

**DIETARY IRON INTAKE AND PREVALENCE OF IRON DEFICIENCY ANEMIA
AMONG WOMEN OF CHILDBEARING AGE IN ADJUMANI REFUGEE
SETTLEMENT**

IKOMOLOLOT CAROLINE

BSc. Human Nutrition (MUK)

Reg No: 21/U/3310/MFN/PS

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DECLARATION

I, **Ikomolot Caroline** hereby declare that the content of this dissertation is my original work and has never been submitted for the award of a degree in any higher institution of higher learning.

Signature: 

Date: 

IKOMOLOT CAROLINE

APPROVAL

This dissertation has been submitted for review with our approval as university supervisors:

1. Dr. Olum Solomon

Lecturer,

Department of Food Science and Post-Harvest Technology, Faculty of Agriculture and Environment, Gulu University, Uganda

Signature  Date..... 09-01-2024

2. Mr. Wanyama Ronald

Lecturer,

Faculty of Medicine, Gulu University, Uganda

Signature  Date..... 09/01/2024

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ABSTRACT

Anemia is a big threat to global population of women of childbearing age (WCBA). Factors such as malnutrition, infections, and poor sanitation are identified as the main contributors to high prevalence of anemia in this age category. However, information about the contribution of iron deficiency anemia (IDA) to general anemia prevalence remains unknown especially in a refugee settlement where iron intake is compromised by many factors. This study investigated: (i) dietary iron intake; (ii) contribution of iron deficiency to anemia prevalence and (iii) socio-economic and dietary factors influencing serum iron status of 462 WCBA in Adjumani refugee settlement using cross-sectional survey. IDA was determined by analyzing serum ferritin using Human Ferritin ELISA kit (Bio-technique company, United Kingdom), following standard procedure and manual from the manufacturer. According to the results, the dietary iron intake of the study sample was not significantly different ($p \leq 0.05$) from recommended daily intake (RDI) of iron except for the intake of the study samples from Pagirinya refugee settlement which was lower than RDI ($p \leq 0.05$) and mainly from plant sources. Engagement in income generating activities (IGAs) especially farming and fishing resulted in a significant increase in iron intake ($p \leq 0.05$). The prevalence of anemia in the sample was 34.42% with mean hemoglobin concentration of 10.25g/dL but the prevalence varied among the different settlements studied. Iron deficiency anemia (IDA) accounted for 37% of anemia among those who were found to be anemic after the initial screening. Overall, there was a significant impact of IGAs, education, and monthly income on serum iron status of women ($p < 0.05$). This study has demonstrated that the intake of iron among refugee women was primarily from starchy plant-based food sources but was generally not significantly different from recommended intake except for inter-settlement variations. Despite meeting the recommended iron intake, iron deficiency is still persistent, and the level of anemia is high among refugee women of childbearing ages, suggesting poor

quality of dietary iron sources. Therefore, consumption of a mix of animal-based and iron rich-plant food sources among women of childbearing age in Adjumani refugee settlement should be encouraged. The promotion of nutrition interventions could also consider diversifying the economic activities of women in the refugee context to improve the impact.

Keywords: Adjumani refugee settlements, Anemia, Dietary iron intake, Iron deficiency anemia, serum ferritin

CHAPTER ONE

INTRODUCTION

1.1. Background

Anemia is a condition that results from decreased erythrocytes which is inadequate to meet the physiological needs of the body (Kare & Gujo, 2021). Globally, approximately 2 billion people are affected by Anemia annually which accounts for a third of the world's population (Garzon *et al.*, 2020). It affects all age groups, but women are more vulnerable to anemia (Id *et al.*, 2019), attributed to their increased nutrient needs because of loss of blood during menstrual periods, pregnancy, and lactation (Storm *et al.*, 2007). More than half a billion Women of Child-bearing Age (WCBA) are anemic globally (Abou-rizket *et al.*, 2021). The global prevalence among non-pregnant and pregnant women is estimated to stand at 29% and 38% respectively (Kay *et al.*, 2019) with African countries being the most affected with the highest prevalence of 62.3% (Gebremeskel *et al.*, 2020). In Uganda, 32% of women of child bearing age are anemic (Nankinga & Aguta, 2019; Nampijja *et al.*, 2022). In Adjumani among refugees, the prevalence of anemia among WCBA stands at 53.7% (FSNA, 2020) which reflects inadequate iron intake or low iron bioavailability in the diet (Djokic *et al.*, 2010). The foods rich in iron include meat, fish, eggs, beans, millet, green leafy vegetables, and dietary iron enhancers include foods rich in vitamin C such as fruits. Although food assistance is shifting from food id to cash based transactions (WFP, 2022), a significant number of refugees still solely rely on food rations which are deficient in most essential micronutrients including iron (Kemmer *et al.*, 2003; Woodruff *et al.*, 2006; Koren *et al.*, 2019). The intake of iron and folate among asylum seekers is clearly seen to be below the reference values (Khan *et al.*, 2019).

Anemia contributes to half of the total deaths with up to 31% in Africa (Pasricha *et al.*, 2013). It is the leading cause of maternal deaths accounting for 20%-40% of total maternal deaths (Balis *et al.*, 2022) and leads to poor pregnancy birth outcomes such as low birth weight, preterm birth, perinatal and neonatal mortality (Mantadakis *et al.*, 2020). Among infants, it's one of the leading causes of morbidity and mortality (Dutta *et al.*, 2020) and leads to both behavioral and cognitive development delays with adverse effects such as impaired learning, poor school performance and lower scores on mental and motor development (Brotanek *et al.*, 2005; Chandyo *et al.*, 2015). Development of anemia is associated with age, ethnicity, education levels, gender, and poverty levels (Elmardi *et al.*, 2020). However, iron deficiency does not only lead to anemia but also development of symptoms that compromise the quality of life such as weakness, increased fatigue, impaired attention, memory loss and increased susceptibility to infections (Makhmonov *et al.*, 2021). Although anemia is caused by many factors, iron deficiency anemia contributes to more than 50% of the total anemia cases (Tadege *et al.*, 2018). Other causes of anemia are deficiencies in other micronutrients such as vitamin B12, folate, vitamin A and infections like malaria, HIV and TB (Jablonka *et al.*, 2018; Mehrotra *et al.*, 2018).

Despite the high prevalence of iron deficiency anemia among WCBA in Adjumani, there is still limited information on biochemical assessment of iron in the body and its relationship with the dietary iron intake as the available information is on the general anemia obtained using a portable hemocue machine. There is no data available on assessment of dietetic and population-related factors related to the iron level in the serum of these age groups among refugees. Therefore, this study sought to investigate these factors and conduct biochemical assessments to

measure the serum ferritin levels in blood and then comparing it to the dietary iron intake among the WCBA in the refugee settlements.

1.2. Statement of Problem

Many nutrition sensitive interventions such as nutrition sensitive agriculture, livelihood enhancements, nutrition education, school feeding programs and nutrition specific interventions such as management of malnourished cases, food aids, micronutrient supplementation are being offered by both the government and non-government organizations to reduce the triple burden of malnutrition including micronutrient deficiencies of public health concern such as iron. Despite all these efforts, the prevalence of Anemia among refugees in Adjumani continues to be worrying.

Anemia remains a significant public health challenge and a primary cause of both morbidity and mortality among women of childbearing age (WCBA) in Adjumani district. The prevalence of anemia among WCBA in West Nile sub-region and Adjumani district stands at 76% and 53.7% respectively (UNHCR 2020), statistics which are higher than the 42% report for Uganda (Nankinga & Aguta, 2019) and beyond the WHO acceptable levels of below 20%. Anemia is the primary cause of maternal deaths and results to poor birth outcomes, including low birth weight, premature birth, perinatal and neonatal mortality (Mantadakis *et al.*, 2020). Refugees mostly rely on food rations which are deficient in most essential micronutrients including iron (Koren *et al.*, 2019; Woodruff *et al.*, 2006; Kemmer *et al.*, 2003) and has escalated the prevalence of anemia.

Despite this, previous anemia studies among refugees focused on anemia screening and reported the general anemia status (UNHCR, 2017; WFP, 2022). While it is important to understand the

general anemia situation, these studies did not reveal the proportion attributed to iron deficiency Anemia (IDA). This therefore makes it difficult to relate the anemia deficiency to levels of consumption of iron. In addition, limited information exists on dietetics and socio-demographic factors related to serum iron levels of these age groups among refugees evidenced by studies conducted by (Tadege et al., 2018; WFP, 2022)) Therefore, this study sought to investigate these factors and conduct biochemical assessments to measure the serum ferritin levels in blood and compare it to the dietary iron intake among the vulnerable population groups in the refugee settlements.

1.3. Objectives

1.3.1. General Objective

The main objective of this study was to investigate the contribution of dietary intake and demographic factors to the iron deficiency anemia amongst WCBA in Adjumani refugee settlements.

1.3.2. Specific Objectives

- i. To determine the levels of dietary iron intake among women of childbearing ages in Adjumani refugee settlement.
- ii. To determine the extent to which of iron deficiency anemia contributes to the total anemia among WCBA in Adjumani refugee settlement.
- iii. To evaluate the socio-demographic and dietary factors related to serum iron status of WCBA in Adjumani refugee settlement.

1.4. Research Questions

- i. What is the status of dietary iron intake among WCBA in Adjumani refugee settlements?
- ii. To what extent does iron deficiency anemia contribute to the total Anemia among WCBA in Adjumani refugee settlements?
- iii. How do the dietary and socio-demographic factors influence iron deficiency Anemia of WCBA in Adjumani refugee settlements?

1.5. Justification

Despite the availability of both nutrition specific and sensitive interventions offered by both the government and NGOs across all the settlements, that are aimed at reducing the prevalence of anemia among the refugees, anemia remains a significant public health burden and the leading cause of illness and deaths in under five years and among WCBA in Adjumani District. All studies that have been conducted in Adjumani district aimed at establishing the total anemia among WCBA. No studies have been conducted to either establish the contribution of iron deficiency anemia to the total anemia nor to determine the influence of socio-demographic and dietary factors to body iron status. Unveiling the serum ferritin levels in relation to dietary iron intake alongside understanding the dietary and socio-demographic factors related to serum iron status which will be used by NGOs and government to design effective interventions such as iron supplementation, promotion of kitchen gardening and promotion of consumption of diversified diets that will lead to improved nutritional status among WCBA in Adjumani.

1.6. Significance of the Study

This study provided baseline information on the dietary iron intake and prevalence of iron deficiency anemia among WCBA on which further research can be carried out. By addressing

the root causes of some identified factors and implementations of recommendations from this study, it will lead to improvement of the dietary iron intake of this target group. The identified factors such as low dietary iron intake stemming from largely consumption of plant-based foods could be addressed by fortification of food rations, biofortification and diversifying economic activities of the target group. The insights from this study can be used to inform policies and interventions such as blanket iron supplementation for all WCBA by the public, private sectors, and non-government organizations aimed at improving the nutritional status of iron status of WCBA.

