more likely to become anemic as compared to those with higher BMI for age (Mengistu *et al.*, 2019). This may be the reason for the observed higher prevalence of anaemia among adolescent girls in rural communities compared to their counterpart in urban communities. The adolescent girls in rural communities were more underweight (23.8%) compared to their urban counterparts (19.6%).

Table 4: Haemoglobin (Hb) status of adolescent girls in urban and rural communities

Category (conc. g/dl)	**Overall**		**Urban**		**Rural**		**P-value**
	N	**%**	**N**	**%**	**N**	**%**	
Normal (≥ 12)	259	83.3	122	85.3	137	81.5	**P**<0.05
Mild anaemia (11 – 11.9)	38	12.2	17	11.9	21	12.5	**P**<0.05
Moderate anaemia (8 – 10.9)	14	4.5	4	2.8	10	6	**P**<0.05

4.2.2 Hematocrit status of adolescent girls in urban and rural communities

Table 5 shows that, out of 311 adolescent girls examined in the study, (65.3%) had normal (38-46%) Hct levels, (7.7%) had Hct levels above the normal range (> 46%) and (27%) had low Hct levels (< 38%). More than 60% of adolescent girls from both urban (66.4%) and rural (64.3%) communities had normal Hct levels. Adolescent girls from

rural (29.2%) communities had low Hct levels (< 38%) compared to adolescents girls in urban communities (24.5%). There was a significant difference in Hct status between adolescent girls from urban communities and their peers in rural communities ($P < 0.05$).

According to hematocrit measurements (the liver iron storage) the overall prevalence of anaemia among adolescent girls was 27%. More adolescent girls in rural communities had a poor iron storage (29.2%) compared to their peers in urban communities (24.5%), indicating they were more anaemic. Similarly to the results from Haemoglobin (Hb) status, adolescent girls in rural communities had higher prevalence of anaemia compared to their counterpart in urban communities. The results in this study, demonstrated that the prevalence of anaemia among adolescents was mild. This shows the importance of including adolescents within the risk group to enhance their iron status and therefore the need for planning interventional programs that might increase the haemoglobin levels among adolescent girls.

Table 5: Hematocrit status of adolescent girls in urban and rural communities

Category	Overall		Urban		Rural		P-value
	N	%	N	%	N	%	
Low (<38%)	84	27	35	24.5	49	29.2	P<0.05
Normal (38-46%)	203	65.3	95	66.4	108	64.3	P<0.05
Above-normal (>46%)	24	7.7	13	9.1	11	6.5	P<0.05

4.3 Dietary Diversity of the Adolescent Girls in Urban and Rural Communities

Table 6 shows that more than half of the adolescent girls (77.8%) had medium dietary diversity (4-5 food groups/day), (15.4%) had high dietary diversity (≥ 6 food groups/day) and (6.8%) had low dietary diversity (< 3 food groups/day).

More than 70% of adolescent girls from both urban (81.1%) and rural (75%) communities had medium dietary diversity. Adolescent girls in rural communities had higher dietary diversity (16.7%) compared to their peers in urban communities (14%). There was a significant difference in dietary diversity among adolescent girls in urban and rural communities of Moshi ($P < 0.05$). Adolescent girls in rural communities had lower dietary diversity (8.3%) compared to their peer in urban communities (4.9%), meaning they're eating from fewer number of food groups, which may be an attributable factor to why adolescent girls in rural communities had higher prevalence of anaemia and higher levels of undernutrition compared to their peers in urban communities.

High prevalence of lower dietary diversity observed among adolescent girls in rural communities compared to their counterpart in urban communities may be due to differences in culture, feeding habits, and environmental factors. It might also be due to economic differences in economic status among communities.

Table 6: Individual Dietary diversity of adolescent girls in urban and rural communities

Category (food groups)	Overall		Urban		Rural		P-value
	N	%	N	%	N	%	
Low diversity (<3)	21	6.8	7	4.9	14	8.3	P<0.05
Medium diversity (4-5)	242	77.8	116	81.1	126	75	P<0.05
High diversity (≥6)	48	15.4	20	14	28	16.7	P<0.05

4.4 BMI Status of Adolescent Girls in Urban and Rural Communities

Table 7 shows that (21.9%) adolescent girls were underweight (< -2 SD ƶ-score), 18 (58.2%) had normal weight (≥ -2 to ≤+1 SD ƶ -score), (16.7%) were overweight (>+1 to ≤+2 SDƶ -score) and (3.2%) were obese (>+2 SD ƶ -score)

There was a significant difference between the urban and rural study groups (P<0.05). Overall, the study indicated that, (21.9%) of adolescent girls were underweight while (3.2%) were obese. These findings were similar to a study by Chen (2012) which was conducted in Kilosa district and showed a prevalence of (16.2%) underweight and (1.9%) obesity. Another study by Gebremariam *et al.* (2015) among adolescents girls in Northen Ethiopia reported that, prevalence of underweight was 37% while obesity was 0.4%.