CHAPTER TWO

LITERATURE REVIEW

2.1. Dietary iron intake among women of childbearing age

There exist two distinct types of iron present in various food sources, namely heme and non-heme iron (Rens, 2020). During the gestational period, there is a decrease in the overall concentration of hemoglobin due to an expansion in plasma volume, resulting in hemodilution. This physiological change renders pregnant individuals more vulnerable to the development of anemia (Srour *et al.*, 2018). The diets of refugees tend to have high levels of iron inhibitors, such as phytates and polyphenols, due to their heavy reliance on corn as a staple food. Consequently, women of reproductive age often struggle to exceed the required daily intake of iron (de la Cruz-Góngora *et al.*, 2018). As a consequence of the decrease in overall food provisions, a significant number of households have turned to consuming tea with their meals. This practice has been found to impede the absorption of iron, so rendering refugees more vulnerable to the development of anemia. A study by Id *et al.* (2019) reported that a significant proportion exceeding 50% of the refugee population faces a heightened vulnerability to insufficient intake of essential micronutrients, including iron and folate. The prevalence of inadequate intake of iron-rich foods, such as organ meats and green leafy vegetables, among refugee communities can be attributed to the influence of traditional and cultural beliefs (Mohammed *et al.*, 2019). A significant proportion of women within the reproductive age group exhibited dietary iron intake that fell below the required thresholds, as indicated by Milman (2020). This inadequacy in iron consumption has been identified as a contributing factor to the occurrence of low levels of iron in the body, as highlighted by Milman (2019b).

In a study conducted by Muggaga, *et al.* (2021), it was observed that a significant proportion of women of childbearing age (WCBA) in the Karamoja Sub-region of Uganda did not meet the Recommended Daily Allowance (RDA) for various nutrients. Specifically, the study found that, on average, 57.7% of WCBA did not meet the RDA for energy, 66.6% for protein, 78.5% for calcium, 60.3% for iron, 67.7% for zinc, and 93.7% for folic acid. The Karamoja sub-region frequently depends on food donations provided by the government and other charitable individuals or organizations. This situation is also observed in refugee settlement camps within Uganda, such as Adjumani.

In a separate study aimed at evaluating the extent to which Fortified Foods contribute to the Apparent Intakes of micronutrients that are of significant public health relevance in the Diets of Women of Reproductive Age in four African countries, including Uganda, researchers found that fortified foods played a substantial role in providing vitamin A and iodine, but did not significantly contribute to iron intake (Valerie *et al.*, 2020). The study additionally revealed that in most nations implementing iron fortification programs, such as Uganda, it is necessary to augment the iron levels in fortified foods to achieve desired improvements in iron intake, while still complying with established regulatory guidelines. In Uganda, recent evaluations suggest that there is a suboptimal choice of foods for fortification due to the limited consumption of fortifiable wheat and maize flours at the population level (Valerie *et al.*, 2020). In this scenario, it is important to note that even if the industry adheres to the fortification regulations, the possible impact on iron intake would be minimal. Most refugee camps in Uganda primarily receive energy-dense food supplies, such as maize and wheat flour, which consequently leads to a decrease in dietary diversity and limited availability to essential micronutrients, such as iron (Valerie *et al.*, 2020).

In a recent study conducted by Action Against Hunger, UNICEF, and other development partners in the period of November 2020 to April 2021, titled "Overview of the Integrated Food Security Phase Classification (IPC) Acute Malnutrition Analysis of the Refugee Settlements in Uganda," it was observed that the refugee settlements of Adjumani, Palabek, Bidibidi, Rhino Camp, Palorinya, and Kiryandongo were classified under IPC Phase 2 (Alert). The study revealed that these settlements had prevalence of Global Acute Malnutrition at 8.3%, 8.2%, 6.7%, 6.9%, 5.3%, and 8.7% respectively. In contrast, the Imvepi settlement exhibited a prevalence rate of 4.3%, while Lobule had a rate of 3.5%. Similarly, Kampala, Kyaka II, and Kyangwali settlements had rates of 3.7%, 1.2%, and 1.1% respectively. Nakivale, Oruchinga, and Rwamwanja settlements also fell within this category, with prevalence rates of 2.2%, 2.1%, and 2.2% respectively. These settlements were all classified under the IPC Phase 1, indicating an acceptable level of food security. In the projected timeframe from May to September in 2021, it is expected that Adjumani, Palabek, and Kiryandongo refugee settlements will be categorized under IPC AMN Phase 3 (Serious), while Bidibidi, Imvepi, Lobule, Palorinya, and Rhino Camp will be classified under IPC Phase 2 (Alert). The remaining settlements will continue to be classified under IPC Phase 1 (Acceptable). This information is both intriguing and concerning.

The primary determinants that contribute to the occurrence of acute malnutrition among refugee settlements are: 1) The food consumption of refugees is insufficient in terms of both quality and quantity. This is evidenced by a 40% reduction in food rations for refugees, resulting in only 22% of children achieving Minimum Dietary Diversity. Additionally, it is estimated that 36% of refugee population in rural settlements experiences food insecurity (CARI indicator), and only 29% of women are able to meet Minimum Dietary Diversity. 2) The COVID-19 disruptions, along with stigma and fear, have led to a decline in health-seeking behavior among refugees. 3)

There is a high burden of disease among refugees, particularly malaria, diarrhea, and acute respiratory infections. 4) There are inadequate practices related to infant and young child feeding (IYCF) and maternal, infant, and young child nutrition (MIYCAN). Approximately 62% of infants are exclusively breastfed, and 70% for complementary feeding of children aged 6-8 months 5). Most settlements have low coverage of Community-based Management of Acute Malnutrition (CMAM) and insufficient Vitamin A supplementation, with only 70% of the population receiving it. In addition, the prevalence of anemia in children aged 6-59 months and nonpregnant women aged 15-49 years in refugee settlements is a matter of public health significance, with severe cases accounting for 2%, moderate cases accounting for 28%, and mild cases accounting for 24%. The current rate of iron-rich food consumption remains very low, with only 24% of individuals meeting the recommended intake.

Between the period of May to September 2023 it is projected that there will be an escalation in disease burden, particularly with regards to malaria and diarrhea. Additionally, there is a likelihood of further deterioration in food consumption hence low dietary iron intake. Moreover, certain settlements may experience a rise in the influx of refugees due to the relaxation of border restrictions, combined with the prevailing instability in the Democratic Republic of Congo and South Sudan. It is quite probable that these causes would result in a rise in acute malnutrition rates among children below under five and pregnant or lactating mothers (PLMs). At a further analysis of the determinants of acute malnutrition, particularly at Adjumani camp, it was observed that the primary factors leading to this condition were recurring crises resulting from typical shocks, anemia among children 6-59 months, and non-pregnant women. However, there was a lack of available data pertaining to the prevalence of anemia specifically pregnant women.

Hence, it was imperative to conduct an evaluation of the dietary iron consumption amongst women within the reproductive age category, including those who are currently breastfeeding, pregnant, as well as those who are neither pregnant nor lactating.

2.2. Contribution of iron deficiency anemia to total anemia

Iron insufficiency is well recognized as the most prevalent form of micronutrient deficit among refugee populations. In regions where the frequency of anemia surpasses 30 – 40%, the majority of cases of anemia seem to be attributed, at least partially or entirely, to iron deficiency (ID) (Koren et al., 2019; Davidson et al., 2022). Iron-deficiency anemia (IDA) is well recognized as a significant medical issue on a global scale, particularly within refugee populations. The insufficiency of iron in food rations is a common occurrence, which contributes significantly to the prevalence of anemia among displaced populations over an extended period of time. Previous studies have not yet conducted comprehensive nutritional evaluations, specifically in the determination of iron levels, among refugee children under five and WCBA residing in the Adjumani refugee camp (Brittenham GM., 2018).

Iron deficiency anemia (IDA) during pregnancy is reported to be linked with adverse consequences such as intrauterine growth retardation, premature birth, low birthweight, prolonged labor, increased susceptibility to infections, raised rates of maternal and perinatal death, impaired muscle function, and reduced physical capacity. Iron deficiency anemia can be identified during pregnancy when the levels of hemoglobin drop below 10 g/dl. Levy *et al.* (2005) linked this condition to unfavorable outcomes for the fetus, such as low birthweight and preterm delivery, as well as an elevated risk of maternal illness and death. Between the gestational period of 6 to 12 weeks, there is an observed rise in maternal plasma volume ranging from 10% to 15%. This growth persists and continues until the 34th week of gestation.

Approximately half of the plasma volume experiences a growth during successful pregnancies, while the volume of red blood cells (RBCs) increases by 20% to 30% until the conclusion of pregnancy, provided that women are able to maintain adequate iron levels. The diagnostic tests utilized for the detection of iron deficiency anemia encompass, transferrin saturation, serum iron concentration, total iron binding capacity, serum ferritin and complete blood count. The diagnosis of the condition is commonly determined through the measurement of serum ferritin concentration, as highlighted by Nawsherwan *et al.* (2020).

IDA is primarily attributed to inadequate diet in affected persons. The likelihood of experiencing such a deficiency is heightened throughout the initial stages of life, as well as during pregnancy in women. The reason for this phenomenon is that throughout these specific time periods, there is a greater demand for iron in comparison to other historical times. The prevalence of IDA is expected to rise in refugee settlements because of reductions in food rations and the predominance of energy-dense food donations. Given the significance of the idea, this study aims to examine the role of IDA total anemia in Adjumani refugee camp in Uganda (Mishra *et al.*, 2018; Srour *et al.*, 2018), as there is limited understanding of its impact on anemia in these specific circumstances. Based on the results of Abdul-Fatah *et al.* (2018), and Mishra *et al.* (2018), it was determined that IDA accounted for 43% of all occurrences of anemia in children, whereas 91% of pregnant women in Pakistan were identified as having iron deficiency anemia. Additionally, the research findings indicated that the maternal hemoglobin status had a significant impact on the outcome of pregnancy. Infants born to women with low hemoglobin levels had a tendency towards decreased birthweight.

In a study conducted by Mbunga *et al.* (2021), the researchers examined the prevalence of anemia, specifically IDA, and its related factors among children 1-5 years in the rural, malaria-

endemic region of Popokabaka in the Democratic Republic of Congo. The study revealed that the prevalence of IDA was 1.8% when diagnosed solely based on adjusted ferritin levels, while it was 12.9% when determined using transferrin saturation of the analyzed samples. However, the impact of IDA on anemia in this region was shown to be minimal. Nevertheless, World Health Organization (WHO) reported that approximately 50% of anemia cases worldwide may be attributed to iron deficiency (ID). The WHO further asserts that ID is the primary factor contributing to the overall burden of anemia (Miller, 2013). Consequently, it is imperative to examine the extent to which IDA contributes to the overall prevalence of anemia in refugee camps located in Uganda, specifically in Adjumani.

The study conducted by Julieta *et al.* (2022) on the impact of Iron and Vitamin A Levels on Pregnant Women and Birth Outcomes in Uganda found out that there was no significant association between maternal iron status (ferritin and BIS) and anemia (hemoglobin) with the assessed birth outcomes. Nonetheless, a noteworthy correlation was observed between serum soluble transferrin receptor (sTFR) levels and occurrences of preterm deliveries, as indicated by an adjusted odds ratio (AOR) of 0.67 and a 95% confidence interval (CI) ranging from 0.48 to 0.94. These data suggest that additional research is required to examine the correlation between maternal iron status and birth outcomes. The relationships observed varied depending on the specific biomarker utilized, with some indicating a potential negative impact on birth outcomes while others did not show a meaningful relationship. Furthermore, it was verified that elevated levels of maternal RBP may have a positive influence on delivery outcomes. Briefly, the results suggested that the association between maternal serum iron levels antenatal and birth outcomes wasn't characterized by a straightforward linear connection, thus necessitating additional research to gain a deeper understanding. The correlation between the biomarker used and the

relationship under investigation appears to vary. Specifically, when serum ferritin or BIS were utilized, the results did not exhibit statistical significance. However, when sTFR was employed, a significant association with premature deliveries was seen.

2.3. Influence of dietary and socio-demographic factors to iron status

The serum iron status of household members is influenced by the size of the family. It was shown that persons belonging to families with more than five members had a higher prevalence of anemia compared to individuals in smaller families (Shaka & Wondimagegne, 2018). The anemic status of individuals is directly influenced by their level of literacy and job position (Shaka & Wondimagegne, 2018). The primary factor contributing to suboptimal adherence to iron supplementation among women during the antenatal period is the insufficient provision of counseling, leading to a lack of knowledge (Id al., 2019). In a study conducted by Ram *et al.* (2019), the provision of nutrition education was found to have a substantial impact on the dietary intake of iron-rich foods within households, resulting in notable improvements in their iron status. According to a study conducted by Id *et al.* (2019), households with little financial resources are at a decreased likelihood of being able to afford and include into their diets foods that are abundant in bioavailable iron, such as meat, eggs, fish, and poultry. According to Gautam *et al.* (2019), there is no statistically significant association between decision making and autonomy in health care and the iron status of married women. Swaminathan *et al.* (2019) found that there exists a tenuous correlation between iron intake and the prevalence of anemia. However, the consumption of vitamin C and vitamin B12 amplifies this correlation. Insufficient intake of milk, meat, and vegetables in children has been found to be linked to an elevated prevalence of anemia (Martin *et al.*, 2018). The body iron status of women has a direct correlation with their understanding of anemia during pregnancy (Wemakor, 2019). Children

under the age of five, who are born to mothers with anemia, come from impoverished households, and experience undernourishment, have an elevated likelihood of getting anemia (Yusuf *et al.*, 2019). A substantial correlation has been reported between anemia prevalence in children and women of childbearing age and certain socioeconomic factors, such as residing in rural areas, having poor household wealth, and possessing low levels of education among caregivers (Kumera *et al.*, 2018; Berhe *et al.*, 2019; Mohammed, Larijani, *et al.*, 2019). The research conducted by Gonete *et al.* (2018) demonstrates a statistically significant correlation between anemia and both food insecurity and the living conditions of children and mothers. A significant association has been seen between maternal age and the occurrence of anemia in infants born to mothers between the age range of 15-29 years, as reported by Onyeneho *et al.* (2019). According to Nurhayati *et al.* (2019), individuals who possessed limited understanding of iron deficiency were found to be susceptible to developing iron deficiency anemia. There is an observed inverse association between women's empowerment in agriculture and the likelihood of experiencing poor iron status.

Anemia is a complex condition influenced by multiple causes, which can be categorized based on their role in the pathophysiological progression. Socioeconomic and demographic variables, such as limited access to education, and cultural norms, such as adherence to food taboos, can contribute to the susceptibility of children and women to anemia. This susceptibility arises from immediate causes, including physiological, biochemical, dietary, and infectious factors. Nevertheless, there is a scarcity of published literature about anemia in refugee settlements in Uganda, likely attributed to the limited availability of data and the underreporting of socioeconomic and demographic characteristics related with this condition. This research study aims to examine the association between socioeconomic and demographic factors and anemia

among children and WCBA. Additionally, it seeks to explore the association between childhood anemia and child nutritional status. The findings of this study can be utilized to inform policy development, planning, and implementation efforts (Kandala., 2013).

Muggaga *et al.* (2021) found that WCBA in Karamoja sub-region in Uganda had inadequate dietary intake, highlighting nutritional challenges. Several socio-economic and demographic factors were identified as influential in the insufficient intake of energy and nutrients among women of childbearing age. These factors comprised of age, the education level, the number of women married and occupation of the household head and spouse, as well as the status of being a lactating mother. In 2016, there was an observed association between women residing in households with non-improved sources of drinking water and an increased likelihood of experiencing anemia (odds ratio [OR] 1.32, 95% confidence interval [CI] 1.09-1.61). The presence of anemia in women was found to have significant associations with variables such as wealth index, area, and age. Based on the aforementioned studies, it has been observed that various factors significantly impact an individual's iron intake status. These factors include water and sanitation conditions, age, educational attainment, occupation of the household head and spouse, lactation or breastfeeding status, number of children within a family, number of women married, and access to or ownership of land. Most studies examining the factors that influence iron intake have been undertaken in well-established urban areas, among refugee populations, and in developed nations. This study aims to address the research gap pertaining to the examination of dietary and sociodemographic factors that impact serum iron levels in both developing country settings and recently formed refugee settings. Hence, this underscores the necessity of investigating the socio-demographic determinants that impact the prevalence of iron consumption in the Adjumani refugee camp.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Study Area

The study was carried out in Adjumani district. It's among the nine districts in West Nile region that is hosting South Sudanese refugees. It comprises of a total population of 439,900 among which 207,500 are refugees and 18.3% (37,350) of these are women of childbearing age (UBOS, 2016). It shares borders with Moyo District to the north, South Sudan to the northeast, Arua District to the southwest, Amuru District to the east and south and Yumbe District to the northwest. it consists of 6 sub counties in which the 19 refugee settlements are embedded (Authority, 2019). This district was selected because it's one of the refugee hosting districts with a high prevalence of anemia despite the existing interventions to avert anemia. The prevalence is up to 53.7% among women of childbearing ages (FSNA, 2020)

3.2. Research Design

This study employed a cross-sectional design consisting of a survey on dietary iron intake and laboratory analysis for iron status of women of childbearing ages. Laboratory examination of blood samples was used to determine serum iron status and iron deficiency anemia. Collection of the samples and administration of questionnaires using face to face interviews was done in the health facilities embedded in the different settlements.

3.3. Study population and sampling

3.3.1. Study population

The study population comprised of WCBA because they are more vulnerable to iron deficiency anemia. Only registered, validated refugees and those willing to participate met the criteria for participation in the study.

3.3.2. Inclusion criteria

For the women to qualify to be recruited for the study, one had to be non-pregnant during the study and should have had their last menstrual period within three weeks period since the likelihood of them being pregnant was considered low. In addition, only refugees were considered, and they should have stayed in the settlement for a period not less than 3 months. Finally, for women below 18 years, only those with children were considered for the study as a proof that they were of reproductive ages.

3.3.3. Exclusion criteria

Pregnant women were not considered since they were taking iron supplements which would have given results not reflective of their dietary iron intake. In addition, Lactating women were excluded as their needs for iron would be higher than the other WCBAs. Furthermore, non-refugee WCBAs were not considered and WCBA who had stayed in the settlement for less than 3 months were also excluded since they had not been exposed to the dietary iron intake situation in the settlement.

3.3.4. Sample size determination

The sample size was obtained using Danial sample size formula as applied by (Neme & Olika, 2017) using the following equation.

$$n = \frac{Z^2 P (P - 1)}{d^2}$$

Where:

Z = z statistics at 95% confidence level = 1.96.

d= Marginal error at 5%= 0.05

P= Prevalence of anemia in study groups. Given that the prevalence of anemia among WCBA in Adjumani settlement is 50.3%, P= 0.503

Assumption of 10% non-response was made and the final sample size adjusted accordingly.

Sample size was then,

$$n = \frac{1.96^2 * 0.503(1 - 0.503)}{0.05^2}$$

$$= 385 + 10\%$$

$$= 424 \text{ Subjects}$$

3.3.5. Sampling Procedure

Adjumani district was purposively selected since its one of the districts in West Nile hosting the highest number of refugees with the highest anemia prevalence. Eight out of the 19 refugee settlements in Adjumani district were selected using simple random sampling and furthermore,

only one block was randomly selected from each of the 8 settlements. Within the selected block a cluster was chosen using simple random sampling. Study participants were selected from a sampling frame containing households with WCBA in the different clusters that were obtained from the Village Health Teams (VHTs). The total number of households were divided by the required sample size to get the interval (N) and Simple random sampling was used to obtain the first household. This was followed by a systematic sampling method where every Nth household on the sampling frame was selected and included in the sample. Only one participant was selected from a household since members of the same household share the same meals. The sample size per settlement was 62 subjects except for Pagirinya settlement that had 28 sampled subjects. The lower number in pagirnya was attributed to the its small size as compared to other settlements.

3.4. Data Collection

3.4.1. Team composition

During data collection, each team comprised of the following people: a laboratory assistant who was responsible for anemia screening and sample collection, a nutritionist, or a nurse who administered the questionnaire on socio-demographic and dietary assessment. Then one VHT responsible for translating the questions from English to the local language.

3.4.2. Assessment of dietary iron intake among women of childbearing age

A food frequency questionnaire consisting of standard 10 groups for women of childbearing age was used to capture the frequency of consumption of the food groups by the study subjects for a period of 7 days. Estimated portion sizes in grams were also captured and was used to calculate the daily iron intake with the aid of harvest plus food composition tables. A similar method

applied by Skolmowska & Głabska (2019) to study intake of dietary iron among menstrating adolescents in national Polish population and Głabska *et al.*, (2017) to study the same among young Polish women. The following steps were used to calculate the iron intake: Quantities of iron consumed per 100 grams of each food were determined from the food composition tables, the iron quantities were then multiplied by the portion sizes of each food per food group consumed to get the total iron intake from the different foods. Finally, the total dietary iron in milli grams consumed by each subject was got by summing the iron quantities from the individual foods consumed for 7 days.

3.4.3. Determination of iron deficiency anemia among women of childbearing age

3.4.3.1. Anemic screening of study participant in the field

To determine dietary iron deficiency anemia, anemia screening was conducted for all selected participants using a portable Hemocue machine Hb301 which was used to determine their anemia status. Anemia was defined as Hemoglobin Concentrations of <12.0g/dl for non-pregnant women of childbearing age (15-49years). The following table shows the cutoffs for different levels of anemia among women of childbearing ages that was used to classify anemia status.

Table 1: Categories of anemia among women of reproductive ages based on cut offs for levels of hemoglobin

Sample category for non-pregnant WCBA	Cut HB level
Severe anemia	< 8.0g/dl
Mild anemia	11.0-11.9g/dl
Moderate anemia	8.0-10.9g/dl
Normal anemia status	>12g/dl
General anemia	<12g/dl

Source: WHO classification of anemia 2020.

Upon screening, blood samples were collected from the study group that were found to be anemic based on the Hemoglobin cuts offs for further investigation using ferritin levels as an iron biomarker. Serum iron levels were determined as a biomarker of iron in the blood using ELISA method according to the previous study (Dahman *et al.*, 2022). Use of ELISA as alternative method to analyze human ferritin level as biomarker for iron has been recommended in recent studies. The study by Dahman et al revealed that ELISA method showed a higher accuracy, specificity and sensitivity as compared to Cobas Integra method. The results from the serum ferritin analyzed by Cobas e411 were strongly correlated with ELISA.

3.4.3.2 Collection of blood samples to determine serum iron status

During household interviews, the samples of participants who were identified as anemic during screening were collected for further analysis to determine the serum ferritin levels using DuoSet ELISA kit batch numberDY3541-05 (Bio-technique company, United Kingdom). The amount of blood that was drawn from each participant was 4mls using 5 ml syringes and was placed in red top plain tubes and stored in the cool boxes for a maximum of 6 hours while still in the field before they were transported to the nearest health facilities for storage in a refrigerator. The samples were stored in the freezer for a maximum of 2 days upon which they were transported to the multifunctional lab at Gulu University for final analysis. Triple packaging of the blood samples was done to avoid sample spillage during transportation to Gulu University multifunctional lab. Cool and freeze storage at all points was done to ensure that the quality of the blood samples was not compromised to be able to produce accurate results which were a true reflection of the client iron levels.

3.4.3.3 Safety during Sample collection

To ensure safety during sample collection, the health workers followed the standard operating procedures for blood sample collection. Trained laboratory medical personnel were used to draw blood from the participants, subjects were informed about the procedure prior to sample collection which aimed at preparing them mentally to reduce risks of invasive accidents during pricking of the participants. Personal Protective Equipment (PPEs) such as gloves, masks and face shields were used to prevent disease transmission. Finally, proper waste segregation and management were done in that the sharps such as used needles and prickers were dumped in the sharps box while the used gloves, alcohol swabs and cotton were dumped in red bin liners. Both wastes were incinerated at the health facilities daily after field which eliminated any chance of infection.