In this study, prevalence of undernutrition among adolescent girls in rural communities (23.8%) was higher compared to their peers in urban communities (19.6%). These results were consistent with other reports (Maiti *et al.,* 2011; WHO, 2006) and is supported by evidence that rural girls are more likely to suffer from under-nutrition compared to their urban peers (Berheto *et al.,* 2015; Hadley, 2011). Prevalence of overweight (21.7%) and obesity (4.9%) among adolescent girls in urban communities was higher compared to adolescent girls in rural communities (overweight 12.5%, obesity 1.8%) as observed in the present study.

The high prevalence of undernourishment among adolescent girls in rural settings may be attributable to low dietary diversity or social and economic differences. However, better nutritional status among urban girls may be attributed to the impact of better living conditions, better nutrition and medical facilities (Mondal and Sen, 2010).

Table 7: **Anthropometric status of adolescent girls in urban and rural communities**

Category (SD z-scores)	Overall		Urban		Rural		P-value
	N	%	N	%	N	%	
Underweight (< -2)	68	21.9	28	19.6	40	23.8	P <0.05
Normal weight (≥ -2 to ≤+1)	181	58.2	77	53.8	104	61.9	P <0.05
Overweight (>+1 to ≤+2)	52	16.7	31	21.7	21	12.5	P <0.05
Obese (>+2)	10	3.2	7	4.9	3	1.8	P <0.05

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Differences in iron status and dietary diversity were found between urban and rural girls. Haemoglobin status revealed that prevalence of anaemia was higher among adolescent girls in rural communities compared to their peers in urban communities, also adolescent girls in rural eats from fewer number of food groups and were more underweight compared to their counterparts. This suggests that there is a need for nutrition intervention among the rural population and more stress should be laid on planning and implementing nutritional programmes for adolescents in rural settings. Since the urban and rural variations in nutritional status in terms may be attributed to social and/or economic disparities, future community-based longitudinal studies ought to be instigated as before long as doable to further investigate the explanations for this.

5.2 Recommendations

Based on the findings of this study, the following recommendations were drawn for adolescent's girls in both urban and rural communities.

- Adolescent girls with anaemia should check their health for any underlying illness or condition and increase their intake of iron and vitamin c rich foods such as amaranth, spinach oranges, red meat, beetroot liver and others.
- Adolescent girls who are underweight should increase the intake of alimental diet rich in fruits and vegetables (such as amaranth, spinach, oranges, bananas, papaya,

and avocado), protein (such as eggs, nuts, meat, fish, and poultry), carbohydrates (rice, banana, maize, wheat) and fat/oil to boost their nutritional status.

- Adolescent girls who are overweight and obese ought to engage/increase physical activities by ensuing participation in home activities, games and sports.
- With increased focus on adolescents girls appropriate nutrition interventions which will result to a permanent resolution ought to be designed by all concerned bodies and stakeholders (the community, government, non-public sectors, media, NGO'S and alternative community based organizations) in nutrition sector to boost their nutritional status.

5.3 Strength and Limitations of this Study

The study was a random community based household survey, which provided empirical data that can serve as a baseline data for further study. Food intake questions were asked retrospectively so there was a chance for recall bias or over reporting.

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APPENDICE

Study Questionnaire- Iron status and dietary diversity of adolescent girls in selected urban and rural communities of Moshi district, Tanzania.

Please give correct answer to the following questions **No……..**

Date…….. **Ward**……

Village……

Date of birth……**month**……**year**……

Part I: interview questions

Have your received blood transfusion 4 months prior to this day? (Yes/no) ……..

Are you currently receiving treatment for anaemia? (Yes/no) ……..

Are you currently breastfeeding /pregnant? (Yes/no) ……..

Hb measurement: ……g/dl

Part II: Anthropometric measurements

Height ……

Weight……

Part III: Dietary diversity

24 hours dietary recall

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.

Time	Food	Ingredients
Morning		
Mid-morning		
Afternoon		
Mid afternoon		
Evening		

Part IV: Individual dietary diversity score

	Food group	Example	YES=1 NO =0
1	STARCHY STAPLES	corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, noodles, porridge or other grain products) + *insert local foods e.g. ugali, nshima, porridge or pastes or other locally available grains.* white potatoes, white yams, white cassava, or other foods made from roots	
2	DARK GREEN LEAFY VEGETABLES	dark green/leafy vegetables, including wild ones + *locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach etc.*	
3	OTHER VITAMIN A RICH FRUITS AND VEGETABLES 2	pumpkin, carrots, squash, or sweet potatoes that are orange inside + *other locally available vitamin A rich vegetables (e.g. red sweet pepper), ripe mangoes, cantaloupe, apricots (fresh or dried), ripe papaya, dried peaches + other locally available vitamin A rich fruits*	
4	OTHER FRUITS AND VEGETABLES 3	other vegetables (e.g. tomato, onion, eggplant), including wild vegetables, other fruits, including wild fruits	
5	ORGAN MEAT	liver, kidney, heart or other organ meats or blood-based foods	
6	MEAT AND FISH 4	beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds. Fresh or dried fish or shellfish	
7	EGGS	chicken, duck, guinea fowl or any other egg	
8	LEGUMES, NUTS AND SEEDS	beans, peas, lentils, nuts, seeds or foods made from these	
9	MILK AND MILK PRODUCTS	milk, cheese, yogurt or other milk products	
	Did you eat anything (meal or snack) OUTSIDE the home yesterday		