There was an anticipated risk of hemophilia/ unstoppable bleeding during sample collection. During the data collection, no such case was registered but however, standard operating procedures were put in place during the data collection to accommodate and manage such cases such as ensuring that such cases are linked to specialized medical doctors at the health centers and the field team had obtained phone numbers of these medical doctors before going to the field to ensure quick referral and linkage. Another possible adverse effect was infections of the punctured site during sample collection. To prevent this, the health workers ensured proper disinfection of the punctured site with alcohol swabs before pricking of the site was done.

3.4.3.4. Laboratory procedure for serum ferritin (iron) determination

The serum ferritin levels were estimated using Enzyme-Linked Immunosorbent Assay (ELISA) Method. The DuoSet ELISA kit that was used was purchased from Bio-technique company, United

Kingdom with a batch number of DY3541-05. This method was selected because of its high sensitivity, accuracy and specificity. This was realized when three methods were compared such as ELISA, Cobas e411 and Ciba Integra in analyzing serum ferritin levels, it was found out that there was no significant statistical difference between ELISA and Cobas e411 while there were significantly higher values from Cobas Integra 400 method (Dahman *et al.*, 2022). In this study, the steps used in analyzing serum ferritin levels included the following: Plate Preparation was done which involved: Initially, the capture antibody was diluted to a working concentration in Phosphate-buffered saline (PBS) without any carrier protein. Subsequently, 100 μ L of the diluted capture antibody was added to each well of a 96-well microplate. The plate was sealed and left to incubate overnight at room temperature. Afterward, the contents of each well were aspirated, and a buffer was used to wash each well. This washing process was repeated two more times, resulting in a total of three wash cycles. To perform the washes, each well was filled with 400 μ L of wash buffer using a squirt bottle.

To block the plates, 300 μ L of reagent diluent was added to each well and incubated at room temperature for one hour, as described by Dahman et al. (2022). Subsequently, plate aspiration was performed to prepare them for sample addition. The assay procedure involved the following steps: 100 μ L of sample or standards in reagent diluent were added per well, covered with an adhesive strip, and incubated for 2 hours at room temperature. Afterward, plate washing was conducted. Following the washing step, 100 μ L of the detection antibody, diluted in reagent diluent, was added to each well, covered with a new adhesive strip, and incubated for an additional 2 hours at room temperature. Plate aspiration was repeated once again. Next, 100 μ L of the working dilution of streptavidin-HRP B was added to each well, covered, and incubated for 20 minutes at room temperature, followed by another round of washing/aspiration.

Subsequently, 100 μ L of substrate solution was added to each well and incubated for 20 minutes at room temperature, away from direct light. Finally, 50 μ L of stop solution was added to each well, and the plate was gently tapped to ensure thorough mixing. The optical density of each well was determined immediately using a microplate reader set at 450nm.

Calculation of results

For the calculation of results, duplicate readings for each standard, control, and sample were averaged, and the average zero standard optical density was subtracted. A standard curve was constructed by plotting the mean absorbance for each standard on the y-axis against the concentration on the x-axis, with a best-fit curve drawn through the points on the graph. Afterward, the data was linearized by plotting the logarithm of the human ferritin concentrations against the logarithm of the optical densities, and the best-fit line was determined through regression analysis.

3.4.4 Assessment of factors associated with serum iron status

Data on factors linked to serum iron levels was collected from the respondents using a pre-tested questionnaire which was administered and filled in by trained enumerators. These included demographic data (e.g., age, education levels) and dietary data (e.g., frequency of food consumption) predicted to affect the levels of iron in the body. Analyses were made to ascertain if these factors were associated with participants levels of iron in the blood. All the data collected was checked and verified for accuracy, completeness, and eligibility daily in the field and upon returning.

3.5. Data Analysis

The data analysis was performed using SPSS version 25 (Statistical Package for Social Scientists). Preceding the analysis of data, a process of data cleaning was conducted to improve the overall quality of the data. The analysis of data was done per objective as follow:

3.5.1 Dietary iron intake by women in childbearing age in Adjumani Refugee Settlement

The captured portion size estimates from the Food frequency questionnaire were recalculated into daily iron intake using predetermined formulas from the food composition tables. This objective was analyzed in following parts (i) socio-demographic characteristics, frequency of commonly consumed foods, and estimated weekly iron intakes were summarized using descriptive statistics particularly frequency, percentage, mean, and standard deviation (ii) comparison of daily iron intake to recommended daily iron intake was done using one sample t-test and (iii) factors influencing the dietary iron intake was analyzed using multilinear regression. The multilinear regression model utilized is represented in equation 1.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_{12} X_{12} + \mu \dots 1$$

Where Y is dependent variables depicting the dietary iron intake, X_1 to X_{12} are the independent variables; α is the regression constant; β is the regression coefficient; and μ is the error term. A Pearson correlation analysis was conducted before performing regression analysis. This was done to remove variables that were highly correlated (Achiro *et al.*, 2023) ($r > 60\%$).

3.5.2. Assessment of the contribution of iron deficiency anemia to total anemia

Descriptive statistics and graphs were utilized to summarize iron concentration of anemic participants. One sample t-test was used to compare the mean serum iron concentration with the WHO recommended cut off (15 $\mu\text{g/L}$) of iron concentration in women in childbearing age.

3.5.3. Determination of impact of dietary and socio-demographic factors on serum ferritin status of women of childbearing age in Adjumani Refugee Settlement

Factors influencing the serum ferritin were analyzed using multilinear regression and the regression model utilized is represented by the following equation 2.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_{12} X_{12} + \mu \quad \text{---2}$$

Where Y is dependent variables depicting the serum ferritin concentration, X_1 to X_{12} are the independent variables; α is the regression constant; β is the regression coefficient; and μ is the error term. A Pearson correlation analysis was conducted before performing regression analysis. This was done to remove variables that were highly correlated ($r > 60\%$).

3.6. Ethical Considerations

Ethical clearance was obtained from Gulu University Ethical Committee under GUREC number-2023-552. Permission to conduct the study in the refugee settlement was also sought from the Office of the Prime (OPM), community leaders and the participants. An informed assent form was used to seek consent from their caretakers since they cannot consent by themselves. Sample collection was done by trained and experienced laboratory personnel and clinical officers. Use of personal protectives such as gloves, sanitizers and face masks were done to prevent infection and safeguard the study participants. Finally, confidentiality of data collected was ensured and data / blood samples collected were only analyzed for parameters under study.

3.7. Study Limitations

Iron deficiency anemia affects all age groups and the most vulnerable groups being children, women, and adolescents. This study only considered WCBA from 15-49 years. Therefore, there is need for other studies to unveil the influence of socio-demographic and dietary iron intake to

body iron status and to also conduct biochemical analysis of iron among the other groups vulnerable to iron deficiency.

The correlation between the biomarker used and the relationship under investigation appears to vary. Specifically, when serum ferritin or BIS were utilized, the results did not exhibit statistical significance. However, when sTFR was employed, a significant association with premature deliveries was seen.

CHAPTER FOUR

RESULT

4.1. Socio-demographic statistics of women of childbearing age sampled from Adjumani refugee settlement

Table 2 presents the sociodemographic characteristics of 462 Women of Child-Bearing Age (WCBA) residing in Adjumani Refugee Settlement who were targeted during the study. The average age and household size of the participants were approximately 31 years and 8 members, respectively. The study was primarily composed of married women. However, approximately 11% of the participants reported being single (Table 2). Most of the participants identified as Christian, while Islamic and reformer participants represented a smaller proportion of the study population. Slightly over 50% of the participants had received formal education, with a significant proportion having finished their primary education while more than 30% of them did not receive any formal education (Table 2). In relation to occupation, participants were involved in farming and informal employment, accounting for 39% and 42.9% respectively while only 5.6% and 12.6% worked as formal employees and businesspersons respectively. 51% of the women had household income that falls below the poverty line, with an average earning of approximately UGX 100,800. Relatedly, most of the food items consumed by the household were acquired through donations, with only 8.4% of the food items acquired through household purchases. Although household production accounts for approximately 17% of the household's food supply, approximately 50% of the produce is sold to generate revenue (Table 2).

Table 2. Socio-demographic characteristics of Women of childbearing ages sampled from Adjumani Refugee Settlement

Socio-demographic characteristics		N	Proportion (%)	Mean	Std deviation
Religion	Christian	447	96.8		
	Islamic	11	2.4		
	Reformer	4	0.9		
Marital status	Single	54	11.7		
	Married	374	81		
	Divorced	14	3		
	Widowed	20	4.3		
Education Level	Primary	231	50		
	Secondary	70	15.2		
	Tertiary	7	1.5		
	No formal education	154	33.3		
Occupation	Farming	180	39		
	Business	58	12.6		
	Formal employment	26	5.6		
	Informal employment	198	42.9		
Obtaining Household Food	Own production	78	16.9		
	Purchase	39	8.4		
	Donation	345	74.7		
Income generating activity	Business	71	15.4		
	Farming	228	49.4		
	Formal employment	40	8.7		
	None	116	25.1		
	Fishing	7	1.5		
Average Household income (UGX)				100837	136196
Age (years)				31.08	8.805
People Earning Some Income				1	1.18
Household Size				8	3.488

UGX = Uganda shillings, (N = 462), N = number

4.2. Dietary iron intake by women of childbearing age in Adjumani Refugee Settlement

4.2.1. Frequency of weekly consumption of foods rich in iron

Table 3 presents an analysis of the frequency of consumption of common foods, including cereals, root and stem tubers, legumes, nuts and oil seeds, dairy products, meat, fish and poultry, eggs, vitamin A-rich vegetables and fruits, green leafy vegetables, and other fruits. Plant-based foods were found to be more frequently consumed than animal-based foods. Overall, the most consumed foods were cereals with Sorghum and Maize having the highest frequencies of 58% and 50% respectively while millet and rice were the least consumed cereals. Legumes were commonly consumed as a sauce, with an average frequency of 3 times per week and under the legumes, beans were the most consumed, while garden peas (*Pisum sativum*) and pigeon peas (*Cajanus cajan*) were less consumed. In terms of green leafy vegetables, cowpeas were consumed to a moderate extent compared to other food categories. Conversely, a significant proportion of refugees did not partake of food items categorized as vitamin A-rich vegetables, meat, fish & poultry, dairy products, and eggs in the period of 7 days that preceded the survey.

Table 3: Weekly consumption of different sources of iron by women of childbearing age sampled from Adjumani Refugee settlement (n=462)

Food items		Frequency consumption per week (%)					Mean frequency of consumption (days)	Std. Deviation
		Never	Once	2-3 times	4-6 times	Daily		
Cereals	Sorghum	26.400	4.100	12.100	3.2	54.1	2.55	1.733
	Millet	82.000	4.800	5.200	1.1	6.1	0.46	1.119
	Maize	18.000	12.300	22.700	3.2	43.7	2.42	1.565
Root & stem tubers	Potatoes	78.000	9.500	8.400	0.4	2.8	0.39	0.879
	Cassava	57.800	20.800	13.800	1.1	6.7	0.78	1.147
	Yams	79.200	5.500	5.000	5.0	5.0	0.41	0.970
Legumes	Beans	14.300	13.600	41.300	3.9	26.8	2.15	1.342
	Garden peas	95.700	2.800	1.100	1.1	0.4	0.07	0.369
	Pigeon peas	60.200	18.600	18.600	0.6	1.7	0.65	0.923
Green leafy vegetables	Spinach	89.200	6.300	4.300	4.3	0.20	0.16	0.496
	Apparanthus (Dodo)	78.100	20.100	1.500	1.3	0.20	0.24	0.489
	Cabbage	69.300	23.800	6.500	1.5	0.40	0.39	0.648
	Cow pea leaves	27.700	25.500	39.000	6.5	6.3	1.33	1.089
	African spider plant	94.400	4.800	0.600	1.5	0.20	0.07	0.322
Vitamin A-rich fruits	Mangoes	93.300	4.800	0.400	0.4	1.50	0.12	0.543
	Papaws	80.100	15.200	3.500	3.5	1.30	0.27	0.651
	Carrots	98.100	1.700	0.200	1.7	0.20	0.02	0.160

(n = 462), std = standard

4.2.2. Estimated weekly intake of iron from foods commonly consumed by women of childbearing age in Adjumani Refugee settlement

Table 4 presents the estimated dietary iron intake from common foods. Sorghum exhibited a dietary iron intake about 7mg/week, while the ladies' fingers (Okra), ground nut, cowpea leaves, tomatoes, and bean-based diets showed a dietary iron intake below 1mg/week. Nonetheless, the consumption of dietary iron derived from simsim, Osobi, okra, and pigeon peas did not exhibit a significant difference at a p-value of 0.05.

Table 4: Mean weekly dietary iron intake from food items commonly consumed by women in childbearing age in Adjumani refugee settlement

Consumed foods	Mean (mg/week)	Std deviation
Sorghum	7.20 ^a	0.282
Maize	3.96 ^b	0.007
Beans	0.56 ^{de}	0.028
pigeon peas	0.38 ^{gf}	0.014
G/nut	0.16 ^c	0.007
Simsim (sesame seeds)	1.03 ^{gf}	0.007
Cowpea leaves	0.23 ^{gf}	0.014
Tomatoes	0.04 ^g	0.009
Okra	0.13 ^{gf}	0.007

Means with different letter in the same column are significantly different at $p \leq 0.05$ (n = 462), std = standard

4.2.3 Comparison of daily iron consumption to the recommended threshold of iron intake among women of children bearing age

Overall, the mean iron intake by women of childbearing was 17.60 mg/day which was not significantly different from the WHO recommended daily allowance (RDA) for this age category of 18.0mg/day. There were variations across the settlements with Boroli having the highest iron intake of 29.95 mg/day and Pagirinya with the lowest average iron intake of 7.60mg/day which was attributed to the differences in the sample size.

Table 5: Comparison of total mean daily iron intake of study participants to recommended daily intake of iron for women in childbearing age

Settlements	Daily intake (mg/day) (Mean $\pm$ SD)	Proportion below recommended intake	MD	p-Value
Ayilo 1	16.45 $\pm$ 2.3		-2.71	0.257
Ayilo 2	24.95 $\pm$ 1.1		-3.6	0.097
Boroli	29.0	2.2	9.4	0.107
Maaji2	12.19	1.23	-6.42	0.06
Maaji3	22.2	2.38	2.3	0.44
Nyumanzi	23.43	1.0	-2.24	0.14
Mungula	16.26	1.5	4.18	0.185
Pagirinya	7.61	0.9	-10.84	0.026**
All settlements	17.76	1.6	-1.04	0.417

MD = Mead difference from recommended daily iron intake for WCBA of 18mg/day (*WHO 2020*), ** = shows significance of 5%

4.2.4. Factors influencing iron intake by women of childbearing ages in Adjumani Refugee Settlement

Table 6 presents the result of the multiple linear regression utilized to identify the predictors that impact iron consumption. Iron intake was found to be influenced by various socio-economic factors. There was a significant influence of income generating activities and occupation on iron intake. The study findings indicate that engagement in farming and fishing resulted in a significant increase in iron intake by a factor of 7.07 and 8.929 respectively. The variables of age, method of food acquisition, and household size were found to have no significant influence on iron intake.

Table 6: Influence of socio-economic factors on iron intake by women of childbearing ages in Adjumani Refugee Settlement

Predictors	Coefficients		p-Value
	B	Std. Error	
Age (years)	-0.987	0.529	0.063
Most common way of obtaining food.	5.07	3.68	0.12
Household purchase			
Donation	10.06	4.262	0.467
In kind	-5.088	6.395	0.427
Household size (number of people)	1.624	1.33	0.223
Income generating activity.	7.07	2.48	0.032**
Farming			
Bricklaying	8.06	10.262	0.433
Fishing	8.929	4.459	0.046**
Business	6.45	2.37	0.159
Formal Employment	0.22	1.02	0.21

** shows significance of 5%, IGA = Income Generating Activity which included farming, bricklaying, and business

4.2. Contribution of iron deficiency anemia to anemia among women of women of childbearing age in Adjumani settlement

The initial assessment involved screening participants for anemia using the WHO cutoff of <12g/dl for being Anemic, and thereafter, serum ferritin lab analysis of anemic samples to identify those with iron deficiency anemia using the cutoff of <15 µg/L was done.

4.2.1. Proportion of women with anemia from Adjumani refugee settlement

Table 7 presents the outcome of anemia screening among selected WCBA within Adjumani refugee settlement. Overall, 34.4% were anemic with variations across the different settlements such as Ayilo 2 stood at 30.0%, Boroli was at 26.6%, Maaji 2 at 30.6%, Maaji 3 at 40.6%, Mungula at 45.2%, Ayilo 1 at 27.9%, Nyumanzi at 47.5% and Pagirinya at 17.9%. Mean hemoglobin concentration (Hb) was 12.5 g/dl. However, some settlements had higher Hb but among the anemic sample, the mean Hb was 10.76 g/dl.

Table 7: Prevalence of anemia among women of childbearing age in Adjumani refugee settlement (n=462)

Settlement	Total Screened (count)	Mean Hb (g/dL)	Anemic (Counts)	Mean Hb anemic (g/dL)	Proportion of anemia (%)
All settlements	462	12.5 ^a	159	10.76	34.4
Ayilo 2	60	12.6 ^a	18	10.67	30.0
Boroli	64	12.5 ^a	17	10.3	26.6
Maaji 2	62	12.5 ^a	19	10.7	30.6
Maaji 3	64	12.2 ^a	26	10.8	40.6
Mungula	62	11.9 ^a	28	10.6	45.2
Ayilo 1	61	12.3 ^a	17	11.2	27.9
Nyumanzi	61	12.4 ^a	29	10.1	47.5
Pagirinya	28	12.3 ^a	5	10.4	17.9

N = 462, WCBA = Women in Childbearing Age

4.2.2. Evaluation of serum iron concentration of Anemic women in Adjumani refugee settlement

The study analyzed the blood samples of 159 participants whose hemoglobin levels were below 12 g/dL. The overall serum ferritin concentration for the selected participants was 8.7 µg/L which was below the WHO recommended threshold of >15 µg/L. Ayilo 2 settlement had the highest serum ferritin concentration of 11.9 µg/L while Pagirinya settlement had the lowest ferritin concentration of 0.4 µg/L.

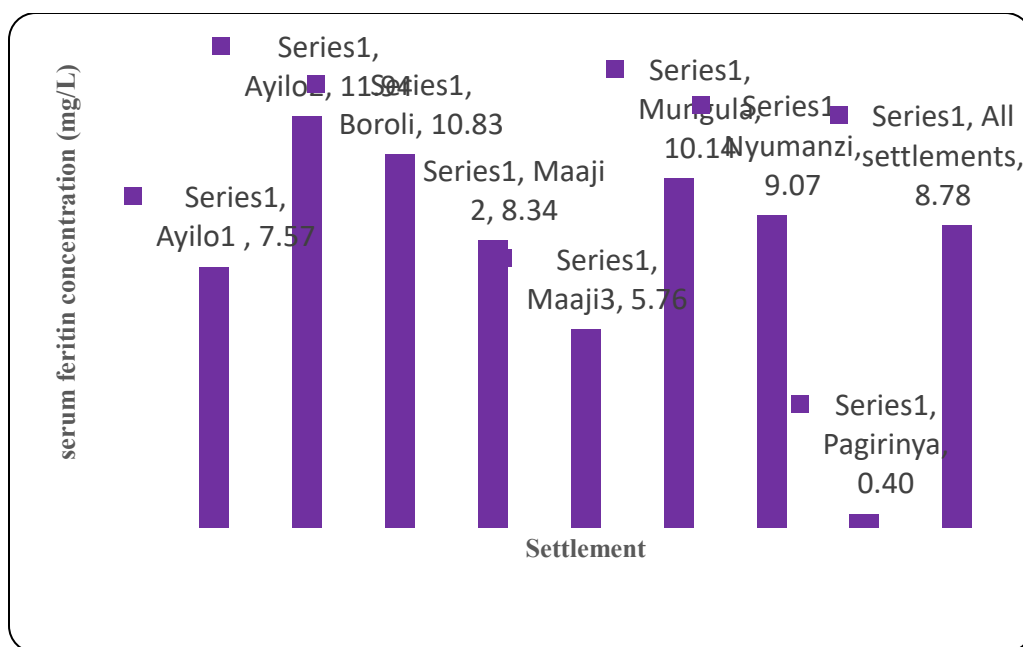


Figure 1: serum ferritin concentration of WCBA selected from different settlements in Adjumani settlement

4.2.3. Proportion of women of childbearing age with iron deficiency anemia in Adjumani refugee settlement

Figure 2 displays the proportion of IDA and non-iron deficiency anemia among WCBA in Adjumani refugee settlement. 37% of samples analyzed were found to have iron deficiency anemia (serum iron concentration less than 15 $\mu\text{g/L}$) while the highest proportion (approximately 62%) of the samples did not exhibit iron deficiency anemia.

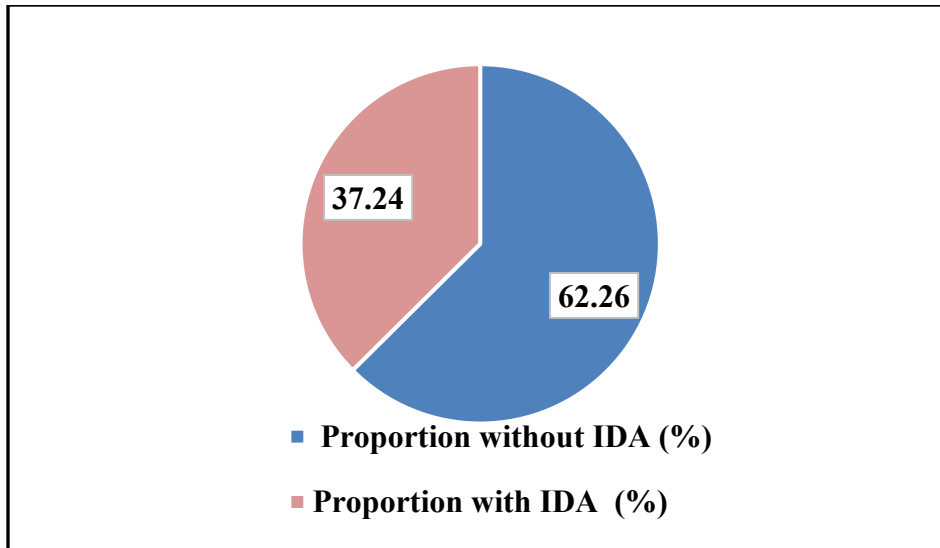


Figure 2: Proportion of participants with and without iron deficiency anemia

4.2.4. Comparison of serum ferritin concentration to WHO recommended threshold

The result of comparison of total serum ferritin concentration of iron deficiency anemic refugees with WHO recommended threshold is summarized in Table 8. Overall, the serum ferritin concentration of all participants (8.78 µg/L) was significantly lower than the WHO recommended threshold of 15 µg/L ($p < 0.05$). However, there was variation among samples from the different settlements studied. Ayilo 2 settlement had the highest mean serum iron concentration of 11.94 µg/L and was not significantly different from WHO threshold of 15 µg/L.

Table 8: Comparison of total serum ferritin concentration of iron deficiency anemic refugees with WHO recommendation of 15 µg/L

	MSIC	Mean Difference	p-value
All IDA	8.78	-6.2466	< 0.01**
Ayilo 1	7.57	-4.94	0.005**
Ayilo 2	11.94	-0.185	0.086
Boroli	10.83	-2.3	0.003**
Maaji 2	8.34	-4.52	0.001**
Maaji3	5.76	-6.6	<0.001**
Mungula	10.14	-3.67	0.001**
Nyumanzi	9.07	-3.97	0.001**
Pagirinya	0.4	-14.65	0.002**

** show level of significance at 5%, IDA = iron deficiency anemic, and MSIC = Mean Serum Iron Concentration.

4.3.1. Influence of dietary and socio-demographic on serum iron status of women sampled from Adjumani refugee settlement

Table 9 presents the result of the multiple linear regression of predictors of serum iron status of women. Iron status was impacted by various socio-economic factors. There was a significant effect of income generating activities, level of education, and monthly income. Engagement in income generating activities primarily farming resulted in a significant increase in serum iron concentration by a factor of 1.351. Conversely, level of education and estimated monthly income was found to have a negative impact on serum iron concentration.

Table 9: Influence of socio-economic factors on serum iron status of women in childbearing age in Adjumani

Predictors		Coefficients		p-Value
		B	Std. Error	
Age (year)		0.031	0.062	0.623
Marital Status		0.302	0.868	0.729
level of Education		-1.017	0.463	0.033**
Sorghum consumption		0.338	0.693	0.626
Total daily iron intake		6.395	0.432	0.362
Number of people earning some income		0.307	0.730	0.676
Income generating activity	Farming	5.07	2.48	0.042**
	Bricklaying	8.06	10.262	0.433
	Fishing	-17.22	14.24	0.228
	Business	3.45	3.37	0.309
	Formal Employment	-7.22	5.98	0.229
Estimated monthly income		-1.196E-05	0.000	0.029**

** shows significance of 5%, B = coefficient

CHAPTER FIVE

Discussion

5.1. Dietary iron intake by women in childbearing age in Adjumani Refugee Settlement

Anemia is a big threat to global population of women of childbearing age (WCBA), elderly, and children (Elmardi *et al.*, 2020). This challenge is attributed to inadequate intake of iron rich foods, arising from limited diets (Kay *et al.*, 2019), a situation that can be worsened by compromised access to diverse food by displaced population in refugee settlements. Thus, from this study, it was evident that the majority of WCBA consumed plant-based foods more frequently than animal-based foods. This is similar to findings by Muggaga *et al.*, (2023) who reported that consumption of plant-based foods such as starchy staples, dark green leafy vegetables, legumes, nuts and seeds was higher than intake of animal-based foods. The overreliance on plant-based foods could be attributed to lower purchasing power and relief dependency syndrome. The high intake of plant-based foods may provide adequate amounts of fiber, antioxidants, and phytochemicals that can modulate the gut microbiota, lower inflammation, improve metabolic parameters and reduce the risk of chronic diseases. However, plant-based diets may also pose some challenges, such as ensuring adequate intake of micronutrients like iron by lowering its bioavailability, which is essential for oxygen transport and cellular metabolism. This implies that over reliance on starchy plant-based food sources could lead to lower dietary iron intake as evidenced in the present study whereby the observed estimated daily total iron intake among refugee WCBA in Pagirinya settlement was 60.22% lower than the recommended daily intake (RDI). This can be adduced to the fact that majority of common plant-based foods consumed like sorghum, maize have low concentrations of iron.

Therefore, the findings suggest that most of the iron-rich plant foods, such as fortified cereals, beans and lentils should dominate the food ration given to refugees. In addition, the low dietary iron intake could be attributed to limited diets as seen with low consumption of animal-based diets rich in Iron (Kay *et al.*, 2019). According to Ahmed *et al.* (2021), low frequency of consumption of animal-based foods, particularly meat products among WCBA in refugee settlements is associated with high rates of anemia. Animal sources of iron, such as meat, poultry, and fish, have higher bioavailability and absorption rates than plant sources, such as beans, lentils, and leafy greens (Rousseau *et al.*, 2020). However, because of the constrained affordability of animal products, primarily due to low estimated average monthly income (Table 2), refugees often depend on what is available and accessible, which is plant-based foods (Table 3) as their primary source of nutrition. It is worth noting that these plant-based foods generally have lower iron bioavailability (Alowo *et al.*, 2018), and may need to be traditionally processed to enhance bioavailability. Hence, it is imperative to provide refugees with education on basic traditional methods of food processing. These techniques have the potential to improve the bioavailability of iron in plant-based food sources (Nwadi and Uvere, 2019), thereby aiding in the elevation of iron levels in the bloodstream and the prevention or treatment of anemia.

Given that several factors influence the intake of micronutrients by WCBA, the observed positive influence of income generating activities - farming and fishing on iron consumption can be attributed to possibility of having increased dietary diversity for households with such economic activities (Yokoyama *et al.*, 2017). The observed results are in line with the findings by Muggaga *et al.*, (2023) who showed that employment status (occupation) influenced consumption of nutrients by WCBA. The observed lack of significant influence of age, method

of food acquisition, and household size on iron intake however contradicts with findings by Muggaga *et al.*, (2023) who highlighted otherwise.

5.2. Assessment of the contribution of iron deficiency anemia to total anemia

5.2.1. Proportion of women with anemia from Adjumani refugees' settlement

Anemia is a common health problem among refugees, especially in children and women (Kay *et al.*, 2019). According to a study by Teketelew *et al.*, (2023), anemia can affect up to 70% of refugees in some settings, due to factors such as malnutrition, infections, and poor sanitation. The prevalence and types of anemia may vary depending on the region, the camp conditions, and the age group of the refugees (Pavli & Maltezou, 2017). Study by Mutua *et al.*, (2022) reported that hemoglobinopathies were more frequent among refugees from Africa and Asia resettled in Germany. As per the present study, the overall prevalence of anemia among women in childbearing age (WCBA) was 34.4%. According to the cut off values established by the World Health Organization (WHO), the prevalence of overall anemia among WCBA of Adjumani refugee settlements in this study is considered to be a moderate public health issue (Legason *et al.*, 2017). Although the prevalence of overall anemia (34.4%) reported in this study was above the WHO recommended threshold, the prevalence was lower compared to the rates reported in other studies among refugees. For instance, a study conducted in South Sudanese refugees in Pugnido, western Ethiopia, reported a prevalence of 36.1% (Alemayehu *et al.*, 2016). Similarly, Palestinian refugees in the occupied Palestinian Territory had a prevalence of 38.6% (Khader *et al.*, 2009). Among South Sudanese refugees living in camps in Uganda, the prevalence was 36.3% in 2016 (Adaku *et al.*, 2016), and in Malaysia, it was 35.0% (Alemayehu *et al.*, 2016). However, it should be noted that the prevalence in this study was higher than the findings of a

study conducted in Southeast Ethiopia, which reported a prevalence of 27.9% (Kefiyalew *et al.*, 2014). The observed variation in results could potentially be attributed to differences in timing and methodology (Verhagen *et al.*, 2020). For instance, the studies examining South Sudanese refugees in Pugnido, western Ethiopia, and Palestinian refugees in the occupied Palestinian Territory were conducted at different facilities in 2015 and 2006, respectively. On the other hand, the study conducted in Southeast Ethiopia focused on pregnant women residing in specific facilities. The Malaysian study had a similar focus as the present study, examining the residential population. However, it is important to note that there are additional differences between the two contexts. Displaced individuals of the Malaysian study may not have had equal access to food aid and other facilities compared to refugees in the present study (Sherif *et al.*, 2022).

According to the settlement data, Nyumanzi, Mungula, and Maaji 3 refugee settlements exhibited a higher proportion of anemia compared to the overall proportion of anemia in Adjumani refugee settlement. This shows significant variation in anemia prevalence among women in different regions or locations. The prevalence of anemia in Eastern Sudan, was found to be 52.4% (Adam *et al.*, 2005). Similarly, in Wolayta Sodo Town, Southern Ethiopia, the prevalence was 60% (Ageru *et al.*, 2019). In Karnataka, India, the prevalence was 50.4% (Scott *et al.*, 2022), and in West Algeria, it was 49.5% (Chowdhury & Chakraborty, 2017). These findings highlight the significant burden of severe anemia in WCBA across different geographical locations. For the refugees in Uganda, a study conducted in 2015 examined South Sudanese refugees living in refugee camps in Uganda, where severe anemia accounted for 89.2% of cases (IPCC., 2022). Similarly, a study conducted in Southeast Ethiopia found that severe anemia constituted 55% of cases (Alemayehu *et al.*, 2016). Additionally, among South Sudanese refugees in the New Caseload of Uganda, 86.2% of cases were classified as severe anemia

(Wamani , 2014). There are potential factors that may have contributed to inconsistencies in the study conducted among Sudanese refugees residing in refugee camps in Uganda. One such factor is the timing (Kare & Gujo, 2021) of the present study, which took place in 2023. Additionally, it is worth noting that the present study was not conducted within a facility-based setting compared to studies. The study conducted in Southeast Ethiopia was based on a small sample size and focused exclusively on facilities, excluding individuals who were refugees. Different cut-off points were utilized in studies conducted on Palestinian refugees in occupied Palestinian Territory and Kakamega, Eastern Sudan where severe cases were defined as having a score greater than 10.9 (Hashim & Ali, 2017). However, iron deficiency is the main cause of anemia among refugees' population, yet Hb (hemoglobin) score may not provide an accurate representation of the issue. This is because low Hb levels can be attributed to various other factors besides iron deficiency. Hence, section 5.2.2 offers a further understanding of anemia because of iron deficiency.

5.2.2. Prevalence of iron deficiency anemia in Adjumani refugee settlement

Iron deficiency is a prevalent and significant health issue that frequently affects women in childbearing age (Armah-Ansah, 2023), particularly in refugee settings characterized by limited access to sufficient nutrition and healthcare resources (Pavli & Maltezos, 2017). Based on data provided by the World Health Organization, a significant proportion of women aged 15-49 years, experienced anemia (WHO, 2020a). Notably, the African region exhibited the highest prevalence of anemia (Sharif *et al.*, 2023), with a rate of 60.2%. The current study revealed that approximately 37% of women in childbearing age who were anemic presented with iron deficiency anemia (IDA), showing that IDA contributed to 37% of the anemia cases reported among the study participants. This finding may be attributed to the low dietary diversity (Delil *et*

al., 2018; Jordaan *et al.*, 2020) observed in the study, as it was observed that the most frequently consumed food sources were predominantly plant-based with low amounts of iron. It is important to note that plant-based foods have a significant presence of antinutritional factors (Samtiya *et al.*, 2020), which can potentially hinder the bioavailability of non-heme iron (Nath *et al.*, 2022). This suggests that a reduced amount of non-heme iron will be absorbed, resulting in an insufficient supply to meet the daily iron requirement. Consequently, the body may experience a deficiency in iron necessary for the production of hemoglobin (Miller, 2013), the protein responsible for transporting oxygen in the bloodstream. This leads to a decrease in the delivery of oxygen to the tissues and organs, resulting in symptoms such as fatigue, weakness, pallor, dyspnea, and heightened vulnerability to infections (Świątczak *et al.*, 2022).

The overall serum ferritin concentration of women in childbearing age was significantly below the recommended daily iron requirement. A lower concentration of serum ferritin may have detrimental effects on both maternal and fetal health (Georgieff, 2020; Świątczak *et al.*, 2022). These effects may include an increased risk of preterm delivery, low birth weight, and perinatal mortality (Abu-Ouf & Jan, 2015; Smith *et al.*, 2019). The current study's findings indicate a higher prevalence of iron deficiency anemia (IDA) among women of childbearing age compared to previous studies conducted by Fite *et al.*, (2022) and Pobee *et al.*, (2021) in Eastern Ethiopia and Ghana, respectively. The disparities in dietary practices, sociocultural variations, and iron absorption could potentially contribute to the elevated prevalence of iron deficiency in the study done in Eastern Ethiopia. Moreover, the utilization of community-based selection, as opposed to solely relying on women presenting to healthcare facilities as applied in the study done in Ghana, could be responsible for the findings of the current study. However, there is a growing body of evidence suggesting that the percentage of anemia attributed to iron deficiency (ID) varies

depending on geographical location, the burden of infectious diseases, and the prevalence of other causes of anemia (Verhagen *et al.*, 2020; Scott *et al.*, 2022; Sherif *et al.*, 2022). This is supported by the findings of the current study, which observed variations in serum ferritin concentration of the sampled WCBA from different settlements within Adjumani district. This suggests that interventions aimed at reducing IDA should consider the geographical context prior to implementation to optimize their effectiveness.

However, anemia is a medical condition that impacts the production and functionality of red blood cells, which play a crucial role in transporting oxygen throughout the body (Smith *et al.*, 2019). There are numerous potential causes of anemia, with iron deficiency being among them (Pobee *et al.*, 2021). Based on recent current study findings, it has been determined that iron deficiency is not the sole factor contributing to the occurrence of anemia, a medical condition characterized by impaired red blood cell production. Other factors, such as nutritional deficiencies, could have been identified as significant contributors (Smith *et al.*, 2019; Scott *et al.*, 2022). The other contributing factors may include infections, inflammation, genetic disorders, as well as instances of blood loss (WHO, 2020a). It is imperative to accurately diagnose the root cause of anemia prior to initiating any treatment. In order to address this issue, it is necessary to enhance the diagnosis and classification of anemia through the utilization of standardized methods and criteria (An *et al.*, 2021). Additionally, it is imperative to conduct population-based surveys and studies to evaluate the prevalence and severity of iron deficiency anemia (IDA), along with its associated risk factors and consequences. The inclusion of such information would greatly contribute to the development and implementation of impactful interventions aimed at preventing and treating iron deficiency anemia (IDA), ultimately leading to improved health outcomes and overall well-being among women of reproductive. However,

the associated risk factors of anemia among women in childbearing age in a refugee setting are unclear, and the section 5.3 provides more insight about such information.

5.3. Influence of dietary and socio-demographic factors related to serum ferritin status of women of childbearing age in Adjumani Refugee Settlement

Serum ferritin serves as a valuable biomarker for assessing both iron status and inflammation (Kell & Pretorius, 2014). It is important to consider that this biomarker can be influenced by several sociodemographic factors (Markt *et al.*, 2023), including age, gender, ethnicity, and migration status. The objective of this study was to examine the impact of various factors on the serum ferritin concentration of refugees who have been resettled in Uganda, a developing country. Based on the findings of Milman *et al.*, (2017), it was observed that there was a significant increase in serum ferritin concentration with age in women in childbearing age. The findings of the study align with the findings of the current study, although the results of the current study were not statistically significant (Table 8). In contrast, agriculture serves as a primary source of income for numerous refugees. As per report by WHO (2020), it was observed that farming exhibited a significant positive correlation with serum ferritin concentration in both refugee camps located in Uganda and Kenya. The findings of this study, as presented in Table 8, are consistent with the report. This consistency may be attributed to an increase in purchasing power (Hailu *et al.*, 2019). The results indicate that farming could potentially have a positive impact on the serum ferritin concentration of refugees. This may be attributed to increased availability of iron-rich foods or a decrease in exposure to infections that hinder iron absorption (Piskin *et al.*, 2022). In contrast, this study identified a negative impact of estimated monthly income with serum ferritin concentration of refugees which could be attributed to potential mismanagement of income whereby most of the income is spend more on food item like alcohol

resulting from stress and psychological factors associated with financial challenges within refugee settings (Chiumento *et al.*, 2020). These factors may impact iron metabolism (Piskin *et al.*, 2022), although the precise mechanisms involved are intricate and not yet comprehensively understood. This study presents findings that are in contrast to the research conducted by Hailu *et al.*, (2019) on non-refugee women in Ethiopia who noted that the women with low-income face challenges in accessing nutritious diets, which can result in poor eating habits and potentially contribute to anemia. There is no direct correlation between education and serum ferritin concentration. However, education can have an indirect influence on serum ferritin concentration through various mechanisms, such as enhancing knowledge about nutrition (Markt *et al.*, 2023). According to the findings of this study, it was observed that individuals with a non-formal education background exhibited a notable adverse effect on their serum ferritin concentration (Table 8). This outcome may be attributed to the limited understanding of nutrition among refugees (Amstutz *et al.*, 2020). The findings of this study align with the research conducted by Kay *et al.*, (2019), which observed that refugees with primary education had a reduced likelihood of experiencing low serum ferritin concentration compared to those without any formal education. This suggests that it is important to prioritize nutrition education for women of childbearing age. Therefore, nutrition interventions in refugee contexts should incorporate nutrition education as a component of their programs. Hence, this analysis may uncover underlying variables that contribute to the susceptibility and severity of iron deficiency, along with potential strategies to enhance the management of anemia.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1. Conclusions

Based on the findings of the current study, the following conclusions can be drawn. Women in childbearing age in Adjumani refugee settlement tend to consume starchy plant-based food sources more frequently than animal-based food sources. Because of heavy reliance on plant foods such as cereals and legumes, their dietary iron intake was significantly below the recommended daily allowance of iron. The study generates additional evidence that income generating activities within the context of refugees play a significant role in positively predicting dietary iron intake.

The prevalence of anemia in the Adjumani refugee settlement can be classified as mild, although this varies among the different settlements within Adjumani district. Women from the Nyumanzi, Mungula, and Maaji 3 refugee settlements demonstrate a higher severity of anemia. The prevalence of anemia upon field screening was 34.4%. The study further shows that iron deficiency makes a significant contribution to the recorded anemia situation among refugee women of childbearing ages. Among the sample grouped as anemic after screening, about 37% exhibited iron deficiency anemia. The predictors that influence the serum iron status of women in childbearing age in a refugee context include income generating activities, level of education, and estimated monthly income. Given the heavy reliance on plant based foods which are poor sources of iron, dietary factors did not have influence on iron status of women in childbearing age in the context of the current study.

6.2. Recommendation

6.2.1. Recommendations for practice

Based on the results of this study:

There is need to promote consumption of animal-based and iron-rich-food sources among women in childbearing age in Adjumani refugees' settlement to reduce the high reliance on starchy plant-based food sources and increase iron intake. The promotion program/interventions should also consider diversifying the economic activities of women in childbearing age in the refugee context. There is need for government agencies and non-governmental organization to consider the geographical context prior to implementation of interventions aimed at reducing IDA in order to optimize their effectiveness. Also, Nutrition interventions in context tailor toward increasing serum iron status in refugee contexts should incorporate nutrition education as a component of their programs.

6.2.2. Recommendations for future research

- i. Future study should assess additional biomarkers, such as transferrin saturation or soluble transferrin receptor, alongside serum ferritin, to evaluate the exact contribution of iron deficiency to anemia.
- ii. Future study should focus on conducting postprandial studies to assess actual bioavailability of iron in the body
- iii. Future should focus on the effects of providing nutrition education on dietary iron intake among the refugees.
- iv. Future research should focus analyzing the on influence of household, income decision making, and cultural norms on serum iron status of women in childbearing age.

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APPENDIXES

Appendix I: Informed consent for WCBA in Adjumani Refugee Settlement

INFORMED CONSENT DOCUMENT

VERSION 2.0, DATED 12th /JUNE/ 2023.

Title of the study: DIETARY IRON INTAKE AND PREVALENCE OF IRON DEFICIENCY ANEMIA AMONG WOMEN OF CHILDBEARING AGE IN ADJUMANI REFUGEE SETTLEMENT

Investigator(s): IKOMOLOT CAROLINE

Institution(s): GULU UNIVERSITY

Introduction

Dear Sir/Madam

My name is Ikomolot Caroline, a student pursuing a Master of Science Food Security and Community Nutrition of Gulu University conducting research on the topic “Dietary Iron Intake and Prevalence of Iron Deficiency Anemia among Women of Childbearing Age in Adjumani Refugee Settlement” with approval from the Gulu University Research Ethics Committee, and the Faculty of Agriculture and Environment, Department Food Science and Post Harvest Technology.

During the study, you will be asked to fill the questionnaire together with guidance from the researcher. This informed consent explains the details of the study to you. After the study has been explained, any questions you may have will be answered, and if you decide to participate in the study, you will be asked to sign a consent form, which document you will retain a copy of.

A brief description of the sponsors of the research project

This study is sponsored by the MasterCard Foundation and Regional Universities' Forum for Capacity Building in Agriculture (RUFORUM). The partnership between the said institutions is to support learning in many African agricultural universities and facilitate students in carrying out research to enable them craft tailor made solutions to the problems in their communities.

Purpose:

This study is purely academic, and its core intention is to help researchers understand the dietary iron intake, the contribution of iron deficiency anemia to total anemia as well as the dietary and sociodemographic factors related to serum iron status among women of childbearing age in Adjumani Refugee Settlement. Your household has been selected randomly to participate in this survey and the information provided by you will be treated in a confidential manner. Please note that there will be no in-depth details that will be used to identify you as the one who gave specific information in this survey. After understanding the above parameters, the researcher will present the findings to the policy makers and the government institutions responsible for designing health interventions for addressing key nutritional problems identified in the community that will better improve on the wellbeing of the community members.

Procedures:

Your participation in this study will involve providing answers to the questions your dietary iron intake and you will also be requested to for a sample of your blood that will be screened for anemia. If you are found to be anemic, another sample that will be sent to the lab for further investigation will be withdrawn. I would be glad if you could spare some time (approximately 35 minutes) to answer our questions.

Who will participate in the study?

A woman of childbearing age aged 15 to 49 years who is a refugee residing in Adjumani

settlement will be eligible for the study. For girls below 18 years, only those who are married will meet the criteria for participating in the study. The interview will last for approximately 35 minutes and a total of 424 respondents will participate in this study.

Risks/discomforts:

There is a foreseeable risk of harm or discomfort that will arise from your participation in this study. There's a risk of hemophilia/ unstoppable bleeding during sample collection. Even though this is a rare occurrence, the health workers will link such cases to specialized medical doctors at the health centers and the field team will obtain phone numbers of these medical doctors before going to the field to ensure quick referral and linkage. Another possible risk is infections of the puncture site during sample collection. To prevent this, the health workers will ensure proper disinfection of the punctured site with alcohol swabs. Also, there is a possibility of contracting Covid-19 or any other communicable diseases among the participants and the research team. However, regulation on contracting the said diseases will be done by strictly adhering to the well laid out standard operating procedures as directed by the ministry of health. There shall be regular washing of hands with clean water and soap, wearing of face masks or face covering, limited body contact (hugging, shaking hands), and maintain 2 meters apart during the interactions. This shall be observed by both the research team and the respondents/ household survey members. The other foreseeable risk may be the inconvenience in terms of time that will be spent during the interview.

Benefits:

You will be provided with refreshments (a drink and a snack) at the end of the interview. You shall also get a bar of washing soap after the interview as a token of appreciation for your valuation participation in the study.

During the study, participants will get the privilege of having any queries related to the study answered. Research participants will get feedback on findings and progress of the study, and that any new information that affects the study participants (including incidental findings) will be made available to research participants. Research participants will also benefit if favorable policies are generated from the study recommendations.

Confidentiality:

Your identity will not be revealed to any one as we shall only use codes to identify participants. Information obtained will also only be accessed by the research team. Soft copies of the data will be protected by encrypting passwords and hard copy files will be kept under lock and key. Confidential information will only be accessed by the principal investigator.

Alternatives:

You do not have to participate in this study if you are not interested. You are not indebted to participate without your free will.

Cost:

There will not be any additional cost incurred as a result of participating in this study.

Questions:

If you have any questions related to the study as a research participant, please contact the principal investigator, IKOMOLOT CAROLINE on telephone number 0781372175 or via

email address caroikomo@gmail.com

Statement of voluntariness:

Participation in the research study is voluntary and you may join on your own free will. You have a right to withdraw from the study at any time without penalty. If you have any issues pertaining to your rights and participation in the study, please contact the Chairperson, Gulu University Research Ethics Committee, Dr. Gerald Obai Tel: No., 0772305621; email: lekobai@yahoo.com/lekobai@gmail.com; or the Uganda National Council for Science and Technology, on plot 6 Kimera road, Ntinda, Kampala on Tel 0414705500.

Respondent's statement of consent

..... has described to me what is going to be done, the risks, the benefits involved and my rights as a participant in this study. I understand that my decision to participate in this study will not affect me in any way. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive off any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name.....

Signature/Thumbprint of participant.....

Date.....

Name.....

Signature/Thumbprint of
witness.....

Date.....

Name.....

Signature of the interviewer.....

Date.....

Appendix II: Survey Questionnaire for WCBA in Adjumani Refugee Settlement

DIETARY IRON INTAKE AND PREVALENCE OF IRON DEFICIENCY ANEMIA AMONG WOMEN OF CHILDBEARING AGE IN ADJUMANI REFUGEE SETTLEMENT

QUESTIONNAIRE

SECTION A: PARTICIPANT BIO DATA

Part 1. General information		
Date of interview		
Name of interviewer		
Participant number		
Contact (Optional)		
Location	Origin	Residence
District		
Division		
Parish		
Village		
Part 2. Sociodemographic factors affecting body iron status. INSTRUCTIONS: Please Tick, write or mark in the box (s) that corresponds to the correct response(s). Record the appropriate response(s) that is (are) missing from the response category where applicable.		
QUESTIONS	RESPONSE(S)	TICK
Age in years of the Respondent.		
Religion	Christianity	
	Islamic	
	Traditional African Religion	
	Others (Specify)	
Marital status of the Respondent	Single	

	Married	
	Divorced	
	Widowed	
Highest level of education attained	Primary	
	Secondary	
	Tertiary	
	No formal education	
What is your occupation	Farming	
	Business	
	Housewife	
	Formal employment	
What is the most common way in which your household obtains food	Own production	
	Purchase	
	Donation/gift/Aid	
	Other (specify)	
How many people live in your household		
How many people earn some income in your household		
What income generating activities does your household engage in	Brick laying	
	farming	
	Other (specify)	
On average, how much does your household earn in total per month from your income generating activities?		
SECTION B: Anemia screening for the women of childbearing age		
Instruction: Please ask the respondent if she is okay for her blood sample to be withdrawn.		

If she agrees, kindly draw the blood sample and test for presence of any form of anemia using a portable Hemocue and record the readings								
Hemoglobin (Hb) reading								
If the participant is anemic, kindly with draw another sample and store in the Red top to be sent for further investigation								
Sample collected for further analysis		yes	1					
		No	2					
SECTION C: Dietary Iron Intake								
Part 4: frequency of consumption of iron rich foods								
Instruction: We are interested in knowing how often you consume the following foods. Please indicate the number of times and the estimated portion sizes consumed in the appropriate column.								
FOOD GROUP	Food items per group	Never	Once daily	2 or more times daily	Once weekly	2-3 times weekly	4 or more times weekly	Estimated portion sizes consumed per food item.
Grains, roots and tubers	Rice							
	Bread							
	Sorghum							
	Millet							
	Maize							
	Potatoes							
	Cassava							
	Yams							
	Other(specify)							
Pulses	Beans							
	Cow Peas							
	Pigeon Peas							
	Other (Specify)							

Nuts and seeds	Groundnuts							
	Simsim							
	Other(specify)							
Dairy	Yoghurt							
	Fresh milk							
	Other(specify)							
Meat, poultry, and fish	Meat							
	Chicken							
	Fish							
	Other(specify)							
Eggs	Eggs							
Dark leafy greens and vegetables	Spinach							
	Dodo							
	Cabbage							
	Osobi							
	Akeyo							
	Other(specify)							
vitamin A rich fruits and vegetables	Mangoes							
	Paw Paws							
	Carrots							
	Other(specify)							
Other vegetables	Okra							
	Egg Plants							
	Ntula							

	Other(specify)							
Other fruits	Apples							
	Guava							
	Tomatoes							
	Oranges							
	Other(specify)							

INTAKE OF IRON SUPPLEMENTS

Instruction: Please ask the correspondents the following questions to ascertain if they are taking any iron supplements. Tick the appropriate answer as per the responses below.

S/NO	QUESTION	RESPONSE
1	Have you ever taken iron supplement?	Yes..... No.....
2	If yes, what made you to take it?	ANC requirement Other diseases e.g anemia Own initiative
3	When was the last time you took iron supplements	One week ago One month ago Three months Above three months

Thank you for participating in this survey.

Appendix III: General ELISA protocol for analysis of serum ferritin (iron) according to (Dahman et al, 2022)

Plate Preparation

1. Initially, the capture antibody was diluted to a working concentration in Phosphate-buffered saline (PBS) without any carrier protein.
2. Subsequently, 100 μ L of the diluted capture antibody was added to each well of a 96-well microplate.
3. The plate was sealed and left to incubate overnight at room temperature. Afterward, the contents of each well were aspirated, and a buffer was used to wash each well.
4. This washing process was repeated two more times, resulting in a total of three wash cycles. To perform the washes, each well was filled with 400 μ L of wash buffer using a squirt bottle.
5. To block the plates, 300 μ L of reagent diluent was added to each well and incubated at room temperature for one hour, as described by Dahman et al. (2022).
6. Subsequently, plate aspiration was performed to prepare them for sample addition.

The assay procedure

1. 100 μ L of sample or standards in reagent diluent were added per well, covered with an adhesive strip, and incubated for 2 hours at room temperature.
2. Afterward, plate washing was conducted.
3. Following the washing step, 100 μ L of the detection antibody, diluted in reagent diluent, was added to each well, covered with a new adhesive strip, and incubated for an additional 2 hours at room temperature.
4. Plate aspiration was repeated once again.

5. Next, 100 μ L of the working dilution of streptavidin-HRP B was added to each well, covered, and incubated for 20 minutes at room temperature, followed by another round of washing/aspiration.
6. Subsequently, 100 μ L of substrate solution was added to each well and incubated for 20 minutes at room temperature, away from direct light.
7. Finally, 50 μ L of stop solution was added to each well, and the plate was gently tapped to ensure thorough mixing.
8. The optical density of each well was determined immediately using a microplate reader set at 450nm.

Appendix IV: GUREC Approval Letter

GULU

P.O. Box 166, Gulu (U)
Website: www.gu.ac.ug
Email: gurec@gu.ac.ug



UNIVERSITY

Tel: +256 471 432 096
Fax: +256 471 432 913
Mob: +256 772 305 621
+256 776 812 147

RESEARCH ETHICS COMMITTEE

01/08/2023

To: Caroline Ikomolot

Gulu University
0782152875

Type: Initial Review

Re: GUREC-2023-552: DIETARY IRON INTAKE AND PREVALENCE OF IRON DEFICIENCY ANEMIA AMONG WOMEN OF CHILDBEARING AGE IN ADJUMANI REFUGEE SETTLEMENT

I am pleased to inform you that at the **98th** convened meeting on **24/03/2023**, the Gulu University REC meeting voted to approve the above referenced application.

Approval of the research is for the period of **01/08/2023** to **01/08/2024**.

As Principal Investigator of the research, you are responsible for fulfilling the following requirements of approval:

1. All co-investigators must be kept informed of the status of the research.
2. Changes, amendments, and addenda to the protocol or the consent form must be submitted to the REC for re-review and approval **prior** to the activation of the changes.
3. Reports of unanticipated problems involving risks to participants or any new information which could change the risk benefit: ratio must be submitted to the REC.
4. Only approved consent forms are to be used in the enrollment of participants. All consent forms signed by participants and/or witnesses should be retained on file. The REC may conduct audits of all study records, and consent documentation may be part of such audits.
5. Continuing review application must be submitted to the REC **eight weeks** prior to the expiration date of **01/08/2024** in order to continue the study beyond the approved period. Failure to submit a continuing review application in a timely fashion may result in suspension or termination of the study.
6. The REC application number assigned to the research should be cited in any correspondence with the REC of record.
7. You are required to register the research protocol with the Uganda National Council for Science and Technology (UNCST) for final clearance to undertake the study in Uganda.

The following is the list of all documents approved in this application by Gulu University REC:



No.	Document Title	Language	Version Number	Version Date
1	Data collection tools	English	Version 2	2023-07-27
2	Informed Consent Form	English	Version 2	2023-07-27
3	Informed Assent Form	Arabic	Version 2	2023-07-27
4	Informed Assent Form	English	Version 2	2023-07-27
5	Informed consent form for parents/ Guardians	Arabic	Version 2	2023-07-27
6	Informed consent form for parents/ Guardians	English	Version 2	2023-07-27
7	COVID-19 Risk Management Plan	English	Version 2	2023-07-27
8	Protocol	English	Version 2	2023-07-23

Yours Sincerely



 Dr. Gerald OBAI
 For: Gulu University REC

Appendix V: Plagiarism Certificate

GULU P.O. Box 166 Gulu, Uganda		UNIVERSITY Tel: +256-471-32924 Fax: +256 471343095 Emails: ul@gu.ac.ug URL: www.gu.ac.ug
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PLAGIARISM CHECK

Declaration for Originality Form
This form must be completed and signed for all scholarly work produced.

Name: CAROLINE IKOMOLOT

Personal File No.(staff) Reg. (student). 21/U/3310/MFN/PS

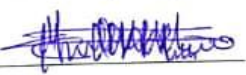
Faculty/Institute: AGRICULTURE

Department: FOOD SCIENCE AND POST HARVEST TECHNOLOGY

Title and bibliographic description of the work
DIETARY IRON INTAKE AND PREVALENCE OF IRON DEFICIENCY ANEMIA AMONG WOMEN OF CHILDBEARING AGE IN ADJUMANI REFUGEE SETTLEMENT

Declaration.

1. I understand what plagiarism is and I am aware of the University policy on this regard,
2. I declare that this ...**Thesis**... (thesis, dissertation, essay, assignment, paper, report etc.) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my work has been used, this has been properly acknowledged and referenced in accordance with Gulu University requirements,
3. I have not sought or used the services of any professional agency to produce this work,
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own,
5. I understand that any false claim of this work shall result in disciplinary action in accordance with University Policy on Plagiarism.

Signature  Date

Originality Report

The article/thesis/document titled above have been subjected to plagiarism check and the level was found to be.....**20%** (percent) this is classified as:

☒ **Minor**
☐ **Moderate**
☐ **Serious**

Yours sincerely,


Dr. Ongaya Kizito (PhD)
Senior Librarian